Endogenously Chosen Boards of Directors and Their Monitoring of the CEO*

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Abstract

A fundamental issue in governance research is how boards can be chosen through a process partially controlled by the CEO but yet can still be somewhat effective in monitoring the CEO. We offer an answer based on a model in which board effectiveness is a function of the board's independence. This, in turn, is a function of negotiations (implicit or explicit) between the existing directors and the CEO over who will fill vacancies on the board. We show how the CEO's bargaining power over the board-selection process depends on his perceived ability. Many empirical findings about board structure and performance arise as equilibrium phenomena in this model.

1 Introduction

Corporations are not governed by the process that corporate law would seem to imply. Corporate law states that shareholders choose the board of directors; in practice, shareholders almost always vote for the slate proposed by

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management.[1] Moreover, this slate is approved by, if not chosen by, the very CEO these directors are supposed to monitor (see, e.g., Mace, 1971; Lorsch and MacIver, 1989; Demb and Neubauer, 1992). The resulting governance system has been criticized by both academics and the press, who perceive it to be ineffective in controlling management (see, for example, Drucker, 1981; Lipton and Lorsch, 1992; Jensen, 1993).

Given these apparent shortcomings, it is easy to forget that the current governance system is the market solution to an organizational design problem (albeit one that must be solved under legal constraints—e.g., all firms must have boards and boards must have certain powers).[2] Competition in product markets, as well as pressure from capital markets, tends to limit how inefficient firms can be. Thus, as Stigler and Friedland (1983) argued, before any criticism of current governance practice is taken too seriously, a thorough understanding of the market forces that have led to its existence seems necessary. This, in part, is what we propose to do here.

The previous literature on corporate governance has focussed on what boards do, without asking how they get to be the way they are. However, the answers to these questions are invariably linked. For instance, a board packed with the CEO's relatives is likely to be less effective than one made up of large shareholders. To understand corporate governance, the questions of director choice and director function must be answered simultaneously.

In modeling corporate governance, we focus on the problem of monitoring the CEO. After hiring a CEO, the board updates its assessment of his ability based on the firm's profits, and can replace him if it chooses. The existing board and the CEO negotiate over both the CEO's wage and who will be put in vacant directorships. These negotiations could be explicit. Alternatively, in keeping with the institutional literature (see, e.g., Mace, 1971; Lorsch and MacIver, 1989; Demb and Neubauer, 1992), these negotiations could be implicit; for instance the CEO could nominate new board members subject to a tacit understanding about the set from which they may be chosen. Were the CEO to violate this understanding, the board would refuse to approve his nominees.

The board's level of independence is determined through these negotiations between the board and the CEO. The CEO's bargaining power in

[1] Even when shareholders do challenge management's slate of directors in a proxy fight, DeAngelo and DeAngelo (1989) find that they win a board seat only about one-third of the time.

[2] For an alternative view, see Roe (1994).

these negotiations comes from his *perceived* ability relative to a replacement. Board independence is important because the board, if it chooses, can acquire additional, costly information about the CEO. Directors vary in their willingness to monitor, so the composition of the board affects the likelihood that it acquires this additional information. The board uses its information about the CEO in deciding whether to retain or to replace him. In this model, therefore, both the structure of the board and its actions are endogenously derived.

To evaluate the model's realism, we compare its predictions to existing empirical findings. Some of the model's predictions are:

1. A CEO who performs poorly is more likely to be replaced than one who performs well.

2. CEO turnover is more sensitive to performance when the board is more independent.

3. The probability of independent directors being added to the board rises following poor firm performance.

4. Board independence declines over the course of a CEO's tenure.

5. Accounting measures of performance should be better predictors of management turnover than stock-price performance.

These predictions are consistent with existing studies of large corporations.

Predictions 1 and 2 match the empirical evidence on CEO turnover. A number of papers (e.g., Coughlan and Schmidt, 1985; Warner *et al.*, 1988; Jensen and Murphy, 1990), find that CEO turnover is negatively related to prior performance. In addition, Weisbach (1988) finds that the sensitivity of CEO turnover to performance is greater for firms with a higher proportion of outside directors, presumably because these firms' boards are more independent of management than are boards dominated by inside directors.

While prediction 1 follows from other models (e.g., Hirshleifer and Thakor, 1994), prediction 2 is more unique. The intuition behind prediction 2 is that new CEOs require more monitoring than old ones, since less is known about a new CEO's ability. Boards that are more independent have a greater tolerance for this added monitoring, so they can afford to be tougher with an incumbent CEO whose performance is marginal.

Prediction 3 is consistent with the pattern of director turnover found by Hermalin and Weisbach (1988). In addition, Hermalin and Weisbach find that the proportion of outside directors on the board decreases over the CEO's career. This suggests that board independence declines over a CEO's tenure, consistent with prediction 4.

Prediction 3 follows because poor performance lowers the board's assessment of the CEO's ability, which reduces his bargaining position and, thus, increases the probability that the CEO will be forced to accept more independent directors. Similar logic explains prediction 4: If a CEO keeps his job, then retaining him must be worth more to the directors than replacing him. This means that this CEO is, to some extent, a rare commodity, which gives him bargaining power *vis-à-vis* the directors; hence, he is able to bargain for a board that is more favorable to him.

Prediction 5 is consistent with both Weisbach (1988) and Murphy and Zimmerman (1993), who estimate equations using both stock returns and earnings to predict management changes and find that earnings do a better job. The intuition for the theoretical result is that earnings are a function of current management only, but that stock returns reflect both current management and the expectation of future management changes.

In addition, the analysis suggests that following predictions, which have not as yet been subject to formal empirical tests.

1. There should be long-term persistence in corporate governance. In particular, changes that either strengthen or weaken board independence should be "permanent" in that they change the long-term bargaining strength of the board against management.

2. The stock-price reaction to management changes should be negative if the manager is fired on the basis of private information and positive if the manager is fired on the basis of public information.

3. A CEO's salary (non-contingent) compensation should be insensitive to *past* performance at relatively low levels of past performance, but sensitive at relatively high levels of past performance.

The first prediction is consistent with anecdotal evidence of long-term patterns in corporate governance. When a firm has an extremely able CEO, he will be able to use his bargaining position to ensure a relatively weak

board throughout his career. Consequently, his successor will inherit a relatively weak board. Thus, the model provides an explanation for long-term persistence in firms' governance practices and, via cross-firm comparisons, an explanation for long-term inter-firm heterogeneity in these practices as well.

The second prediction potentially explains why empirical studies have found no consistent stock-price reaction to management changes (see Warner *et al.*, 1988): there have been no controls for whether the dismissals were due to private or public information. Our prediction follows because a change in management conveys information about both the board and the CEO. If the board bases its firing decision on private information, then a firing reveals that a CEO who was previously seen as better than the expected value of a replacement is not. Expectations of new management are lower than the previous expectations of old management, so the stock price falls. In contrast, if the firing is based on public information, then nothing new is revealed about the CEO, but firing conveys good news about the board's toughness and independence, so the stock price rises.

The third prediction comes from the structure of the bargaining game in our model. When the CEO is either new or a mediocre performer, the lower bound on his wage binds (a bound stemming from a limited-liability assumption). As performance increases, the CEO's bargaining position increases as well, allowing him to capture a fraction of the rents in the form of a higher wage.

Although the focus is on explaining phenomena related to boards of directors, the model we develop is fairly general. It extends the job-matching model of (similar to Jovanovic, 1979) by allowing for *endogenous* monitoring decisions. Among its features is a formalization of the argument that new workers are more valuable than older, better-known workers, *ceteris paribus*, because the former have a greater option value (see Proposition 2 below).

The paper has the following organization. The next section reviews some previous work on boards of directors. Section 3 introduces our model. We extend it in Section 4.1. In Section 4.1, we allow the board to favor the incumbent CEO over replacements. To the extent the board's preference for the incumbent is endogenous, the CEO will have a strong incentive to increase the board's preference for him; that is, to entrench himself. In Section 4.2, we consider how various governance activities affect the firm's stock price and how measures of firm performance will correlate with governance activities. Section 5 considers a reinterpretation of our model that eschews bargaining and ensures that turnover is always optimal from the sharehold-

ers' perspective. Many of our results continue to hold under this alternative interpretation, although we lose the ability to analyze management capture of the board. Section 6 considers some policy prescriptions that have been offered to correct the perceived failings of boards (e.g., regulations on the proportions of outsiders on the board or requirements that all directors be paid in stock rather than cash). Our model predicts that many of these policies will be ineffective. We conclude in Section 7.

2 Boards of Directors in Corporate Governance: Existing Theory and Evidence

Berle and Means (1932) observed that the separation of ownership and control inherent in a diversely held corporation appears to lead to a board of directors controlled by management. They argued that:

> ... control will tend to be in the hands of those who select the proxy committee and by whom, the election of directors for the ensuing period will be made. Since the proxy committee is appointed by the existing management, the latter can virtually dictate their own successors. Where ownership is sufficiently subdivided, the management can thus become a self-perpetuating body even though its share in ownership is negligible (Berle and Means, 1932, pages 87–88).

Management's apparent control of the board selection process led Berle and Means, as well as more contemporary authors such as Jensen (1993), to question whether directors were effective monitors and, thus, whether corporations can operate efficiently.

A counter-argument is that directors' concern for their reputations in the managerial or director labor market causes them to be effective monitors (Fama, 1980; Fama and Jensen, 1983). Specifically, directors' reputations as managers or monitors depend on the performance of the companies on whose boards they serve. This, in turn, provides incentives for them to make value-maximizing decisions. Kaplan and Reishus (1990) find evidence consistent with this argument: directors of poorly performing firms, who therefore may be perceived to have done a poor job overseeing management, are less likely to become directors at other firms. On the other hand, as Holmstrom (1983)

shows, reputational concerns need not correct all agency problems and can, in fact, create new ones.

To resolve these conflicting arguments about board effectiveness, an empirical literature assessing the board's role has developed. This literature has focused on the relationship between the composition of the board—typically measured as the fraction of directors who are insiders (i.e., management) or outsiders (i.e., those not otherwise affiliated with the firm)—and corporate decision-making. For instance, Brickley *et al.* (1994a) find that board composition affects firms' decision to adopt poison pills; Byrd and Hickman (1992) find that the greater the fraction of outside directors, the better the stock market's reaction to their firm's tender offers for other firms; Shivdasani (1993) finds the composition of the board and the board's shareholdings affect the likelihood a firm is acquired in a hostile takeover; and Weisbach (1988) finds that the sensitivity of CEO turnover to firm performance increases with the fraction of outside directors on the board. In summary, these studies indicate that the board's structure matters when there is an unusually important decision to be made. Unfortunately, measuring the day-to-day effect of board composition on corporate profits is made difficult by simultaneity problems, since board composition itself changes because of corporate performance (see Hermalin and Weisbach, 1991, for further discussion).[3]

For measurement reasons, this literature generally divides directors into two, sometimes three, classes. Yet there are nonetheless important differences within classes of directors, especially among outsiders. Directors differ in terms of their pecuniary incentives, their share ownership, and personal financial situations. Their personal labor markets are different, leading to different reputational concerns about the performance of the firms on whose boards they serve. Directors also differ in terms of their relationship with the CEOs who appoint them and their willingness to monitor these CEOs.

Several papers have documented that these differences are important. Shivdasani (1993) finds evidence of better monitoring from outside directors who own a substantial number of shares and who hold more corporate directorships. The shareholdings affect the directors pecuniary incentives, while the additional directorships measure the importance of directors' reputations

[3]Some papers that nonetheless attempt to estimate the day-to-day effect are Baysinger and Butler (1985) and MacAvoy *et al.* (1983). Also see Booth and Deli (1996), Borokhovich *et al.* (1995), Brickley and James (1987), Brown and Maloney (1992), Cotter *et al.* (1996), Kini *et al.* (1994), Klein (1995), Mayers *et al.* (1992), Rosenstein and Wyatt (1990), and Yermack (1996) for related empirical work.

in the labor market. Hallock (1995) finds that firms whose boards are interlocked (containing a CEO on whose board the firm's CEO serves) tend to pay their CEOs more. Presumably, interlocked directors are less willing to interfere in the affairs of the CEO who appointed them because of a friendship or other business relationship.

While the empirical literature on boards is fairly well developed at this point, there has been little formal modeling of the board. Existing papers have considered important issues about the board's conduct, but have ignored the process by which boards get to be the way they are (see Brickley *et al.*, 1994b; Hirshleifer and Thakor, 1994; Noe and Rebello, 1996; Warther, 1994). Our view is that such modeling is useful, but that the fundamental issue in governance research is to explain why the market solution is for boards to be chosen through a process partially controlled by the CEO but yet are still somewhat effective in monitoring the CEO.

3 The Model

We model the board selection process as a bargaining game between the CEO and the board. We assume no active role for the shareholders (although some of them could be directors). Rather shareholders simply ratify the slate put forward by the company. This is consistent with studies such as Berle and Means (1932); Mace (1971); Lorsch and MacIver (1989), and Demb and Neubauer (1992). We discuss shareholder activity, particularly in crisis situations, later.

3.1 Timing

The game between the directors and the CEO has multiple stages with the following timing.

1. At the beginning of the game, the firm has a new CEO. The commonly held prior distribution about the CEO's ability, α, is normal with mean zero and variance $\frac{1}{\tau_0}$(τ_0 is the *precision* of the distribution). We set the mean to zero for convenience, but without loss of generality.

2. The first realization of earnings, x, occurs. Earnings are determined stochastically and are distributed normally with a mean equal to the CEO's true ability, α, and a variance equal to $\frac{1}{r}$.

3. Based on the realized earnings, the board updates its estimate of the CEO's ability. The board may at this stage decide to fire the CEO and hire a replacement CEO. The prior distribution of *any* replacement CEO's ability is normal with mean zero and variance $\frac{1}{\tau_0}$.

4. The CEO (either the incumbent or the replacement) negotiates with board over the filling of vacancies on the board and his wage (salary), w.[4] If the bargaining is unsuccessful, the CEO is fired and a replacement is hired. If a replacement is hired at this stage, the board bargains with him concerning the filling of vacancies on the board.

5. The board may then acquire a private signal, y, about the CEO. The probability that the board acquires this signal depends on the intensity with which it monitors the CEO. The signal is distributed normally with a mean equal to the CEO's ability, α, and a variance equal to $\frac{1}{s}$.[5] The random variables $y - \alpha$ and $x - \alpha$ are independently distributed.

6. If the board acquires the signal, it will update its estimate of the CEO's ability. Based on this posterior estimate, the board may decide to fire the CEO and hire a replacement.

7. The second realization of earnings (profits gross of the CEO's compensation), x, occurs. As with the first realization, earnings are distributed normally with a mean equal to the CEO's true ability and a variance equal to $\frac{1}{r}$.

3.2 Preferences and Ability

The CEO in charge at stage 7 receives a control benefit of $b > 0$. A CEO who is dismissed prior to this (or not hired) receives a benefit of 0.

[4] We treat the creation of vacancies on the board as exogenous in this model. This is fairly realistic, since many vacancies arise for presumably exogenous reasons such as death, illness, or reaching the customary retirement age. We also do not explicitly consider how the number of vacancies might limit the ability of the board to adjust board composition. This is with little loss of generality, since (i) only the proof of Proposition 6 depends on achieving an interior solution (i.e., one in which vacancy limits don't bind); and (ii) board size often changes (see Hermalin and Weisbach, 1988, for evidence).

[5] Alternatively, we could assume that the board always receives a signal, but its precision (i.e., s) is endogenous (we thank Canice Prendergast for this point). This alternative leads to similar results, except the comparative statics with respect to τ are ambiguous.

The CEO is also compensated with a wage, w, which is determined as part of the bargaining process between him and the board. This wage is paid *regardless* of whether the CEO survives to stage 7. A critical assumption is that the CEO is protected by limited liability; specifically, the wage must be non-negative (i.e., $w \geq 0$).

A CEO's ability is fixed throughout his career. We follow Holmstrom (1983) by assuming that the CEO knows only the *distribution* of his ability. His knowledge on this matter is no better than the board's. That is, both the board's and the CEO's knowledge of the CEO's ability (as a CEO) is limited to knowing that it is drawn from a normal distribution with mean zero and precision τ_0. We justify this assumption by noting that the people hiring and the people being hired often have similar priors about how the people being hired will do on their *new* jobs.

To study the relationship between the board's composition and its monitoring of the CEO, we assume that each director, i's, utility is

$$\theta_i x - \kappa_i d(p). \tag{1}$$

The constant $\theta_i > 0$ equals the director's marginal utility from firm profits, x. We imagine that directors put different weights on profits for two reasons. First, directors' incomes will depend on their own shareholdings and the extent to which their directors' fees vary with the firm's profits. Second, directors' concerns for building reputations as competent managers may vary. This variation in θ_i can potentially explain cross-firm variation in board performance: some boards have directors who put a lot of weight on profits (e.g., large institutional investors), while other boards have directors who put little weight on profits (e.g., friends of the CEO). It should, however, be remembered that the *realized* values of θ_i in equilibrium are *endogenous* in our model, so the ultimate sources of cross-firm variation are the historical differences in the abilities of the firms' CEOs and the previous structure of their boards.

The variable p is the probability that the board obtains an additional signal, y, about the CEO. It reflects the intensity with which the board monitors the CEO. The disutility of monitoring the CEO is $\kappa_i d(p)$, where $d(\cdot)$ is a common, strictly increasing, strictly convex, and twice-differentiable function and κ_i is the director's distaste for monitoring. We imagine that directors' distaste for monitoring the CEO varies for three reasons. First, inside directors' careers are tied to the CEO's, so they rarely find it in their

interest to monitor him. Second, the opportunity cost of the directors' time will vary among outside directors. Finally, directors who value the opportunity to serve on other boards could have an incentive to establish reputations for not "rocking the boat"; i.e., for not intensely monitoring the CEOs on whose boards they currently serve.[6] As with the parameter θ_i, variation in κ_i can also help to explain cross-firm variation in boards' performances.

Since utility functions are defined up to an affine transformation only, we are free to replace (1) with the following:

$$x - k_i d(p) \tag{2}$$

where $k_i = \kappa_i/\theta_i$. We can interpret k_i as a measure of director i's *lack* of independence, at least in terms of the way he or she behaves.

We assume k_i is *fixed* for a given director i (at a specific firm and for a specific set of pecuniary incentives). In particular, we assume it is invariant with respect to who the CEO is. Specifically, a director cannot be more loyal to one CEO than another. We relax this assumption somewhat in Section 4.1, where we show that it does not change the qualitative nature of our results.

3.3 Updating Beliefs and Optimal Monitoring

When new information is observed, either profits or a signal, the players update their beliefs about the CEO's ability. Specifically, if $\hat{\alpha}$ and τ are the prior estimates of the mean and precision of the distribution of the CEO's ability, then the posterior estimates are

$$\hat{\alpha}' = \frac{\tau\hat{\alpha} + tz}{\tau + t} \text{ and } \tau' = \tau + t, \tag{3}$$

where z is either x or y and t is either r or s (see DeGroot, 1970, p. 167). Note that the posterior distribution is also normal.

It follows from (3) that the board has a more precise estimate of an *incumbent* CEO's ability at stage 3 than it would of any *replacement* CEO it hires. That is,

$$\tau > \tau_0, \tag{4}$$

[6] In fact, this reason appears to be an important consideration among directors. Some recent "corporate coups," for instance, were led by one director who was also a prominent CEO, and who, therefore, had little demand for additional directorships (see "The King is Dead," *Fortune*, January 11, 1993, pp. 34–48).

where τ is the precision of the estimate of the incumbent CEO's ability. Intuitively, this reflects the idea that an incumbent is a "known entity," so there is less uncertainty about him than there is about a new CEO.

The distribution of the signal y given the CEO's *true* ability, α, is normal with mean α and variance $\frac{1}{s}$; hence, the distribution of y given the CEO's *estimated* ability, $\hat{\alpha}$, is normal with mean $\hat{\alpha}$ and variance $\frac{1}{s}+\frac{1}{\tau}$.[7] Define

$$H = \frac{s\tau}{s+\tau}$$

to be the precision of y given $\hat{\alpha}$.[8]

Consider a CEO who, prior to being evaluated, has an estimated ability of $\hat{\alpha}$, which is known with precision τ. Suppose his evaluation returns a signal y. Using (3), the board will form a posterior estimate of his ability. This posterior estimate is also the expected value of profits (his wage, recall, is sunk at this point).

The alternative to retaining a CEO is to hire a replacement. The expected earnings from a replacement at this stage is, by assumption, zero. Moreover, because all replacements are *ex ante* identical, they have no bargaining power. Hence, the directors can set a minimum wage, $w = 0$. The expected profit from a *replacement* CEO is, therefore, zero. The incumbent CEO will, therefore, be dismissed whenever $\hat{\alpha}' < 0$. Using (3), we can state this dismissal condition as

$$-\frac{\tau\hat{\alpha}}{s} > y. \tag{5}$$

The firm's expected value prior to evaluation is

$$V \equiv \int_{-\infty}^{\infty} \max\left\{0, \frac{\tau\hat{\alpha}+sy}{\tau+s}\right\}\sqrt{\frac{H}{2\pi}}e^{-\frac{H}{2}(y-\hat{\alpha})^2}dy.$$

Since the option to fire the CEO is a valuable option, it follows that $V > \hat{\alpha}$ for all τ.

[7] The random variable $y-\hat{\alpha}$ is the sum of two independently distributed normal variables: $y-\alpha$ and $\alpha-\hat{\alpha}$; hence $y-\hat{\alpha}$ is also normally distributed. Since the means of these two random variables are both zero, the mean of y given $\hat{\alpha}$ is, therefore, $\hat{\alpha}$. The variance of the two variables are $\frac{1}{s}$ and $\frac{1}{\tau}$ respectively, so the variance of $y-\hat{\alpha}$ and, thus, y given $\hat{\alpha}$ is $\frac{1}{s}+\frac{1}{\tau}$.

[8] As a convention, we will denote functions of many variables, such as H, by capital letters. When we have to be explicit about an argument of such functions—for example, the function F evaluated at $x = x'$—we will write $F_{x=x'}$.

Straightforward calculations reveal that V can be written as

$$V = \hat{\alpha}\Phi\left(-\left(Y_c - \hat{\alpha}\right)\sqrt{H}\right) + \frac{\sqrt{H}}{\tau}\phi\left(\left(Y_c - \hat{\alpha}\right)\sqrt{H}\right), \tag{6}$$

where Y_c is the left-hand side of (5), $\Phi(\cdot)$ is the distribution function of a standard normal random variable (i.e., with mean zero and variance one), and $\phi(\cdot)$ is the density function of a standard normal random variable. Note that

$$\Phi\left(-\left(Y_c - \hat{\alpha}\right)\sqrt{H}\right)$$

is also the probability that the CEO will be retained if evaluated.

Although a higher ability CEO is always better, the value of the option to fire the CEO is decreasing in $\hat{\alpha}$:[9]

Lemma 1 *V is increasing in $\hat{\alpha}$, while $V - \hat{\alpha}$ is decreasing in $\hat{\alpha}$.*

That is, the value of information about the CEO's ability decreases the greater is the prior estimate of his ability.

Consider, now, the issue of how the board decides on the intensity (probability, p) with which it will monitor the CEO. We assume that the board chooses p to maximize the following function:

$$\max_{p\in[0,1]} pV + (1-p)\max\{0,\hat{\alpha}\} - \bar{k}d(p), \tag{7}$$

where $\bar{k}$ reflects, in some way, the collective preferences of the board (i.e., $\partial\bar{k}/\partial k_i \geq 0$ for all i and strictly positive for at least one i). For instance, $\bar{k}$ could be the average of the k_is. Alternatively, and perhaps more consistent with voting by the board, $\bar{k}$ could be the median k_i on the board. Note that the resulting p will be Pareto optimal from the perspective of the board members.

The first-order condition for (7) is

$$V - \max\{0,\hat{\alpha}\} - \bar{k}d'(p) = 0. \tag{8}$$

Expression (7) is concave in p, so (8) is sufficient as well as necessary. Define P^* to be the solution to (8). To keep the analysis as straightforward as possible, we will focus here on interior solutions (i.e., $P^* \in (0,1)$). The extension to corner solutions is straightforward. The following properties of P^* are readily established:

[9] All proofs are in the appendix.

Proposition 1 *The intensity with which the board monitors the CEO, p, is*
(i) decreasing with its prior estimate of his ability, $\hat{\alpha}$, if $\hat{\alpha} \geq 0$;
(ii) decreasing with the precision of its prior estimate, τ;
(iii) decreasing with its collective lack of independence, $\bar{k}$; but
(iv) increasing with the precision of the signal (i.e., s).

Intuitively, the more costly monitoring is to the board's members (or the less weight they place on the firm's profits), the greater is the marginal cost of monitoring, so they engage in less of it. The more able the board believes the CEO to be, the less valuable is the option to fire the CEO. The less valuable this option, the lower the marginal benefit of monitoring. Consequently, the board monitors less. The option to fire the CEO is similarly less valuable the less uncertainty there is in its estimate, so the board monitors less intensely when the CEO's ability is known more precisely. On the other hand, the option to fire the CEO is more valuable the greater is the precision of the signal, so the board monitors more intensely when the signal is more informative.[10]

Proposition 1 is consistent with the general perception that less independent boards do less monitoring and that long-established CEOs (i.e., CEOs with high values of τ) receive less scrutiny. Being monitored increases the likelihood of being dismissed, so Proposition 1 is also consistent with the evidence in Weisbach (1988), which suggests that outsider-dominated boards (which are presumably more independent) are more likely to fire a poorly performing CEO than insider-dominated (less independent) boards.

3.4 Negotiations between the CEO and the Board

When they enter into negotiations, the board brings

$$pV + (1-p)\max\{0, \hat{\alpha}\} - \bar{k}d(p) + R$$

in surplus to the bargaining table, where R is the surplus the board can expect to capture from a replacement CEO. However, given the limited-liability assumption ($w \geq 0$), the board cannot capture any surplus—share of b—from a replacement CEO. Consequently, $R = 0$. The incumbent CEO brings

$$\left(p\Phi\left(-(Y_c - \hat{\alpha})\sqrt{H}\right) + 1 - p\right)b$$

[10] We thank Canice Prendergast for suggesting that we include this result.

in surplus to the table. So their joint surplus is

$$pV + (1-p)\max\{0,\hat{\alpha}\} - \bar{k}d(p) + \left(p\Phi\left(-(Y_c - \hat{\alpha})\sqrt{H}\right) + 1 - p\right)b. \quad (9)$$

Maximizing (9) with respect to p yields the first-order condition

$$V - \max\{0,\hat{\alpha}\} - \bar{k}d'(p) - (1-\Phi)b = 0. \quad (10)$$

Comparing (10) to (8), we see that the marginal benefit of monitoring is lower in (10) by $(1-\Phi)b$, which means that the level of monitoring that maximizes joint surplus (9) is lower than the level of monitoring that maximizes the board's expected utility (7). That is, if P^{**} is the solution to (10), then $P^{**} < P^*$.

It is worth considering why $P^{**} < P^*$. Part of the surplus that can be shared by the *incumbent* CEO and the board is the incumbent's chance of getting the control benefit, b. If he is fired, then this chance is lost; it goes to the *replacement* CEO. Moreover, limited liability prevents the board from recapturing it by setting a negative wage. Consequently, the marginal *joint* benefit of monitoring is reduced. In many ways, the situation is similar to Aghion and Bolton (1987)'s exclusive-dealing model. There, a retailer (our board) and a monopoly producer (our incumbent CEO) enter into an exclusive-dealing contract because of their concern that an entrant (our replacement CEO) will capture future surplus.

In contrast to Aghion and Bolton, our parties are limited in the contracts they can write. In particular, we assume that the board and the CEO cannot contract *directly* on the probability that the board will evaluate the CEO (i.e., p). This is consistent with the general perception that it is difficult for outside parties to verify how diligent the board is in its monitoring function (if it were easy for outside parties to verify the board's diligence, presumably the board would contract with the shareholders on this issue). This, however, creates a problem, because the board's private incentive is to choose a level of monitoring greater than that which maximizes *joint* surplus; i.e., the board would choose P^* instead of P^{**}.

The only way for the CEO and board to avoid this problem and commit to a level of monitoring is by changing $\bar{k}$, since this, then, changes the board's incentives for monitoring. The independence of the board is inversely related to $\bar{k}$. Therefore, we interpret the negotiations over $\bar{k}$ as decisions over factors likely to affect the independence of the board, such as board composition

(e.g., proportion of insiders versus outsiders), board compensation, and so forth.

We note that when the board negotiates with the CEO over $\bar{k}$ and w it cares about its utility only; that is, it does *not* consider the new (future) directors' utility in their negotiation.

Let $\bar{k}_0$ denote the collective lack of independence of the *continuing* directors.[11] Let $\bar{k}_1$ denote the collective lack of independence of the *new* board. If bargaining with the CEO yields a new board with a different lack-of-independence parameter, $\bar{k}_1$, then the *continuing* directors' expected utility is

$$P^*_{\bar{k}=\bar{k}_1} V + \left(1 - P^*_{\bar{k}=\bar{k}_1}\right) \max\{0, \hat{\alpha}\} - \bar{k}_0 d\left(P^*_{\bar{k}=\bar{k}_1}\right) - w. \tag{11}$$

Note that in (11), the equilibrium probability of obtaining a signal, P^*, is a function of the *new* board's lack of independence, $\bar{k}_1$, not the continuing directors' lack of independence, $\bar{k}_0$.

We model the negotiations between the CEO and the board as a Nash bargaining game. That is, the CEO and board agree to the composition (i.e., $\bar{k}$) and wage that maximize the product of their surpluses from trade. Provided the limited-liability constraint does not bind, the resulting composition (i.e., $\bar{k}$) will also maximize their joint surplus. Other bargaining games would do as well. All we require is that the CEO have part of the bargaining power in some circumstances. Assuming that the CEO has bargaining power is consistent with the empirical literature on boards (e.g., Mace, 1971; Lorsch and MacIver, 1989; Demb and Neubauer, 1992), which finds that CEOs, both in the U.S. and abroad, have considerable say in who is nominated for board positions. It is also consistent with the view that a CEO who has proven himself to be more valuable (in expectation) than any potential replacement should have some degree of bargaining power.

The surplus of the players is the difference between what they expect to receive if an agreement is reached and what they expect to receive if no agreement is reached. If no agreement is reached, the CEO leaves the firm; in which case his utility is 0. The CEO's surplus is, therefore,

$$P^* \Phi\left(-\left(Y_c - \hat{\alpha}\right)\sqrt{H}\right) b + \left(1 - P^*\right) b + w.$$

[11] Note the flexibility to change board composition comes from filling *exogenous* vacancies or *adding* directors to the board—no continuing director need leave to realize a change in board composition.

If no agreement is reached, the board hires a replacement CEO. Let U_0 be the board's expected utility if they hire a replacement (we will derive the value of U_0 shortly—see Lemma 2 below). The board's surplus is, thus,[12]

$$P^*V + (1 - P^*)\,\hat{\alpha} - \bar{k}_0 d\,(P^*) - w - U_0.$$

Nash bargaining assumes that the board and the CEO choose $\bar{k}$ and w to maximize

$$\begin{aligned}\left(P^*V(\hat{\alpha},\tau) + (1 - P^*)\,\hat{\alpha} - \bar{k}_0 d\,(P^*) - w - U_0\right) \\ \times \left(P^*\Phi\left(-\left(Y_c - \hat{\alpha}\right)\sqrt{H}\right) b + (1 - P^*)\,b + w\right).\end{aligned} \tag{12}$$

To maximize (12), we need to know the value of U_0:

Lemma 2 *$U_0 = P_0V_0 - \bar{k}_0 d(P_0)$, where V_0 is V evaluated for a new CEO—i.e.,*

$$V_0 = \frac{\sqrt{H}}{\tau_0}\phi\,(0)$$

—and P_0 solves the equation

$$V_0 - \bar{k}_0 d'(p) = 0;$$

that is, P_0 is the existing *board's utility-maximizing level of monitoring of a new CEO. Moreover, the wage paid a* replacement *CEO is zero.*

Intuitively, new CEOs have no bargaining power, since they all have equal expected value. Consequently, the board can set a minimum wage and get its most preferred choice of composition, which is to replicate its current composition (i.e., $\bar{k}_0$).

Recall our assumption that the board can choose to fire the CEO *prior* to bargaining. It might, at first, seem that the board would fire the incumbent CEO if and only if his estimated ability was less than the estimated ability of a replacement (i.e., if and only if $\hat{\alpha} < 0$). This is not, however, true:

Proposition 2 *A unique finite cutoff, $A_c > 0$, exists such that an incumbent CEO is fired prior to bargaining if and only if his estimated ability is less than A_c.*

[12]The reader will note that we have replaced $\max\{\hat{\alpha}, 0\}$ with $\hat{\alpha}$. As we will show in Proposition 2, any *incumbent* CEO who is not fired prior to bargaining must have an estimated ability greater than zero.

Proposition 2 follows because the right to evaluate a CEO creates a valuable option. The value of this option increases with the prior uncertainty about the CEO (i.e., $1/\tau$). Consequently, its value is greater for a new CEO than for an incumbent CEO. A new CEO is, therefore, more desirable than an incumbent CEO *ceteris paribus*. An incumbent's estimated ability must, therefore, be strictly greater than a new CEO's if he is to retain his job.

A natural question to ask is whether less independent boards tolerate worse performance than do more independent boards; that is, do greater values of $\bar{k}_0$ lead to lower values of A_c. The answer is yes:

Proposition 3 *The minimum estimated ability for the incumbent CEO at which he will be retained, A_c, falls as the board becomes less independent; that is,*

$$\frac{\partial A_c}{\partial \bar{k}_0} < 0.$$

Remark 1 *Since $\hat{\alpha}$ is a decreasing function of performance (recall (3)), Proposition 3 implies that CEO dismissals are more sensitive to (negative) firm performance when the board is more independent. As such, Proposition 3 is consistent with Weisbach (1988).*

Proposition 3 holds because a replacement CEO must be monitored more than an incumbent CEO. The less independent is the board (i.e., the greater is the board's distaste for monitoring, $\bar{k}_0$), the lower is the benefit to such a board from hiring a CEO who needs more monitoring. Hence, such a board is more willing to tolerate a mediocre CEO than is a more independent board (i.e., a board with less distaste for monitoring).

Consider, now, bargaining between the board and an incumbent CEO who will be retained (i.e., one for whom $\hat{\alpha} > A_c$). Maximizing (12) with respect to $\bar{k}$ and w yields first-order conditions that are equivalent to

$$\begin{aligned} \left(V - \hat{\alpha} - \bar{k}_0 d'(p)\right)\left(p\Phi b + (1-p)\, b + w\right) & \qquad (13) \\ + \left(p(V-\hat{\alpha}) + \hat{\alpha} - \bar{k}_0 d(p) - w - U_0\right)(\Phi - 1)b &= 0 \text{ and} \\ p(V-\hat{\alpha}) + \hat{\alpha} - \bar{k}_0 d(p) - w - U_0 - \left(p\Phi b + (1-p)\, b + w\right) &\leq 0 \qquad (14) \end{aligned}$$

Since $\hat{\alpha} > A_c$, the board's expected utility exceeds U_0; hence the second line of (13) is negative. The first line must, therefore, be positive, which entails

$$V - \hat{\alpha} - \bar{k}_0 d'(p) > 0. \qquad (15)$$

From the first-order condition for the board's optimal p (i.e., (8)), condition (15) implies that $p < P^*_{\bar{k}=\bar{k}_0}$, which, from Proposition 1, implies $\bar{k} > \bar{k}_0$. We have, thus, established:

Proposition 4 *If the* continuing *directors chooses to retain the CEO, then the new board will have less independence than did the* continuing *directors (i.e., $\bar{k} > \bar{k}_0$).*

We emphasize the word "continuing" because the new board is less independent only relative to those directors who continue to serve. The proposition does not compare the new board with the previous board (i.e., the continuing *and* departed directors). To better understand this point consider a hypothetical board with ten directors, five outsiders and five insiders. Suppose that $k_i = k_{\text{out}}$ for the outsiders and $k_i = k_{\text{in}}$ for the insiders, where $k_{\text{out}} < k_{\text{in}}$. Suppose, too, that $\bar{k}$ is given by the board's average k. This board's average k is $\frac{1}{2}k_{\text{in}} + \frac{1}{2}k_{\text{out}}$. Suppose two insiders depart, then the average k of the *continuing* directors is $\frac{3}{8}k_{\text{in}} + \frac{5}{8}k_{\text{out}}$. Suppose, consistent with Proposition 4, bargaining between the continuing directors and the CEO results in the addition of one insider and one outsider. The new board's average k of $\frac{2}{5}k_{\text{in}} + \frac{3}{5}k_{\text{out}}$. The new board is, therefore, less independent than the continuing directors, but is more independent than the original board.

If, on the other hand, "normal" attrition from the board leads to an average level of independence among the continuing directors that approximates the level of independence of the original board, then Proposition 4 suggests a theoretical explanation for the finding that boards become less independent over the career of the CEO (see, e.g., Hermalin and Weisbach, 1988).

Proposition 4, therefore, suggests that corporate governance is subject to a stochastic form of "entropy" in this model: on average, boards become less independent over time, rather than more independent.[13] This result is subject to two caveats that potentially affect its interpretation. First, a key assumption behind this result is that the monitoring burden is shared equally by the directors (i.e., each must expend p). If the monitoring burden could be shared unequally—if for instance monitoring was a team production problem such as considered in Holmstrom (1982)—then this entropy result need not hold. Directors would have an incentive to free-ride on the diligence of other directors. This in turn would give them an incentive to want new directors

[13] The "on average" qualification follows from the continuing versus original directors distinction.

with strong proclivities for monitoring (i.e., low k_is) rather than, as here, the same proclivity they have. In a richer model of board activity, entropy would, then, depend on the degree to which monitoring is a collective activity (as here) versus a private activity (as in a teams problem).

Second, we have totally abstracted from the role of the shareholders. We do so partially for convenience, but also because of the institutional evidence that shareholders rarely play a direct role in either the "normal" selection of directors or the day-to-day operations of the company (see, e.g., Mace, 1971). Because they break the entropy, Proposition 4 serves to emphasize the importance of those occasions when shareholders do play a role, such as hostile takeovers, proxy fights, and direct negotiations between large shareholders and management.

Whether the bargaining maximizes the board and incumbent CEO's joint surplus depends on whether the limited-liability constraint binds. If it doesn't bind, then (14) is an equality. Using it, (13) becomes

$$V - \hat{\alpha} - \bar{k}_0 d'(p) - (1 - \Phi) b = 0,$$

which is the first-order condition for maximizing joint surplus (9). If the limited-liability constraint does bind, then (13) is equivalent to

$$V - \hat{\alpha} - \bar{k}_0 d'(p) - (1 - \Phi) \zeta b = 0,$$

where $\zeta < 1$. Consequently, the solution to the problem in which the limited-liability constraint is binding involves more monitoring and, hence, greater board independence than if the constraint is not binding. This establishes

Proposition 5 *Suppose that the incumbent CEO is retained. If the limited-liability constraint is not binding, then the level of monitoring will maximize the CEO and board's joint surplus. If it is binding, then the level of monitoring will exceed the joint-surplus-maximizing level. Correspondingly, board independence will be greater if the constraint is binding than if it is not binding.*

We also want to know how estimated ability affects the ultimate equilibrium level of scrutiny (the probability of being evaluated) that the CEO will face.

Proposition 6 *The equilibrium probability that the* future *board evaluates an incumbent CEO who is retained is decreasing with the prior estimate of his ability.*

Remark 2 *Given the monotonic relationships between monitoring and board independence and between first-period earnings performance and estimated ability, Proposition 6 implies that performance and the independence of* additions *to the board should be negatively correlated, which is consistent with Hermalin and Weisbach (1988)'s findings.*

Propositions 4 and 6 show that history matters in corporate governance; that is, we can expect some hysteresis. Strong, independent boards will beget stronger, more independent boards than will weak boards. Consequently, if we follow two firms, A and B, over time, then there is a good probability that we will find A always has a stronger board than B if A initially has the stronger board than B. Moreover, this could still be true even if B's recent performance is better than A's; indeed, from Proposition 6, better performance by B (i.e., a higher estimate of $\hat{\alpha}$) could actually accentuate the difference between the two boards' relative strength. These results underscore the importance of considering endogeneity in empirical studies of corporate governance and they potentially explain the inconclusive results of MacAvoy *et al.* (1983) and others.

Finally, we consider the relationship between the wage, w, and estimated ability:

Proposition 7 *There exists an $\tilde{A}$, $A_c < \tilde{A}$, such that an incumbent CEO with estimated ability in $[A_c, \tilde{A}]$ is paid a wage of zero. There also exists an $\hat{A}$, $\tilde{A} < \hat{A} < \infty$, such that an incumbent CEO's wage is increasing in his estimated ability for estimated abilities in $[\hat{A}, \infty)$.*

For a retained CEO, the relationship between his wage and estimated ability (past performance) is initially flat (zero). When the wage is positive, it equals one-half times the difference between the surplus that the board brings to the table, $p\left(V-\hat{\alpha}\right)-\bar{k}_0 d\left(p\right)$, and the surplus that the CEO brings to the table, $\left(p\Phi+1-p\right)b$. Whether the wage is increasing in estimated ability depends on whose surplus is increasing faster in $\hat{\alpha}$. Since the board's surplus is unbounded, while the CEO's is bounded, it must be that the wage is eventually increasing in estimated ability. What we have not been able to establish is how the wage varies with estimated ability between $\tilde{A}$ and $\hat{A}$.[14]

[14] We have been able to establish it, however, for specific examples. For instance, wage is strictly increasing in estimated ability (above $\tilde{A}$) if $d\left(p\right)=\frac{1}{2}p^2$, $\bar{k}_0=1$, $\tau=1$, $\tau_0=\frac{1}{2}$, $s=1$, and $b=\frac{1}{4}$ (the *Mathematica* program that establishes this and other examples is available from the authors upon request).

Overall, Proposition 7 predicts that the level at which the *non*-contingent portion of a CEO's compensation is set should be insensitive to past performance for relatively low levels of past performance, but sensitive at relatively high levels of past performance.

It is worth noting that even if the CEO's wage is non-increasing in his estimated ability, his overall well-being, $w + (p\Phi + 1 - p)\, b$, is increasing in his estimated ability.

4 Extensions

4.1 The Board has a Preference for the Incumbent CEO

It is easy to imagine that the board has a preference for keeping the incumbent CEO. This could be a result of personal loyalty to the CEO—after all, many a directorship is the result of close ties between the CEO and the director (see, e.g., Mace, 1971). Alternatively, an incumbent CEO may take actions to entrench himself; that is, actions that make him better suited to running the firm than an average replacement or, equivalently, that make him costly to dismiss.

Let m be the additional value that an incumbent CEO yields the board. If $\hat{\alpha}$ is the board's estimate of his ability, then the board will treat him *as if* his estimated ability were $\hat{\alpha} + m \equiv \tilde{\alpha}$. It follows that the results from the previous section continue to hold, except with $\tilde{\alpha}$ replacing $\hat{\alpha}$. In particular, the next proposition is an immediate corollary of our earlier results.

Proposition 8 *As the additional value that the incumbent CEO yields the board, m, rises the following occur:*

(i) the intensity with which the current *board monitors the CEO, p, decreases;*

(ii) the independence of the future *board decreases; and*

(iii) the minimum estimated ability for the incumbent CEO at which he will be retained prior to bargaining decreases.

(The three results follow from Propositions 1, 6, and 2 respectively.)

In other words, Proposition 8 simply indicates that the more the board values the incumbent CEO independent of his ability, the less intensely he

will be monitored by the board and the lower the standard to which he will held by the board. These results are consistent with the widely held belief that entrenched CEOs or CEOs who have cultivated personal loyalty among the board members are less scrutinized and face lower standards.

To the extent m is endogenous, Proposition 8 predicts that a CEO would undertake activities that raise m. An example of such an activity is given by Shleifer and Vishny (1989). They argue that CEOs attempt to reduce the probability that they will be dismissed by making CEO-specific investments; that is, investments that are more profitable under the current CEO than any replacement CEO. Even if such investments decrease firm value, the CEO has an incentive to make them because they raise his value *vis-à-vis* any replacement.

Proposition 8 identifies another cost of entrenchment in addition to Shleifer and Vishny's investment-distortion cost: The more entrenched the CEO is, the less intensely he is monitored. Consequently, the board is less likely to identify problem CEOs who should be dismissed (even if the benefit m must be foregone), which further reduces expected firm value.

This analysis also shows that a CEO is better off with his friends on the board (i.e., people for whom m is positive). A CEO is, therefore, likely to use whatever influence he has to put directors who will be loyal to him on the board and to ensure the loyalty of those already on board.[15] Given this, it is not surprising that boards often become interlocked (i.e., with the CEO of one company serving on another's board and *vice versa*). Hallock (1995) documents that the prevalence of interlocks is too great to occur by chance, which lends credence to the argument that CEOs take actions to raise their value to the board.

4.2 Effects of Board Action on Share Price

In this section, we consider how the value of the firm is affected by the board's decision to fire or to retain the CEO. We consider this decision at two stages: prior to when the board could obtain a signal and after it would have obtained a signal. For convenience, but without loss of generality, we will assume that $m = 0$; that is, the incumbent CEO offers no additional benefit to the board.

[15] For an extreme example see Burrough and Helyar's (1990) discussion of the board of RJR-Nabisco.

Prior to monitoring, but after the first fire/retain decision, the value of the firm is[16]

$$P^{*}V + (1 - P^{*})\,\hat{\alpha}. \tag{16}$$

Since P^{*} is decreasing in $\hat{\alpha}$ (recall Proposition 1), (16) need not be increasing in $\hat{\alpha}$. If, however, the disutility-of-effort function, $d(\cdot)$, is convex enough, then (16) will be increasing in $\hat{\alpha}$:

Lemma 3 *If*

$$d(p) \leq d(1) - \frac{d(1) - d(0)}{\log(2)} \log(2 - p) \quad \forall p \in [0, 1], \tag{17}$$

then (16) is increasing in $\hat{\alpha}$*.*

We will henceforth assume that (17) holds.[17]

Let FV equal (16) under an incumbent CEO and let FV_0 equal (16) under a replacement CEO. The probability of realizing a first-period profit such that the CEO is *dismissed* is

$$\Phi\left(\frac{\tau_0 + r}{r} A_c \sqrt{\frac{r\tau_0}{r + \tau_0}}\right),$$

where A_c is the cutoff ability level defined in Proposition 2. Consequently, at the beginning of the game the firm will be worth

$$\mathbb{E}_x\left\{\mathrm{FV}\,\middle|\, x \geq \frac{\tau_0 + r}{r} A_c\right\}\left(1 - \Phi\left(\frac{\tau_0 + r}{r} A_c \sqrt{\frac{r\tau_0}{r + \tau_0}}\right)\right) + \mathrm{FV}_0\,\Phi\left(\frac{\tau_0 + r}{r} A_c \sqrt{\frac{r\tau_0}{r + \tau_0}}\right).$$

After the first realization of profits, x, the firm's value is

$$x + \chi\,\mathrm{FV} + (1 - \chi)\,\mathrm{FV}_0, \tag{18}$$

[16] Our analysis ignores the present discounted value of the firm *beyond* the period considered by our model. This is slightly problematic because, as we argued in Propositions 4 and 6, we should expect hysteresis across CEO regimes. Given, however, the relatively long tenure of CEOs (ten years on average—see, e.g., Hermalin and Weisbach, 1988), this future, omitted part of firm value will generally represent a very small portion of the firm's value.

[17] If $d(\cdot)$ is not convex enough, then (16) may be decreasing in $\hat{\alpha}$ over some range of $\hat{\alpha}$. To see this, suppose $d(\cdot)$ were affine. Then there would exist an $\hat{\alpha}^{*}$ such that $P^{*} = 1$, for $\hat{\alpha} < \hat{\alpha}^{*}$ and $P^{*} = 0$, for $\hat{\alpha} > \hat{\alpha}^{*}$. Since $V > \hat{\alpha}$, this would imply that (16) must decrease as $\hat{\alpha}$ crosses $\hat{\alpha}^{*}$.

where

$$\chi = \begin{cases} 1 & \text{if } P^*V + (1-P^*)\,\hat{\alpha} - \bar{k}_0 d\,(P^*) > U_0 \\ 0 & \text{otherwise} \end{cases}$$

indicates whether the incumbent CEO is retained or fired.

From Section 3.4, we know that

$$\mathrm{FV}_{\hat{\alpha}=A_c} - \bar{k}_0 d\left(P^*_{\hat{\alpha}=A_c}\right) = \mathrm{FV}_0 - \bar{k}_0 d\,(P_0) \equiv U_0.$$

Moreover, we know from Proposition 1 that $P^*_{\hat{\alpha}=A_c} < P_0$,[18] from which it follows that $\mathrm{FV}_{\hat{\alpha}=A_c} < \mathrm{FV}_0$. It follows, therefore, that there exists an interval of $\hat{\alpha}$'s starting at A_c such that investors would prefer that the CEO be fired, but such that the board would prefer to retain the CEO. Consequently, there is a discontinuous drop in the value of the firm at $\hat{\alpha} = A_c$. Since $\hat{\alpha}$ and x are monotonically related, we can conclude that firm value, expression (18), is increasing for all values of x *except* at

$$x = \frac{\tau_0 + r}{r} A_c,$$

where there is a discontinuous drop in firm value.

We summarize the analysis so far in the following proposition.

Proposition 9 *Higher first-stage profit is positively related to whether the CEO keep his job. But higher firm value is not monotonically related to whether the CEO keep his job. Moreover, there is a range of first-stage profits such that investors would prefer that the CEO be fired, while the board prefers to retain him.*

Remark 3 *Proposition 9 suggests that earnings (i.e., x) should be a better predictor of CEO turnover than share price, which is consistent with the empirical literature (see, e.g., Weisbach, 1988; Murphy and Zimmerman, 1993).*

Proposition 9 and the discussion preceding it indicates that a tension can exist between investors and directors over whether the CEO should be fired, with the investors preferring to fire and the directors preferring to retain. This provides an explanation for the common phenomenon of investors seeming more eager than the board to dismiss management. It can also explain why takeovers and other costly control contests can be worth mounting.

[18] Recall P_0 is the optimal intensity of monitoring for a replacement CEO.

Now we turn to the stock reaction when the board bases its fire/retain decision on its private signal (i.e., private information). If the board fires the CEO, then the expected value of *future* cash flows is zero. Prior to evaluation, the expected value of future cash flows is positive. It follows, therefore, that

Proposition 10 *The firm's stock price falls if the CEO is fired on the basis of the board's* private *information.*

By definition, private information is unknown to investors. Consequently, a dismissal on the basis of private information will be perceived by investors as coming "out of the blue." Proposition 10 can, therefore, be seen as saying that dismissals that come out of the blue will lead to a fall in the stock price.

Finally, suppose $\bar{k}$ is *not* known to investors. Ignorance of $\bar{k}$ does not change Proposition 10, so we will focus on what happens when the board fires the CEO based on public information. For any value of $\bar{k}$ if the board wants to fire the CEO, investors would also want the CEO fired. If we imagine a distribution over $\bar{k}$ such that it is uncertain whether the board will fire the CEO for a given level of first-stage profits, then firing the CEO will be considered good news by investors and will cause the stock price to rise. The stock price will also rise because firing the CEO signals that the board is relatively more independent than was anticipated and will, thus, monitor more intensely. This yields

Proposition 11 *Suppose that the board's independence is unknown to investors. Then the firm's stock price rises if the CEO is fired on the basis of* public *information.*

Remark 4 *Our result that the stock price reaction to a CEO dismissal differs depending on whether the board used public or private information is consistent with, and could even explain, the ambiguous relationship between CEO dismissal and stock price reaction found in event studies of CEO turnover. See Warner* et al. *(1988) for a survey of these studies.*

5 A Non-Bargaining Interpretation

Much of the "action" in the model presented so far comes from our limited liability assumption, which prevents the board from capturing the control benefit, b, that a *replacement* CEO will enjoy. In other words, in the event

of a management change, the limited-liability constraint prevents the board from exploiting its bargaining power by offering the replacement CEO a wage of $-b$. The consequence for the bargaining game between the board and the *current* CEO is to eliminate an additional source of rents that the parties could otherwise have divided, namely the *replacement's* control benefit. Assuming the CEO is worth retaining (i.e., $\hat{\alpha} \geq A_c$),[19] the only way the board and the *incumbent* CEO can get any of the control benefit is not to fire the incumbent. This tilts their incentives toward less diligent monitoring. The way the incumbent board commits to this less diligent monitoring (which is not in its *private* interest) is by agreeing to a board composition with a lower proclivity for monitoring, i.e., a higher $\bar{k}$ (recall it is impossible for the existing board to commit directly to future monitoring policies; i.e., p).

Although this analysis is consistent with current practice—CEOs do appear to enjoy control benefits that cannot be fully captured by the firm and they do appear to have considerable say in who is put on the board—it is nevertheless worth reinterpreting the model in a way that does not depend on a bargaining game.

In this interpretation, the timing is the same, except that the bargaining stage, stage 4, no longer exists. We also want to reinterpret stage 5: Let

$$p\left(V-\hat{\alpha}\right)+\hat{\alpha}-\bar{k}d\left(p\right)$$

be the firm's expected profit; where, now, $\bar{k}d\left(p\right)$ is the cost of monitoring. We now interpret $\bar{k}$ to be a cost parameter known to the firm's decision makers (e.g., the board), but possibly unknown to investors.

We assume, now, that a board's level of monitoring, p, is an intrinsic attribute of the board. In particular, it is invariant with respect to $\hat{\alpha}$ or other parameters. Boards that monitor more—have a higher p—are more costly for the firm than boards that monitor less—have a lower p. That is, $d'\left(p\right)>0$. We assume, moreover, that this *marginal* cost is also increasing in p (i.e., $d''\left(p\right)>0$). There are a number of grounds upon which to justify these assumptions:

- Directors who are predisposed to monitor intensively could be relatively scarce, so they command greater compensation. Moreover, the distribution of intrinsic monitoring predisposition could be such that $d''\left(p\right)>0$.

[19] The cutoff, A_c, does not depend on b—see the proof of Proposition 2.

- It is more costly to recruit outside directors, who are more predisposed to monitor, than it is to recruit inside directors, who are less predisposed to monitor. Moreover, if the firm begins with the outside directors who are least costly to recruit and then moves on to those who are more costly to recruit, $d''(p) > 0$.

- There are benefits to having inside directors on the board (perhaps to groom them as potential successors for the CEO—see Vancil, 1987, on this point) or less-intense-monitoring outside directors (perhaps because they bring needed expertise to the firm). These benefits are increasing in the number of such directors, but with diminishing marginal returns. When these directors are seen as the opportunity cost of more-intense-monitoring outside directors, we have $d'(p) > 0$ and $d''(p) > 0$.

We can now reinterpret Proposition 1 as statement about board composition and the underlying parameters:

Corollary 1 *Under the alternative interpretation of this section, the level of board independence, p, is*
(i) decreasing with the prior estimate of his ability, $\hat{\alpha}$;
(ii) decreasing with the precision of the prior estimate, τ; but
(iii) increasing with the precision of the signal, s.

Note that Corollary 1(i) and (ii) is a substitute for Proposition 4 (surviving CEOs have easier boards), while Corollary 1(i) is a substitute for Proposition 6 (board independence is decreasing with estimated CEO ability).

Propositions 2 and 3 continue to hold under this alternative interpretation, although Proposition 3 no longer has an obvious economic interpretation. The loyalty-entrenchment result, Proposition 8, continues to hold under this alternative interpretation. Likewise, provided $\bar{k}$ is unknown to investors, the share-price results, Propositions 9–11, also continue to hold under this alternative interpretation.

Most of our results are, therefore, not dependent on the existence of a bargaining stage. Rather they are driven by combining a matching model, similar to Jovanovic (1979), with endogenous monitoring. What then does the bargaining add? Two things: First, it allows us to model board behavior in a less reduced-form manner. More importantly, however, it allows us to address the central enigma, set forth by Berle and Means (1932) and others,

of how a seemingly inefficient institution has survived. In particular, it serves to explain how, why, and when CEOs have a say over who serves on the board. It also serves to explain how, despite this say, the board can still provide a valuable monitoring role.

6 Policy Implications of the Model

As corporate governance has remained essentially the same since the days of Berle and Means, so too have the criticisms and proposed reforms of it. For example, Lipton and Lorsch (1992) call for a number of changes, including a board size of at most ten directors (to reduce free-riding), for outsiders to constitute at least two-thirds of the board, bimonthly meetings that are at least one day long, director pay linked to stock performance, and appointment of a "lead" director (if not the chairman) who is separate from the CEO.[20] These policies, in Lipton and Lorsch's view, would lead to better monitoring of the CEO.

In the context of the model presented above, each element of the Lipton and Lorsch proposal serves to reduce the $\bar{k}$ of the board. For example, providing directors with stock-based incentives will lower their k's, while replacing high k insiders with lower k outsiders would lower average k. At first glance, one might think that efforts to lower the board's $\bar{k}$ through regulation or political pressure would lead to more effective monitoring.

This argument, however, ignores the nature of the equilibrium in the model. The CEO and board bargain offer the *effective* $\bar{k}$, which takes account of all incentives that potential directors will have while they are on the board. This effective $\bar{k}$ is determined through a bargaining process between the CEO and the existing board. So long as the bargaining process is unaffected by regulations such as those proposed by Lipton and Lorsch, we would expect the equilibrium $\bar{k}$ to be little affected.

It follows, therefore, that we need to distinguish between those policies that will affect the bargaining process and those that will not. For instance, requiring a specified fraction of the board to be outsiders would result in

[20] This proposal is fairly representative of the many governance reforms that have been proposed by the business press, academics, and business people themselves (see ALI, 1982; Jensen, 1993; Smale *et al.*, 1995; Lublin, 1995). See Brickley *et al.* (1995) for a discussion and evidence on one of these potential reforms, the separation of the CEO and chairman's positions.

an outsider-dominated board, but not necessarily one that is more independent than the insider-dominated board that would otherwise prevail—the CEO and board members will have latitude in the selection process to offset whatever benefits are created by exogenously imposed "independence."[21] On the other hand, the model suggests that requiring incentive pay for directors could have an effect: By lowering $\bar{k}_0$, this requirement would affect the bargaining, leading to more independent boards and greater monitoring (see Proposition 6). Moreover, because of hysteresis, these benefits can persist; although they will tend to diminish over time because of entropy.

Of course this begs the question of why corporations don't voluntarily adopt effective reforms such as this. This paper suggests an answer: just as the board and the CEO negotiate over board composition, they would also negotiate over the implementation of reforms. Provided his past success gave him sufficient bargaining power, the CEO would be able to block or blunt such reforms.

7 Concluding Remarks

A recent *Harvard Business Review* "Perspectives Section" provides some insight into the realism of our model (Smale *et al.*, 1995). John Smale, who became the non-executive chairman of General Motors following Robert Stempel's forced resignation, describes policies adopted by the GM board that have dramatically improved its effectiveness. In contrast, Alan Patricof, a leading venture capitalist, argues: "Deep down [CEOs] really wish they didn't have boards. That's why, at the end of the day, most independent directors get neutralized in one fashion or another (Smale *et al.*, 1995, p. 8)." A model of corporate governance should be consistent with both perspectives; it should explain both how some boards are active monitors of management, yet how some CEOs are able to avoid scrutiny.

By studying the determinants of board composition as a bargaining process, our model is consistent with both active monitoring in some firms and CEO dominance in other firms. The process by which GM acquired a strong board is illustrative of the model's logic: The company had a crisis induced by poor profits in which the board was forced to act. The new CEO had no bargaining power and, thus, had to contend with an active board. None of this would

[21] Since an outsider is simply someone with no other ties to the corporation, it is hard to imagine that high k outsiders could not be found (e.g., through interlocking boards).

have happened had the previous managers performed better; they would have maintained their jobs and their control over the board.

The model is consistent with a number of empirical regularities: CEO turnover is negatively related to performance and this relation is stronger when the board is more independent. The probability that independent directors are added to the board increases following poor corporate performance. And boards tend to become less independent over the course of the CEO's career. The model also explains why management turnover is more related to earnings than to stock returns. Finally, the model provides insight into the effectiveness of various policies designed to enhance the board's monitoring.

Despite the model's consistency with existing empirical evidence, a number of directions for future research remain. One direction is to model the board's operation in greater detail. For instance, we have assumed that the board chooses a common intensity of monitoring, p. What we have not considered is how the board implements this choice. For instance, does p represent the collective output of the board (e.g., what it does at board meetings) or is it an aggregate of individual directors' efforts (e.g., carefully reading reports prior to board meetings)? If it is the second, to what extent is the board able to overcome the problems of free-riding endemic to team production (see, e.g., Holmstrom, 1982)? Once free-riding among directors is an issue, the dynamics of board composition become more complicated. For example, the continuing directors can reduce their own workloads by adding very independent directors (i.e., a low-k directors) to the board. This, in turn, could offset the entropy prediction of Proposition 4.

Understanding such issues motivates further study of corporate governance. For example, there are a number of "family" companies, in which the founding family takes an active role on the board. How diligent the rest of the board will be is unclear. These directors have an additional incentive not to monitor because they can potentially free-ride on the family directors. On the other hand, the family directors would be more likely to encourage appointment of a strong board that will help to increase the value of their claim.

Similar issues occur in international comparisons of governance practices.[22] For instance, unlike most American companies, a German or Japanese

[22] Although the assumptions of our model are consistent with current practice in Europe (see Demb and Neubauer, 1992), as well as the United States.

company typically has strong ties to one particular bank and representatives of this bank usually serve on the company's board.[23] These representatives presumably have a strong interest in the company's well-being.[24] Again, the diligence of the rest of the board is unclear; free-riding considerations would tend to reduce their effectiveness, while the bank representatives have incentives to ensure that directors be selected who will be less likely to free-ride.

One limitation of our model is that it focuses solely on the monitoring role of boards. The institutional literature (see, e.g., Mace, 1971; Vancil, 1987) emphasizes that boards also play an important role providing information and advice to management, and serving as a training ground for future CEOs. A richer model of boards should take into account these roles as well. From our discussion of why $d'(p) > 0$ in Section 5 and its consequence, these other roles—to the extent they represent opportunity costs of monitoring—likely complement the analysis considered here.

Our model could also be extended to investigate the transition from an entrepreneurial firm to a managerial firm. In this transition, an entrepreneur has incentives to design a governance system to maximize the value of his or her claim. In doing so, he or she is presumably aware of the entropy problem, and he or she will attempt to minimize its effect. In addition, start-up firms are often financed through venture capitalists; extending the model to better understand the role of these venture capitalists in the board-selection process is yet another avenue for future work.

One final topic for future research would be to consider non-corporate situations where boards play a monitoring role. For example, universities, trusts, and other non-profit institutions all have bodies that function much like corporate boards of directors. Much of the analysis presented above would seem equally applicable to these boards, but as with international comparisons this question needs to be investigated.[25]

[23] See Kaplan (1994b,a) for recent evidence on the effects of these banking relationships on corporate governance in Germany and Japan.

[24] Although it should be remembered that such directors are themselves agents (of the bank), which could create a second set of agency problems. Despite this, it is still reasonable to expect these directors to be more concerned about the firm's profits than other directors *ceteris paribus*.

[25] See Bowen (1994) for a discussion of the differences between profit and non-profit boards.

Appendix: Proofs

Proof of Lemma 1:

$$\begin{aligned}\frac{\partial V}{\partial \hat{\alpha}} &= \Phi + \hat{\alpha}\phi\sqrt{H} + \frac{H}{\tau}\left(Y_c - \hat{\alpha}\right)\phi\sqrt{H} \text{ (note } \frac{\partial V}{\partial Y_c} = 0\text{)} \\ &= \Phi > 0 \text{ (recall } H = \frac{s\tau}{\tau + s} \text{ and } Y_c - \hat{\alpha} = -\frac{\tau + s}{s}\hat{\alpha}\text{).}\end{aligned}$$

Consequently,

$$\frac{\partial\left(V - \hat{\alpha}\right)}{\partial \hat{\alpha}} = \Phi - 1 < 0.$$

■

Proof of Proposition 1: Let Ω be the expression to be maximized in (7). Consider (i), if $\hat{\alpha} \geq 0$, then:

$$\frac{\partial^2 \Omega}{\partial \hat{\alpha} \partial p} = \frac{\partial[V - \hat{\alpha}]}{\partial \hat{\alpha}} < 0 \text{ by Lemma 1,}$$

so, by the usual comparative statics, $\partial P^*/\partial \hat{\alpha} < 0$. Similarly,

$$\frac{\partial^2 \Omega}{\partial \bar{k} \partial p} = -d'(p) < 0; \text{ and } \frac{\partial^2 \Omega}{\partial \tau \partial p} = \frac{\partial V}{\partial \tau} = \left(-1 + \frac{1}{2}\frac{s}{s+\tau}\right)\frac{\sqrt{H}}{\tau^2}\phi < 0$$

(where the second result uses the fact that$\frac{\partial V}{\partial Y_c} = 0$). Hence, $\partial P^*/\partial \bar{k} < 0$ and $\partial P^*/\partial \tau < 0$. Finally,

$$\frac{\partial^2 \Omega}{\partial s \partial p} = \frac{\partial V}{\partial s} = \frac{\tau}{2\left(\tau + s\right)^2\sqrt{H}}\phi > 0,$$

so, by the usual comparative statics, $\partial P/\partial s > 0$.

■

Proof of Lemma 2: Consider bargaining with a new CEO. If this bargaining is unsuccessful, the board can hire yet another CEO. Hence, from (12), bargaining entails maximizing

$$\begin{aligned}&\left(P^* V_0 - \bar{k}_0 d\left(P^*\right) - w - U_0\right) \\ &\quad \times \left(\left(P^*\Phi + 1 - P^*\right)b + w\right)\end{aligned}$$

with respect to $\bar{k}$ and w. Given the monotonic relationship between P^* and $\bar{k}$ (Proposition 1) we can equivalently maximize this product in P^* and w. The first-order conditions are

$$\begin{aligned}
&\left(V_0 - \bar{k}_0 d'(P^*)\right)\left(\left(P^*\Phi + 1 - P^*\right)b + w\right) + \\
&\left(P^*V_0 - \bar{k}_0 d(P^*) - w - U_0\right)\left(\Phi - 1\right)b = 0 \text{ and} \qquad (19)\\
&P^*V_0 - \bar{k}_0 d\left(P^*\right) - w - U_0 - \left(\left(P^*\Phi + 1 - P^*\right)b + w\right) \leq 0 \qquad (20)
\end{aligned}$$

In equilibrium, $P^*V_0 - \bar{k}_0 d(P^*) - w = U_0$—one new CEO yields the board the same utility as another new CEO. It follows, then, from (20) that $w = 0$. Plugging that back into (19) yields

$$V_0 - \bar{k}_0 d'(P^*) = 0.$$

This is the first-order condition to (7); that is equation (8). Since P^* is monotonic in $\bar{k}$, the solution to the Nash bargaining game is therefore $\bar{k}_1 = \bar{k}_0$. ■

Proof of Proposition 2: Let U^E equal the equilibrium expected utility of the board if they bargain with the incumbent CEO. Since $P^*_{\bar{k}=\bar{k}_0}$ is the board's most preferred level of monitoring, we know

$$U^E \leq P^*_{\bar{k}=\bar{k}_0} V + \left(1 - P^*_{\bar{k}=\bar{k}_0}\right)\max\{0, \hat{\alpha}\} - \bar{k}_0 d\left(P^*_{\bar{k}=\bar{k}_0}\right). \qquad (21)$$

Using the envelope theorem, it is readily shown that the right-hand side of (21) is increasing in $\hat{\alpha}$. Moreover, as $\hat{\alpha}$ goes to infinity, the right-hand side of (21) also goes to infinity. Differentiating the right-hand side of (21) with respect to τ using the envelope theorem yields

$$P^*_{\bar{k}=\bar{k}_0}\left[-1 + \frac{1}{2}\frac{s}{\tau + s}\right]\frac{\sqrt{H}}{\tau^2}\phi < 0 \qquad (22)$$

(the option value is decreasing with the precision with which the CEO's ability is estimated). Suppose, now, that $\hat{\alpha} = 0$. It follows from (4) and (22) that

$$\begin{aligned}
P^*_{\bar{k}=\bar{k}_0} V - \bar{k}_0 d\left(P^*_{\bar{k}=\bar{k}_0}\right) &< P_0 V_0 - \bar{k}_0 d\left(P_0\right) \qquad (23)\\
&= U_0. \qquad (24)
\end{aligned}$$

Combining (21) and (24) establishes that $A_c > 0$. Since the right-hand side of (21) is continuous and increasing without bound but is less than U_0 for an estimated ability of 0, it follows that A_c exists and is unique.

■

Proof of Proposition 3: In the proof of Proposition 2, we established that

$$P^*_{\bar{k}=\bar{k}_0}\left(V_{\hat{\alpha}=A_c} - A_c\right) + A_c - \bar{k}_0 d\left(P^*_{\bar{k}=\bar{k}_0}\right) - U_0 = 0 \tag{25}$$

for all $\bar{k}_0$. Since (25) holds for all $\bar{k}_0$, it is an identity. Differentiating (25) with respect to $\bar{k}_0$ using the envelope theorem yields

$$\left[P^*\Phi + 1 - P^*\right]\frac{\partial A_c}{\partial \bar{k}_0} - d\left(P^*_{\bar{k}=\bar{k}_0}\right) + d\left(P_0\right) = 0. \tag{26}$$

From Proposition 1, $P^*_{\bar{k}=\bar{k}_0} < P_0$. Hence, since $d(\cdot)$ is an increasing function, it follows from (26) that $\partial A_c/\partial \bar{k}_0 < 0$.

■

Proof of Proposition 6: There are two cases to consider: (i) the limited-liability constraint is binding ($w = 0$) and (ii) it isn't binding. Begin with case (i): Since, from Proposition 1, the probability that the CEO is monitored is monotonic in $\bar{k}$, maximizing (12) with respect $\bar{k}$ is equivalent to maximizing:

$$\begin{aligned}&\left(pV(\hat{\alpha},\tau) + (1-p)\hat{\alpha} - \bar{k}_0 d(p) - U_0\right) \\ &\times\left(p\Phi + 1 - p\right)\end{aligned} \tag{27}$$

with respect to p (since the CEO will be retained, we know $\hat{\alpha} > 0$). Define Ψ to equal (27). By well-known comparative statics results, it is sufficient to show $\frac{\partial^2\Psi}{\partial\hat{\alpha}\partial p}$ is negative:

$$\begin{aligned}\frac{\partial^2\Psi}{\partial\hat{\alpha}\partial p} &= 2p\left(\Phi-1\right)^2 + 2\left(\Phi-1\right) + \frac{\partial\Phi}{\partial\hat{\alpha}}p\left[V - \hat{\alpha} - \bar{k}_0 d'(p)\right] \\ &\quad + \frac{\partial\Phi}{\partial\hat{\alpha}}\left[p(V-\hat{\alpha}) + \hat{\alpha} - \bar{k}_0 d(p) - U_0\right].\end{aligned} \tag{28}$$

Using the first-order condition for (27), (28) can be rewritten as

$$\frac{\partial^2\Psi}{\partial\hat{\alpha}\partial p} = 2p\left(\Phi-1\right)^2 + 2\left(\Phi-1\right) + \frac{\partial\Phi}{\partial\hat{\alpha}}\frac{V - \hat{\alpha} - \bar{k}_0 d'(p)}{1-\Phi}.$$

Hence, we have

$$\frac{\partial^2\Psi}{\partial\hat{\alpha}\partial p} < 2\left(\Phi-1\right)^2 + 2\left(\Phi-1\right) + \frac{\partial\Phi}{\partial\hat{\alpha}}\frac{V-\hat{\alpha}}{1-\Phi}. \tag{29}$$

We will now show that the right-hand side of (29) is negative. Note, first, that

$$\frac{\partial \Phi}{\partial \hat{\alpha}} = \sqrt{H}\left(\frac{\tau+s}{s}\right)\phi\left(\sqrt{H}\left(\frac{\tau+s}{s}\right)\hat{\alpha}\right).$$

Next, make the substitution

$$z = \sqrt{H}\left(\frac{\tau+s}{s}\right)\hat{\alpha} \tag{30}$$

and use (6) to rewrite the right-hand side of (29) as

$$2\left(\Phi(z)-1\right)^2+2\left(\Phi(z)-1\right)+\sqrt{H}\left(\frac{\tau+s}{s}\right)\phi(z)\left(-\frac{zs}{(\tau+s)\sqrt{H}}+\frac{\phi(z)\sqrt{H}}{(1-\Phi(z))\,\tau}\right).$$

Simplifying, this reduces to

$$2\left(\Phi(z)-1\right)^2+2\left(\Phi(z)-1\right)-z\phi(z)+\frac{\phi(z)^2}{1-\Phi(z)}. \tag{31}$$

Straightforward calculations reveal that this last expression is negative for all $z \geq 0$ (and, hence, for all $\hat{\alpha} \geq 0$). So the right-hand side of (29) is negative, which, from (29), entails

$$\frac{\partial^2 \Psi}{\partial \hat{\alpha} \partial p} < 0.$$

Now consider case (ii). From Proposition 5, the level of monitoring satisfies (10):

$$V - \hat{\alpha} - \bar{k}_0 d'(p) - (1-\Phi)\,b = 0. \tag{32}$$

Let Ω be the left-hand side of (32). The result follows if $\partial\Omega/\partial\hat{\alpha} < 0$.

$$\begin{aligned}
\frac{\partial \Omega}{\partial \hat{\alpha}} &= \Phi - 1 + b\frac{\partial \Phi}{\partial \hat{\alpha}} \\
&= \Phi - 1 + \frac{\partial \Phi}{\partial \hat{\alpha}}\frac{V-\hat{\alpha}-\bar{k}_0 d'(p)}{1-\Phi} \qquad (33) \\
&< \Phi - 1 + \frac{\partial \Phi}{\partial \hat{\alpha}}\frac{V-\hat{\alpha}}{1-\Phi}
\end{aligned}$$

where (33) follows from (32). Using the z-transformation, we have

$$\frac{\partial \Omega}{\partial \hat{\alpha}} < \Phi(z) - 1 - z\phi(z) + \frac{\phi(z)^2}{1-\Phi(z)}.$$

Straightforward calculations reveal that this last expression is negative for all $z \geq 0$ (and, hence, for all $\hat{\alpha} \geq 0$).

■

Proof of Proposition 7: Consider $\tilde{A}$ first. From (14), $w = 0$ if

$$\left[p\left(V - \hat{\alpha}\right) + \hat{\alpha} - \bar{k}_0 d\left(p\right) - U_0\right] - \left[p\Phi b + \left(1 - p\right) b\right] < 0.$$

At $\hat{\alpha} = A_c$, the first bracketed term is zero, while the second is strictly positive. The existence of $\tilde{A}$ then follows from continuity.

Turn to $\hat{A}$. If $w > 0$, then

$$2w = \left[p\left(V - \hat{\alpha}\right) + \hat{\alpha} - \bar{k}_0 d\left(p\right) - U_0\right] - \left[p\Phi b + \left(1 - p\right) b\right].$$

The first bracketed term increases without limit in $\hat{\alpha}$, while the second has an upper bound of b. It follows then that beyond a certain level, $\hat{A}$, that w must be increasing in $\hat{\alpha}$.

■

Proof of Lemma 3: From Proposition 2, we know $\hat{\alpha} \geq A_c > 0$ or $\hat{\alpha} = 0$. Differentiate (16) with respect to $\hat{\alpha}$:

$$1 + P^* \left(\Phi - 1\right) + \left(V - \hat{\alpha}\right) \frac{dP^*}{d\hat{\alpha}}.$$

From (8), this can be rewritten as

$$1 + P^* \left(\Phi - 1\right) + \bar{k} d'\left(P^*\right) \frac{dP^*}{d\hat{\alpha}}.$$

Also from (8), it is readily shown that

$$\frac{dP^*}{d\hat{\alpha}} = \frac{\Phi - 1}{\bar{k} d''\left(P^*\right)}.$$

So (16) is increasing in $\hat{\alpha}$ if

$$1 + \left(\Phi - 1\right)\left(P^* + \frac{d'\left(P^*\right)}{d''\left(P^*\right)}\right) \geq 0. \tag{34}$$

Since $\hat{\alpha} \geq 0$, $\Phi \geq \frac{1}{2}$, so (34) holds if

$$2 \geq P^* + \frac{d'\left(P^*\right)}{d''\left(P^*\right)}. \tag{35}$$

Define $\bar{d}(p)$ to equal the right-hand side of 17. It is readily shown that

$$p + \frac{\bar{d}'(p)}{\bar{d}''(p)} = 2,$$

so (35) follows if $d'(p)/d''(p) \leq \bar{d}'(p)/\bar{d}''(p)$. By (17), $d(\cdot)$ is more convex than $\bar{d}(\cdot)$. By adapting a well-known result on when one individual will have a greater Arrow-Pratt measure of absolute risk aversion than another individual (see, e.g., Huang and Litzenberger, 1988, p. 29), it readily follows that $d'(p)/d''(p) \leq \bar{d}'(p)/\bar{d}''(p)$ for all $p \in [0, 1]$.

■

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