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Trends in Corporate Governance

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ABSTRACT

The popular press and scholarly studies have noted a number of trends in corporate governance. This article addresses, from a theoretical perspective, whether these trends are linked. And, if so, how? The article finds that a trend toward greater board diligence will lead, sometimes through subtle or indirect mechanisms, to trends toward more external candidates becoming CEO, shorter tenures for CEOs, more effort/less perquisite consumption by CEOs (even though such behavior is *not* directly monitored), and greater CEO compensation. An additional prediction is that, under plausible conditions, externally hired CEOs should have shorter tenures, on average, than internally hired CEOs.

THE CORPORATE FORM HAS EXISTED FOR CENTURIES. The East India Company, for example, was chartered by Elizabeth I in 1600 (Baskin and Miranti (1997)). One might imagine, given this long history, that the issue of how corporations should be governed would have been settled some time ago. Yet, for nearly as long as corporations have existed, there have been complaints about corporate governance and agitation to improve it (e.g., Smith (1776), p. 700: "Negligence and profusion, therefore, must always prevail, more or less, in the management of the affairs of such compan[ies]"). Moreover, these complaints and agitation have had real effects: Over the centuries, they have led to various changes in corporate law and regulation, including up to the present, with laws such as Sarbanes-Oxley. Even ignoring legally imposed changes, there appear to be ongoing trends in corporate governance.[1]

But what do we make of such trends? If regulatory and other pressures are leading to, say, more diligent boards of directors, what else should we expect to see as consequences? Furthermore, how do the various trends in governance relate to each other? What trends may plausibly be causing other trends? What covariance in trends may simply be spurious? The purpose of this article is to

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[1] See, for example, "Emerging Trends in Corporate Governance," a special supplement to *Corporate Board Member* magazine that appeared in 2001. Empirical scholarly work, discussed infra, has also identified trends.

develop a theoretical framework from which to answer such questions. This framework allows one, for instance, to trace through the consequences of pushing for greater representation of outsiders on boards for matters such as who gets hired as Chief Executive Officer (CEO), how long he might be expected to serve, and how much he might expect to be paid.[2]

Reflecting the concern of many reform efforts, this paper focuses on the board of directors. While the statutory authority of the board is relatively broad, the best empirical evidence indicates that boards play a significant role in only a few corporate decisions (see Hermalin and Weisbach (2003) for a survey of this evidence). Among those in which the board does play a significant role, the most common—and arguably among the most important—are those decisions pertaining to the selection, monitoring, and retention (or dismissal) of the CEO (see, e.g., Mace (1971), and Vancil (1987), for discussion; see also Weisbach (1988), for statistical evidence). Consequently, the basic model developed here is one in which the board makes a decision about whom to hire; a subsequent decision about how intensely to monitor him; and, depending on what it learns from its monitoring, a final decision about retaining him or firing him. Section I sets out this basic model, while Section II analyzes it.

For most of the analysis, the board's choice of CEO is between an internal candidate and an external candidate. The primary difference between these candidates is that less is known about the external candidate, which translates into his ability being estimated with less precision than the internal candidate's. Because the board has the option to dismiss the CEO, it values uncertainty about the CEO's ability (it enjoys the upside potential, but can largely escape the downside risk). This makes external candidates more desirable, all else equal. This desirability increases, the more likely it is that the board will be in a position to exercise its option, which, in turn, is more likely the more diligently it monitors the CEO. Hence, a trend toward greater board diligence should produce a corresponding trend toward more frequent external hires as CEOs.

Because the probability of dismissal increases with the intensity of board monitoring, a straightforward prediction of the model is that greater board diligence should lead to shorter CEO tenures on average. This effect is strengthened in an indirect way: Because greater diligence increases the option value of a new CEO, increased diligence makes boards more willing to give up a higher estimated ability in exchange for greater uncertainty about ability. Hence, the

[2] Two points on nomenclature. First, outside directors: Most directors can be classified as *inside* or *outside* directors. Inside directors are employees or former employees of the firm (typically, current or former executives of the firm). Outside directors are not employees of the firm (they are, for example, business school deans, prominent citizens, executives at *other* firms). Outside directors are typically seen as being independent of management (or at least more independent than inside directors). See, moreover, footnote 13 infra for further issues connected to independence; also the discussion in Hermalin and Weisbach (2003, p. 8).

The second point is the use of masculine pronouns for the CEO. While a welcome trend in governance is the appointment of more women to the top job, it remains the case that the overwhelming majority of CEOs are men. I have, therefore, decided the pronoun issue on the basis of majority rule.

average estimated ability of CEOs *hired* should decrease as board diligence increases. Given that the sample of hired CEOs is of lower average quality, their tenure should be correspondingly lower on average as well. Depending on the underlying distribution of estimated abilities in the populations of internal and external candidates, this last insight plausibly suggests that external candidates' expected tenure as CEO will be less than internal candidates'.

In the initial model and analysis (Sections I–III), the question of whether the CEO expends effort is ignored. In Section IV, the issue of CEO effort is considered (alternatively and equivalently, the CEO's decision to forgo consumption of perquisites). A consequence of greater board diligence with respect to monitoring is an increase in CEO effort. At first, this might seem like a "no-brainer" conclusion, but it does, in fact, involve some subtlety. In this model, monitoring reveals *nothing* about CEO effort in equilibrium. The board monitors because it wants to improve its estimate of the CEO's inherent ability, not learn how much effort he has or has not expended. Yet, because the CEO's effort can affect the inferences the board draws, the CEO has an incentive to increase his effort in hopes of raising the board's estimate of his ability (in equilibrium, his hopes go unrealized because the board can subtract out the equilibrium level of effort from the signal it observes). The CEO's incentives to increase effort are greater the more likely it is that the board will make a decision about retaining him based on its inference of his ability, and this likelihood is, in turn, an increasing function of the board's diligence.

If the consequence of a more diligent board is to make the CEO work harder in equilibrium, then the CEO's equilibrium utility will have fallen and he will presumably demand compensation for this. Indeed, even without the issue of CEO effort, greater board diligence translates into lower expected utility for the CEO, all else equal. Hence, as spelled out in Section V, a prediction of the model is that a trend toward greater board diligence should lead to a trend toward greater CEO compensation.

This prediction about the time-series correlation between board diligence and executive compensation would seem at odds with the view, expressed, for example, by Bebchuk and Fried (2003), that it is *weak* boards that tend to "overpay" their CEOs. As I show in Section V, an inverse relation between board diligence and CEO compensation can exist in cross-sectional data even though the two variables positively covary in time-series data: Board diligence and CEO ability are, in a sense, substitutes. Hence, it could be the less diligent boards that have the stronger demand for the CEOs with the higher estimated ability. Because such "star" CEOs command, not surprisingly, a wage premium, it could well be the less diligent boards that are the ones that hire the more expensive CEOs.[3] But as all boards become more diligent, the

[3] The bargaining model of Hermalin and Weisbach (1998) offers an alternative explanation for a negative covariance between board diligence and CEO compensation in cross-sectional data: Better CEOs have more bargaining power vis-à-vis the board and are, thus, able to get more of what they want: less scrutiny from the board and higher pay. That is, in the Hermalin and Weisbach model, the negative correlation between board diligence and CEO compensation is spurious—both variables are driven by CEO ability.

compensation-for-increased-disutility effect leads to an overall trend toward higher CEO compensation.

There are alternative explanations for some of the trends considered here or alternative interpretations of the model set forth here. These are discussed, in brief, in Section VI.

The framework presented here offers a means of tying together a number of trends in corporate governance. Its predictions coincide with the existing empirical evidence and the model makes some predictions that have not yet been tested (e.g., the possibility that CEOs hired from the outside have, on average, shorter tenures than those hired from the inside). Yet, like any model, it has its limits. Many of these limitations are discussed in the course of the paper, but a few are best left for discussion at the end (Section VII).

I. Model

A. *Timing*

The model has the following timing.

Stage 1: At the start, a board of directors needs to hire a new CEO for the firm. It has a choice of an internal candidate (subscript I) or an external candidate (subscript E). There are *commonly* held prior distributions about the ability, α, of each candidate. Specifically, α is distributed normally with mean μ (μ_E for the external candidate and μ_I for the internal candidate) and variance $1/\tau$ (τ is the *precision* of the distribution, τ_E for the external candidate, and τ_I for the internal candidate). Reflecting that more is generally known about how an internal candidate will do as CEO than about how an external candidate will do, assume

$$\tau_I > \tau_E.$$

Stage 2: The board may acquire a private signal, y, about the CEO it has hired. 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 $1/s$. The precision s is the same regardless of which candidate became CEO.

Stage 3: If the board obtains the signal, it updates its estimate of the CEO's ability. Based on this posterior estimate, the board may decide to fire the CEO and hire a replacement. A replacement CEO's ability, α_R, represents a random draw from a normal distribution with mean $\mu_R = 0$ and variance $1/\tau_R$. Setting μ_R to 0 is a convenient normalization without loss of generality. Because what is of interest is the board's replacing the incumbent CEO in response to a bad signal, assume neither μ_E nor μ_I is less than 0 (were μ_E or $\mu_I < 0$, then the incumbent CEO would lose his job both when a bad signal is obtained and when no signal is obtained). The assumption that the mean ability of a replacement CEO is lower than the (unconditional)

mean ability of an incumbent can be justified as follows: Firing the CEO "early" triggers a succession before the normal transition process will have run; hence, the pool of candidate successors is likely weaker than it would be in a normal succession process. A complementary justification is that μ_R is the expected value of the firm under a caretaker administration that is not (fully) able to pursue new initiatives or respond aggressively to changes in the strategic environment. Along these same lines, a further justification is that μ_R represents the expected ability of a new CEO *minus* such disruption costs.[4]

Stage 4: Earnings, x, are realized. Earnings are distributed normally with a mean equal to the ability of the CEO in place (the one hired in stage 1 or his replacement if he is replaced in stage 3). The random variables $y - \alpha$ and $x - \alpha$ are independently distributed.

B. *Preferences and Ability*

A CEO's ability is fixed throughout his career. I follow Holmstrom (1999) by assuming that CEOs and boards are symmetrically informed; in particular, both parties know only that the CEO's ability is drawn from a normal distribution with mean μ and precision τ. This assumption can by justified by noting that a critical component about a CEO's ability is the match between him and the job of being CEO, about which both parties are likely to be equally uncertain. Moreover, both parties are likely to have similar knowledge of those aspects of ability revealed by prior work experience.

I assume that individual directors like higher earnings, but find monitoring to be costly (where monitoring is defined as the efforts made to acquire the signal y).[5] Following Hermalin and Weisbach (1998), I assume the preferences of the individual directors can be aggregated in such a way that the board acts as if it has a single utility function that positively weights earnings, but negatively weights efforts to monitor. Such monitoring efforts can be translated, without loss of generality, into the probability—denoted by p—that the board acquires the signal y. Assume further, as in Hermalin and Weisbach (1998), that the board's utility function is additively separable:

$$U(x, p) = \theta x + (1 - \theta)(-c(p)), \tag{1}$$

where $c(p)$ denotes the cost or disutility incurred by the board and θ and $1 - \theta$ are the weights on the two components. Because utilities are defined up to an

[4] Eldenburg et al. (2004) find evidence that, in hospital CEO transitions, caretaker administrations are appointed with some frequency. See Vancil (1987) for a discussion of the benefits of an orderly transition process.

[5] This monitoring need not be particularly "active"; one could as easily interpret it as taking the effort to be attentive to the performance of the firm and making an effort to seek from the data made available to the board information relevant for estimating the CEO's ability. Section VI considers additional interpretations.

affine transformation only, there is no further loss of generality in dividing (1) by $1 - \theta$ and reexpressing it as

$$\delta x - c(p),$$

where $\delta > 0$ is a measure of the board's diligence or independence. Assume that $c(\cdot)$ is strictly increasing for $p > 0$, strictly convex, and twice-differentiable. The factor δ, which is determined exogenously, is meant to capture those aspects of the board that affect how it weighs the cost of monitoring versus the higher profits that such monitoring can provide. This factor would, for instance, be expected to vary *in*versely with (1) the proportion of inside directors on the board—insiders presumably have reasons to dislike monitoring themselves or their boss, the CEO; (2) the opportunity cost of the directors' time; (3) directors' incentives not to "rock the boat" (e.g., to increase their chances for additional directorships with other firms); and (4) the strengths of the personal ties between directors and the CEO.

C. *Updating Beliefs and Optimal Monitoring*

If the board obtains the signal, y, the posterior distribution of the CEO's ability is normal with mean $\hat{\mu}$ and precision $\hat{\tau}$, where

$$\hat{\mu} = \frac{\tau\mu + sy}{\tau + s} \quad \text{and} \quad \hat{\tau} = \tau + s$$

(see, for instance, DeGroot (1970), p. 167).

Observe that the expected value of earnings, x, is the expected value of the CEO's ability. Therefore, it is $\hat{\mu}$ if a signal is obtained and the incumbent CEO is retained; μ if no signal is obtained and the incumbent CEO is retained; and $\mu_R = 0$ if a replacement CEO is hired. By assumption $\mu_I \geq 0$ and $\mu_E \geq 0$, so, conditional on no signal being obtained, the board maximizes firm expected earnings by retaining the incumbent CEO. If a signal is obtained, then expected earnings are maximized by firing the incumbent CEO and hiring a replacement if and only if $\hat{\mu} < 0 = \mu_R$. Hence, the rule for replacing the incumbent CEO is to replace him if and only if the signal y satisfies

$$y < -\frac{\tau\mu}{s} \equiv Y. \tag{2}$$

Note Y is the cutoff value for the signal, below which the incumbent loses his job (as a convention, functions of many variables, such as Y, will be denoted by capital letters).

The distribution of the signal y given the CEO's *true* ability, α, is normal with mean α and variance $1/s$; hence, the distribution of y given the *prior estimate* of the CEO's ability, μ, is normal with mean μ and variance $1/s + 1/\tau$.[6] Define

[6] The random variable $y - \mu$ is the sum of two independently distributed normal variables $y - \alpha$ and $\alpha - \mu$; hence, $y - \mu$ is also normally distributed. The means of these two random variables are both 0, so the mean of y given μ is, thus, μ. The variance of the two variables are $1/s$ and $1/\tau$, respectively, so the variance of $y - \mu$ and, therefore, y given μ is $1/s + 1/\tau$.

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

to be the precision of y given μ.

The firm's expected earnings if it *will* learn y are

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

The option to fire the incumbent CEO is a valuable one, hence $V > \mu$ for all τ.

A change of variables from y to $z \equiv \sqrt{H}(y - \mu)$ reveals that V can be written as

$$V = \mu\left[1 - \Phi\left((Y-\mu)\sqrt{H}\right)\right] + \frac{\sqrt{H}}{\tau}\phi\left((Y-\mu)\sqrt{H}\right)$$

$$= \mu\Phi\left(-(Y-\mu)\sqrt{H}\right) + \frac{\sqrt{H}}{\tau}\phi\left((Y-\mu)\sqrt{H}\right),$$

where $\Phi(\cdot)$ is the distribution function of a standard normal random variable (i.e., with mean 0 and variance 1), $\phi(\cdot)$ is its corresponding density function, and the second line follows from the first because the standard normal is symmetric about 0. Note that

$$\Phi\left(-(Y-\mu)\sqrt{H}\right) \tag{3}$$

is the probability that the CEO will be retained if a signal is obtained.

II. Analysis

In deciding how intensely to monitor the CEO (i.e., what p to choose), the board solves

$$\max_{p\in[0,1]} \delta(pV + (1-p)\mu) - c(p). \tag{4}$$

This expression is globally concave in p. For convenience, attention will be limited to cases in which (4) has an interior solution.[7] The first-order condition for (4),

$$\delta(V - \mu) - c'(p) = 0, \tag{5}$$

is sufficient, as well as necessary, and admits a unique solution. Let P^* be the solution to (5). Properties of P^* are:

PROPOSITION 1: *The intensity with which the board monitors the CEO, P^*, is*

(i) decreasing with the prior estimate of his ability, μ;

[7] The analysis is readily extended to allow for corner solutions, but little is gained by considering them and excluding them simplifies the analysis. A condition that would insure an interior solution for all parameter values is $c'(0) = 0$ and $\lim_{p\uparrow 1} c'(p) = \infty$.

(ii) decreasing with the precision of the prior estimate, τ; but
(iii) increasing with the board's diligence or independence, δ.

(All proofs may be found in the Appendix.)

One way to interpret Proposition 1 is in terms of the gain from obtaining a signal about the CEO, which is $V - \mu$ (this is, essentially, the marginal return to monitoring, p, see (5)). The marginal value of the signal increases the greater is the likelihood it will be decisive with regard to whether the CEO is retained or fired. If the prior about the CEO's ability is high, then the signal is less likely to be decisive. Similarly, if the precision of that prior estimate is high, then the signal is less likely to be decisive. Because the board will rationally monitor less the lower is the value of the signal, these insights explain results (i) and (ii) of Proposition 1.

The next set of questions has to do with whether the board hires the internal or external candidate in stage 1:

PROPOSITION 2: *Fix $\tau_I > \tau_E$ and define $\Delta = \mu_I - \mu_E$. Then for a given μ_E (or μ_I) there exists a minimum $\Delta_m > 0$ such that the external candidate is hired if and only if $\Delta < \Delta_m$. Moreover, Δ_m increases as the board gains independence (i.e., the greater is δ); that is, more independent boards are more inclined to hire external candidates, all else equal.*

COROLLARY 1 (Necessary Condition): *A necessary condition for the internal candidate to be hired is that his estimated ability be strictly greater than that of the external candidate (i.e., that $\mu_I > \mu_E$).*

Corollary 1 may, at first, seem surprising. After all, we often think of internal candidates having the inside track rather than facing a higher hurdle than external candidates. To understand why internal candidates are not advantaged—indeed, are disadvantaged—recall that an external candidate's ability is less well estimated than an internal candidate's. This greater uncertainty about the external candidate means that he has the greater option value ceteris paribus.[8,9] This greater option value, in turn, makes him the more desirable candidate all else equal. For the internal candidate to be competitive, he must, therefore, have a higher estimated ability than the external candidate.

The second half of Proposition 2 follows because the more independent the board is (i.e., the greater is δ), the more intensely it monitors (i.e., the greater is

[8] The value of having the option is $V - \mu$. From expression (A3) in the Appendix, $\partial V/\partial \tau < 0$, so the option value is increasing in uncertainty about the CEO.

[9] Lazear (1998) makes a similar point, showing that younger workers, about whom less is known, are intrinsically more valuable than older workers. Although it does not play a role in the initial selection of CEO, the value of the option to replace the incumbent CEO subsequently does play a role in Berkovitch and Israel's (1996) model; in particular, it explains the stock price reaction to earnings announcements.

p, see Proposition 1). In turn, this means that a more independent board is more likely to be in a situation to exercise the option of dismissing the CEO, which, in turn, raises the importance it places on having that option. Consequently, the value of the external candidate is greater vis-à-vis the internal candidate ceteris paribus; hence, the higher-ability hurdle for the internal candidate goes up.

The second half of Proposition 2 implies that more independent boards—or boards otherwise more disposed toward monitoring—will be more likely to hire external candidates than less independent boards—or boards otherwise less disposed toward monitoring. Given the perceived wisdom that outside directors are more independent or otherwise more inclined to monitor,[10] this suggests that the tendency to hire external candidates increases with the proportion of outside directors on the board. This prediction is consistent with the empirical findings of Borokhovich, Parrino, and Trapani (1996) and Dahya and McConnell (2001), who find evidence in support of this hypothesis using U.S. and U.K. data, respectively.

Furthermore, controlling for the level of board independence, δ, internal candidates and external candidates will be treated differently if hired as CEO. From Corollary 1, an internal candidate who gets the job must have a higher estimated ability, μ_I, than an external candidate. Moreover, there is less uncertainty about an internal candidate's ability than about an external candidate's ($\tau_I > \tau_E$). These differences result, therefore, in different levels of monitoring and, thus, different probabilities of dismissal.

PROPOSITION 3: *Fix the board's level of independence, δ. Suppose the board is indifferent between hiring the external candidate or the internal candidate as CEO. Then, if the external candidate is hired,*

(i) he is more intensely monitored than the internal candidate would have been (i.e., $P_E^* > P_I^*$);
(ii) he is more likely to be dismissed than the internal candidate would have been conditional on being monitored (i.e., conditional on the signal y being obtained); and, hence,
(iii) he has a shorter expected tenure than the internal candidate would have been expected to have (i.e., is less likely to reach stage 4).

Result (i) of Proposition 3 follows immediately from Proposition 1 because the prior estimate of an external candidate's ability is both lower and estimated with less precision than is the estimate of an internal candidate's ability. The fact that the signal is less decisive vis-à-vis dismissal both when the prior estimate is high or the precision of that estimate is high means that the board is less responsive to a low value of the signal for an internal candidate than

[10] See Weisbach (1988) for evidence that outside directors could be more inclined to monitor. Specifically, Weisbach finds that, as the proportion of outside directors on a board increases, the board has a greater tendency to exhibit behavior consistent with monitoring.

for an external candidate, which explains result (ii) of Proposition 3. If the board is both more likely to monitor a CEO hired externally and more likely to respond to the signal gained from that monitoring by firing him, then his expected tenure must be less than a CEO hired from the inside; that is, result (iii) of Proposition 3 follows immediately from results (i) and (ii).

Because Proposition 3 involves a counter-factual comparison—what would have been the treatment of the not-hired internal candidate—it is not readily tested empirically. It can, however, be turned into a more testable hypothesis if one is willing to make assumptions about the underlying distributions of the estimated abilities of the two types of candidates (i.e., the underlying distributions of μ_I and μ_E). If the two distributions are similar to each other, then internal candidates who become CEO will tend to have higher estimated abilities than external candidates who become CEO all else equal. The three results in Proposition 3 clearly hold whenever comparing candidates for whom $\mu_I \geq \mu_E$. Consequently, a potential prediction of this analysis is that, controlling for board independence, CEOs who are hired from the outside will tend to have shorter tenures than CEOs who are hired from the inside.

It is important to recognize that this prediction relies on the underlying properties of the distributions of the estimated abilities. If the distributions are sufficiently *dis*similar in specific ways, then this prediction will not be borne out in the data. For instance, suppose that the distribution of μ_E was such that the vast majority of realized μ_Es were generally much less than the majority of realized μ_Is, so that the internal candidate is highly likely to win. However, assume further that there is a small mass of exceedingly talented external candidates for whom $\mu_E \gg \mu_I$ relative to the bulk of the internal candidates. Then, comparing the distributions of the μs for *winning* candidates, μ_E will tend to be much larger than μ_I, perhaps to the extent that winning external candidates receive less scrutiny than winning internal candidates (i.e., the "ability" result, part (i) of Proposition 1, outweighs the "uncertainty" result, part (ii) of Proposition 1). Figure 1 illustrates such a hypothetical situation, with panel A showing the underlying distributions of the estimated abilities and panel B showing those distributions conditional on winning the job.

Figure 1 reflects a situation in which there is considerable variation in the possible values of μ_E. Conversely, suppose the variation in the estimated abilities of external candidates is small relative to the variation in the estimated abilities of internal candidates. Indeed, as an approximation, take μ_E to be a constant for the economy. All the variation would, then, be in the quality of the internal candidates. In such a world, one would, then, get the following testable corollary to Proposition 3:

COROLLARY 2 (Testable Hypothesis): *Assume that μ_E is fixed across firms, but there is variation in μ_I among firms selecting a new CEO. Then, controlling for board independence, δ, CEOs hired from the outside will have shorter tenures on average than CEOs hired from the inside.*

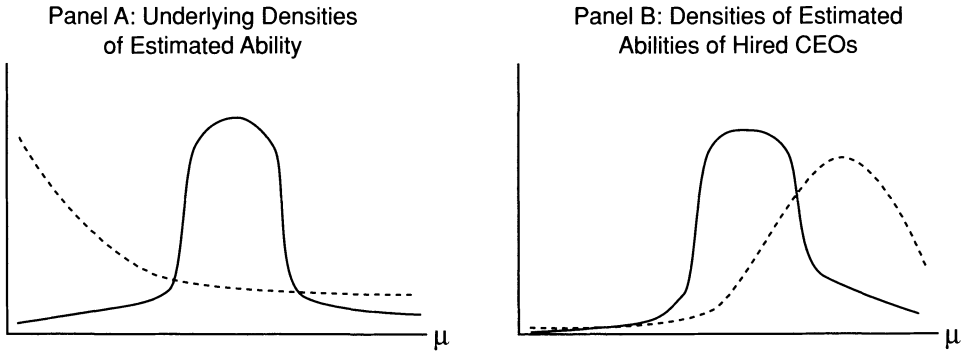

Figure 1. Hypothetical distributions of estimated abilities for internal candidates (solid curves) and external candidates (dashed curves). Panel A shows the underlying densities of μ_I and μ_E, respectively, while Panel B shows the resulting densities *conditional on being hired* as CEO. With such hypothetical distributions as Panel A, those external-candidate CEOs who do get hired could actually have *longer* expected tenures than internal-candidate CEOs.

It is important to remember that the conclusion of Corollary 2 (or any statement similar to it) is dependent on assumptions concerning the underlying distributions of talent in the internal and external candidate pools (recall the discussion surrounding Figure 1). There are two other, empirical, reasons that the prediction of Corollary 2 may be difficult to find in the data:[11] First, firms often hire heir-apparents from the outside a few years in advance of making them CEO,[12] which muddies the distinction between internal and external candidates, creating data-definition problems for the econometrician. A second difficulty is that firms sometimes employ interim CEOs, particularly following unexpected CEO departures, who are almost invariably insiders, but, by definition, will have short tenures (Eldenburg et al. (2004), for instance, found numerous examples of hospitals employing interim CEOs); the use of interim CEOs also raises data-construction issues.

The discussion of potentially different tenures for external CEO hires and internal CEO hires has so far controlled for the level of board independence (measured, possibly, by proportion of outside directors). If one "drops" that control, then Proposition 2, which predicts that more independent boards will be more inclined to hire external CEO candidates, and result (iii) of Proposition 1, which predicts that such boards will monitor more, offer an additional factor—beyond the one identified in Corollary 2 and connected discussion—for why external hires could be expected to have shorter tenures than internal hires;

[11] To the best of my knowledge, no one has tested whether CEOs hired from the outside tend to have shorter tenures than CEOs hired from the inside, controlling for board characteristics.

[12] For example, in 1997, Avon hired Charles Perrin, former CEO of Duracell, to be the heir apparent to James Preston. Perrin became CEO in 1998. Hayes, Oyer, and Schaefer (2003, Table 1) report that 22% of new CEOs have less than 5 years experience with the company they have been appointed to lead.

namely, external hires are more likely to have been hired by boards more inclined to monitor and, thus, more inclined to dismiss a CEO early (i.e., before stage 4). Again, however, the underlying-distributions and data-definition issues raised above could create problems for verifying this prediction in the data.

III. Trends

As the analysis of the previous section makes clear, changes in the exogenous parameter δ will have clear effects on the selection, monitoring, and replacement of CEOs. Huson, Parrino, and Starks (2001) note a number of trends that could correspond to exogenous changes in δ (i.e., trends that lead to a greater willingness of boards to monitor):

(1) The proportion of outside directors on boards has steadily increased in the United States and in other countries. Hermalin and Weisbach (1988, p. 593) report an increase in the average percentage of outside directors on boards from 37.6% to 53.9% over the period 1971 to 1983 for a sample of 142 NYSE-traded companies. Borokhovich et al. (1996, Table I) report an increase from 68.3% to 75.6% over the period 1970 to 1988 for their sample of 588 large public firms.[13] Huson et al. cite evidence that the percentage of manufacturing firms with a majority of outside directors increased from 71% in 1972 to 86% in 1989. In a sample of 700 firms listed on the London Stock Exchange, Dahya and McConnell (2001, Table II) find the average percentage of outside directors increased from 35% in 1989 to 61% in 1999. Perceived wisdom is that outside directors are more inclined to monitor the CEO than are inside directors (see Weisbach (1988), for evidence). Hence, these trends toward greater outsider representation on boards can be seen to correspond to a trend toward higher δs among firms.

(2) In addition, Huson et al. cite evidence that the use of incentive compensation for outside directors has increased considerably: In a Conference Board survey of U.S. firms taken in 1989, 6% made stock grants to outside directors and 14% granted stock options. In 1997, 84% of firms in the survey were utilizing stock-based compensation for their outside directors. Because δ can be seen as the weight assigned greater profits relative to the cost of monitoring, an increase in incentive pay for directors can be viewed as increasing δ; that is, increasing the willingness to monitor.

[13] The large discrepancy in Hermalin and Weisbach and Borokhovich et al.'s figures, despite their considering overlapping periods, is due in small part to differences between their samples and in large part to differences in how the two sets of authors define outside directors. The Hermalin and Weisbach definition of outsider *excludes* directors who, while not management of the company, are not likely to be independent of management (e.g., family members of the CEO, people with significant business dealings with the company). Hermalin and Weisbach refer to such directors as "grey" directors. Borokhovich et al. essentially count grey directors as outside directors. Using Borokhovich et al.'s definition, Hermalin and Weisbach's data reveal an increase in outsiders from 50.9% to 65.7%.

(3) The trend toward greater outsider representation on boards and more board independence could be attributable to public, exchange, and governmental pressure. For instance, Huson et al. report that, in 1978, the NYSE required listed firms to have audit committees consisting solely of outside directors. Dahya and McConnell document the effect the Cadbury report, issued in 1992, had on the subsequent increase in outsider representation on U.K. boards.

(4) In the United States, at least, these trends could also be attributable, in part, to the increase in institutional stock ownership. Huson et al. report that the percentage of U.S. equity held by institutional investors (mutual funds, private pension funds, government pension funds, and insurance company holdings) has increased from 20% of outstanding equity held by U.S. investors in 1971 to nearly 45% by 1994 (Figure 1 of Huson et al.). As Huson et al. discuss, institutional owners tend to be more active in governance matters, and hence they tend to encourage governance practices consistent with higher δs. Gillan and Starks (2000), for instance, find evidence that, in the early 1990s, institutional investors put pressure on firms to increase board independence through the stockholder proxy proposal process. Hence, the overall trend toward greater institutional investment could lead to a trend toward higher δs.

If, as hypothesized, these trends correspond to the parameter δ increasing over time, then the analysis of the previous section leads to the following predictions:

PROPOSITION 4: *As δ increases across firms,*

(i) the proportion of new CEOs who are hired from the outside should increase; and

(ii) the expected tenure of CEOs should become shorter.

Result (i) of Proposition 4 is essentially a restatement of the second half of Proposition 2. Consistent with Proposition 4, Borokhovich et al., Huson et al., and Dahya and McConnell find empirical evidence of a trend toward outsiders' being appointed CEO with increased frequency, coinciding with the aforementioned trends in better governance (higher δs).

Result (ii) of Proposition 4 follows from result (iii) of Proposition 1: An increase in δ leads to more monitoring of the CEO, regardless of whether he was an internal or external candidate. Moreover, an increase in δ leads to marginally more external candidates being hired (Proposition 2) and, because these marginal candidates are beating out internal candidates who would otherwise have become CEOs, they are more heavily monitored (Proposition 3), which further contributes to shorter CEO tenures. Huson et al. find evidence consistent with result (ii) of Proposition 4: Firings, as a percentage of all CEO successions, have been trending upward over the period 1971 to 1994 (see Huson et al.'s Table II).

IV. An Extension: CEO Effort

To this point, the CEO has been implicitly assumed to expend no effort. It might be anticipated that if the CEO can respond to an exogenous increase in the board diligence parameter, δ, by working harder, then he would, perhaps to the point that he undoes his increased risk of dismissal. While it is true that he will work harder, it will not, however, be true that this hard work changes his dismissal probability.

To understand why, suppose that after he is hired in stage 1, but before the board observes the signal (if it does at stage 2), the CEO can expend effort e at cost $k(e)$ to him.[14] Assume that $k'(0) = 0, k'(e) > 0$ for $e > 0$, and that $k(\cdot)$ is strictly convex. Assume that the CEO's utility is $b - k(e)$ if he survives to the end (i.e., stage 4), but $-k(e)$ if he does not survive (i.e., is dismissed in stage 3). The parameter $b > 0$ is a measure of the benefit the CEO derives from retaining his office. Take it to be fixed exogenously. Assume the CEO's choice of e is his private information (i.e., it is a hidden action).

Assume that there are two consequences to the CEO's effort. First, it adds $\beta(e)$ in expectation to the firm's value.[15] Second, it affects the signal observed by the board; specifically, instead of observing y, the board now observes $y + e \equiv \tilde{y}$. Assume that the enhancement to firm value is realized (or, at least, learned by the board) *after* the board must make its decision to retain or fire the CEO (i.e., after stage 3). This last assumption precludes the board from using the enhancement in firm value to estimate e.[16]

Because the board wishes to base its firing decision on y, it would subtract e from $\tilde{y}$ if it knew e. It cannot, in fact, do this, because, by assumption, it does not know e. *If,* however, the CEO plays a pure-strategy in equilibrium, then the board can, nonetheless, infer what e should be in equilibrium. Let $\hat{e}$ denote this inferred or estimated level of e under the presumption that the CEO plays a pure strategy. The board will then base its firing decision on $\tilde{y} - \hat{e} = y + e - \hat{e}$.

[14] Note the CEO chooses e before the board chooses p; that is, the CEO must forecast p. As will become clear, in a pure-strategy equilibrium, the board's choice of p will be the same as in the game without effort (i.e., P^*).

[15] In what follows, nothing depends on the sign of $\beta(\cdot)$ or the sign of its derivative. To the extent that CEO effort is considered a good, $\beta'(\cdot) \geq 0$. On the other hand, if effort refers to actions taken, for instance, to inflate short-term performance at the cost of long-term value, then it could be that $\beta'(\cdot) < 0$; that is, in that case, β corresponds to an additional cost of monitoring. Given an inability of the board to commit to a p, $\beta(\cdot)$ can have no impact on its choice of p.

[16] This assumption is made primarily for convenience. If the board could observe e without error or infer it perfectly from $\beta(e)$ *prior* to its decision on whether to dismiss the CEO, then the model with respect to monitoring and dismissal would be identical to that in the previous sections; effort would be irrelevant to the inference of ability and it would, thus, be as if effort were not in the model. If the board can estimate effort imperfectly, yet the support of its statistic on effort is the same regardless of the level of effort chosen (there is no shifting support), then the analysis will be the same as in this section, given that the CEO is assumed to play a pure strategy; the statistic on effort will be of no value in estimating ability in equilibrium. The case with a shifting support could, however, differ from what follows if, because of the shift in support, the board can infer that the CEO chose an out-of-equilibrium level of effort, but the board cannot determine precisely what level of effort he chose.

The same replacement rule as before—expression (2)—applies, so the CEO loses his job if and only if

$$\tilde{y} - \hat{e} < -\frac{\tau\mu}{s} \equiv Y. \tag{6}$$

Note that the Y in (6) is the same as in (2). This cutoff rule can be reexpressed as the CEO loses his job if and only if

$$y < Y + \hat{e} - e.$$

Therefore, using (3), the CEO's expected utility as a function of e is

$$\left(P^*\Phi\left(-(Y + \hat{e} - e - \mu)\sqrt{H}\right) + (1 - P^*)\right)b - k(e). \tag{7}$$

The CEO chooses e to maximize (7) given the value of $\hat{e}$ he anticipates the board has. The first-order condition is

$$bP^*\phi\left(-(Y + \hat{e} - e - \mu)\sqrt{H}\right)\sqrt{H} - k'(e) = 0. \tag{8}$$

In a pure-strategy equilibrium, the board must correctly anticipate the CEO's effort; that is, $\hat{e} = e$ in equilibrium. The equilibrium value of effort, e^*, is, therefore, the solution to

$$bP^*\phi\left(-(Y - \mu)\sqrt{H}\right)\sqrt{H} - k'(e^*) = 0. \tag{9}$$

Because $k'(\cdot)$ is strictly monotonic, with a range of $[0, \infty)$, a unique e^* exists that solves (9). In other words, *if* a pure-strategy equilibrium exists, then it is unique and, in it, the CEO supplies effort e^*.

The only step thus remaining is to establish that a pure-strategy equilibrium exists, which entails verifying that e^* is a best response for the CEO when the board believes he will supply effort e^*. Unfortunately, without imposing further structure on the model, there is no guarantee that a pure-strategy equilibrium exists: While it can be shown that $e = e^*$ achieves a *local* maximum of the CEO's expected utility when $\hat{e} = e^*$,[17] it is not possible to show that is a *global* maximum. Panel A of Figure 2 illustrates what can "go wrong": In addition to the local maximum at $e = e^*$, there is also a local maximum at $e = e_0$, with the latter representing the global maximum. On the other hand, a pure-strategy equilibrium can exist—such an equilibrium is illustrated in Panel B of Figure 2.

[17] The CEO's marginal benefit of effort can be shown to be

$$bP^*\sqrt{H}\phi\left[\left(\frac{s+\tau}{s}\mu + e - e^*\right)\sqrt{H}\right].$$

Because $\mu > 0$, the expression in square brackets is in the right tail of the normal density for $e \in (e^* - \varepsilon, \infty)$, where $\varepsilon > 0$ is not too large. Because the normal density is shrinking as one moves further out the right tail, it follows that this marginal benefit is downward sloping in e in the neighborhood of e^*. Marginal cost, $k'(e)$, is upward sloping. Hence, at $e = e^*$ marginal benefit intersects marginal cost from above; that is, $e = e^*$ is a local maximum.

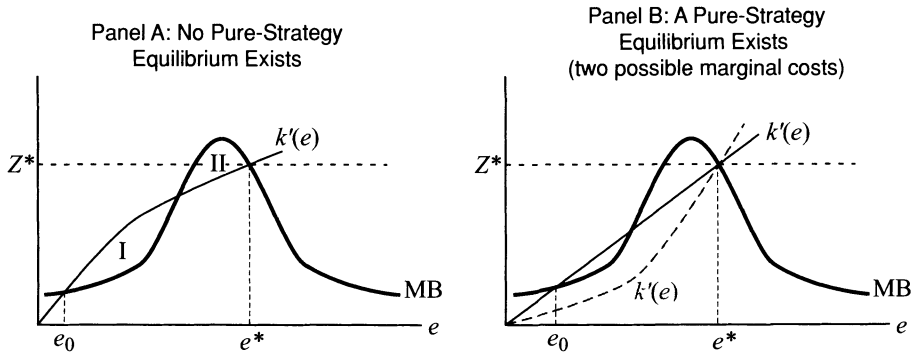

Figure 2. Scenarios in which a pure-strategy equilibrium does not exist (Panel A) and does exist (Panel B). In both panels

$$\text{MB} = bP^*\phi(-(Y + e^* - e - \mu)\sqrt{H})\sqrt{H},$$

and

$$Z^* = bP^*\phi(-(Y - \mu)\sqrt{H})\sqrt{H}$$

(i.e., Z^* is the first term in (9)). In Panel A, there are two local maxima, one at e_0 and one at e^*. The one at e_0 is, however, the global maximum (best response) because, were the CEO to switch to e^*, he would lose the area labeled I, which is larger than the area he would gain, labeled II. In contrast, in Panel B, it is e^* that is the global maximum. Panel B also shows an alternative marginal cost (the dashed grey curve) in which e^* is the sole (and, thus, global) maximizer.

The following lemma establishes one set of conditions under which a pure-strategy equilibrium exists.

LEMMA 1. *If*

(i): $k(e) = e^2/2$ *and*
(ii): $bH < 1/\phi(1)$,

then a pure-strategy equilibrium of the game with effort exists and is unique.

The intuition behind condition (ii) is that b and H determine, in part, the value to the CEO of trying to distort the signal. If the benefit of job retention, b, is great, then the CEO's motive to distort the signal is greater. Similarly, if H, the precision of the signal given μ, is greater, the more weight the board will put on the signal and, thus, the greater the CEO's incentive to distort it. Recall that, in a pure-strategy equilibrium, the board correctly forecasts the CEO's effort at distortion. So large b or H make e^* large. But at some point the increasing cost of e^* makes it no longer a worthwhile strategy for the CEO to expend that effort; he does better to "give up" and deviate to a lower level of effort.[18] To assess the reasonableness of the condition $bH < 1/\phi(1) \approx 4.133$, suppose we scaled the model so that the standard deviations of all distributions (including over earnings) are the same, σ. Then H can be shown to be $\frac{1}{2\sigma^2}$. Hence,

[18] Although a quite different model, it is worth noting that a discouragement effect can also arise in Berkovitch and Israel (1996).

condition (ii) holds unless $b > 8.266\sigma^2$. I would argue that, in many contexts, it is quite reasonable to assume that the private benefit of retaining office is less than eight times the variance of earnings (i.e., to assume condition (ii) holds).

An analysis of this game when no pure-strategy equilibrium exists is quite involved and would take us too far afield. Hence, attention will be limited to situations in which the pure-strategy equilibrium does exist.[19]

PROPOSITION 5: *Assume for the relevant parameter values that the game with CEO effort has a pure-strategy equilibrium (e.g., the parameters satisfy the conditions of Lemma 1). Then the following comparative statics hold:*

(i) the lower the CEO's estimated ability, the more effort he expends in equilibrium; and

(ii) the more diligent is the board (i.e., the greater is δ), the more effort the CEO expends in equilibrium.

Result (i)—the "Avis effect"[20]—predicts that CEOs with lower estimated abilities will work harder than CEOs with higher estimated abilities all else equal. Intuitively, the marginal benefit of trying to boost the signal the board receives if it monitors is greater both the more likely it is that the board monitors (i.e., the greater is P^*) and the more likely it is that the board responds to a low value of the signal by dismissing the CEO (i.e., the lower is Φ). Because, if the prior estimated ability, μ, of the CEO is low, the board is both more likely to monitor and more likely to respond to the signal by dismissing the CEO, the result follows.[21]

Result (ii) predicts that the more diligent a monitor the board is, the harder the CEO works. At first glance, this may seem such an "obvious" result that it hardly warrants attention. Yet, the *mechanism behind* this result is not necessarily obvious. Remember the board is *not* monitoring the CEO's effort; indeed, it cannot observe that effort within the time period in which it must make a decision about retaining him or letting him go. Rather the impact monitoring has on effort is indirect: Because the board seeks evidence about the CEO's ability—not how hard he has worked—the CEO has an incentive to try to influence that signal by working harder. The more likely the board is to seek this evidence (i.e., the greater is δ), the stronger this incentive is. In equilibrium, the board anticipates that the CEO will do this—and the more so the more diligent it is about monitoring—so it correspondingly discounts the signal it observes (subtracts e^* from it). Even though no one is fooled in equilibrium, the CEO is compelled to supply e^* in effort or otherwise risk increasing his odds of being fired.

[19] An example of a situation in which a pure-strategy equilibrium does *not* exist is when $bP^* = 30, H = 1, \mu(s+\tau)/s = 1$, and $k(e) = 3e^2/4$.

[20] In the 1960s, the Avis car rental company launched an ad campaign with the slogan "We're number two, we have to try harder." "We try harder" is still Avis's world-wide slogan.

[21] A theoretical possibility in this model is that the Avis effect could outweigh the direct effect of a more able CEO such that the board prefers to hire CEOs with lower estimated abilities versus CEOs with higher estimated abilities. It seems unlikely that such a curious result would govern actual CEO-succession decisions.

Consequently, result (ii) can be seen as being in the spirit of Fama (1980), which argues that a manager's concern for his reputation in the labor market will cause him to work hard. Here, it is not an external labor market that the CEO seeks to influence, but his own board of directors. It is also true, however, that while this can help to ameliorate any hidden-action problem that exists,[22] there is no reason to expect it to be a particularly effective solution because the CEO's marginal-benefit schedule will not match—except, possibly, by the most random of coincidences—the shareholders' marginal-benefit schedule, $\beta'(e)$. (Holmstrom makes a similar point about mismatched incentives in his critique of Fama.)

In equilibrium, the CEO's expected utility is

$$\left(P^*\Phi\left(-(Y-\mu)\sqrt{H}\right)+(1-P^*)\right)b-k(e^*). \tag{10}$$

Differentiating (10) with respect to board diligence, δ, yields

$$\frac{\partial P^*}{\partial \delta}(\Phi-1)b-k'(e^*)\frac{\partial e^*}{\partial \delta},$$

which is negative because both partial derivatives are positive by Propositions 1 and 5, respectively, $\Phi < 1$, and $k' > 0$. Hence, the CEO's expected utility is falling as the board becomes more diligent. If, as seems reasonable, the CEO needs to be compensated for this loss in utility, then a consequence of a more diligent board is an increase in CEO compensation. To summarize:

PROPOSITION 6: *If CEOs with similar attributes enjoy equal expected utility in the equilibrium of the CEO market, then, controlling for attributes, CEOs who work for more diligent boards will receive greater compensation than CEOs who work for less diligent boards.*

Proposition 6 possibly offers some insight into the upward trend in executive compensation much decried in the popular press and among many in the public, and that has been widely documented in the economic literature (see, in particular, Hall, and Liebman (1998), Table IIa, which documents a 97.3% increase in average CEO salary and bonus from 1980 to 1994 and a 209% increase in average CEO total compensation over this same period; also see Hall (2002), for additional evidence). This period of increase corresponds with the period of increased vigilance in governance documented by Huson et al. (2001), among others (recall the discussion in Section III above). A possible response from executives to more vigilant governance has been to demand and receive greater pay as compensation for the greater disutility they suffer.

One could also ask what the model would look like if the directors could provide the CEO with incentive pay (i.e., tie his compensation to some verifiable signal of e)? A complete answer is beyond the scope of this paper, but observe, from expression (9), the CEO's *effective equilibrium* marginal cost of effort is

[22] It is worth noting that this amelioration could be dependent on the board *not* observing CEO effort. If the board could observe the effort, but could not use this information to compensate the CEO directly, then the CEO would not expend any effort because, if it is directly observable, it cannot possibly influence the board's inference of his ability. See also footnote 16 supra.

$$k'(e) - bP^*\phi\big(-(Y-\mu)\sqrt{H}\big)\sqrt{H} < k'(e);$$

that is, the desire to influence the signal effectively lowers the CEO's marginal disutility of effort when he considers his response to incentive pay. Hence, in a model with monitoring, the equilibrium level of effort is greater than it would be in a similar model with*out* monitoring. From Proposition 1, this effective-marginal-cost reduction effect increases with the board's diligence, δ. As is well known, however, agency models are sufficiently sensitive to assumptions about the degree of risk aversion, the shape of $\beta(\cdot)$, and the stochastic relation between signal and effort that it is not possible to offer general predictions about how the incentive contracts themselves change in going from a model without monitoring to one with monitoring.

As a final note on this extension, the discussion has been framed in terms of CEO effort. "Effort," however, can be understood to refer not only to positive actions (e.g., more time in the office, carrying out necessary, but unpleasant, tasks like firing subordinates) but also to refraining from pursuing actions that are beneficial to the CEO but harmful to the company (e.g., consumption of certain perquisites, empire building, and so forth); that is, one can interpret e as negative perquisite taking.

V. An Extension: CEO Compensation

As Proposition 6 established, the model analyzed above can be extended to yield predictions about CEO compensation. In this section, I explore an alternative extension that also potentially sheds some light on trends in executive compensation.

For convenience, I return to the version of the model with*out* CEO effort. Assume, initially, that there are many CEO candidates and only a few firms, so that the firms have the bargaining power in negotiating employment contracts. In addition, assume initially that all candidates have the same estimated ability, μ, which is estimated with the same precision, τ.

Assume that a candidate for CEO will accept employment only if his expected utility exceeds some reservation level $\underline{U}$. As in the previous section, assume that a CEO enjoys some benefit $b > 0$ if he survives to the last stage (stage 4). If he is dismissed prior to that stage, he receives no benefit. Let w be the wage he is paid. Then he accepts employment only if

$$w + b(P^*\Phi + (1 - P^*)) \geq \underline{U}. \tag{11}$$

Because the firms have all the bargaining power, (11) is binding; that is, a CEO's wage is given by

$$w = \underline{U} - b(P^*\Phi + (1 - P^*)). \tag{12}$$

Differentiating that expression with respect to δ, the measure of the board's diligence, yields

$$\frac{\partial w}{\partial \delta} = -b\frac{\partial P^*}{\partial \delta}(\Phi - 1) > 0 \tag{13}$$

($\partial P^*/\partial \delta > 0$ by Proposition 1). This yields

PROPOSITION 7: *If the market for CEOs is homogenous, then*

(i) firms with more diligent boards will pay their CEOs more than firms with less diligent boards; and
(ii) as diligence increases over time across firms, average CEO compensation will also increase.

The cross-sectional prediction, result (i) of Proposition 7, might seem at odds with a sense, common in the popular press at least, that it is *weak* boards that overpay their CEOs (see Bebchuk and Fried (2003), for a more scholarly argument for this view). Such intuition is clearly mistaken when CEO talent is homogenous in the relevant market. Such intuition can, however, be redeemed—at least in part—if we depart from the assumption of homogeneity: suppose, now, that there are a few "superstar" CEOs in the market with estimated ability μ_1. Let the rest of the market consist of "run-of-the-mill" CEOs, with estimated ability $\mu_0 < \mu_1$. Assume, however, that the estimated abilities of both sets of CEO candidates are estimated with the same precision (i.e., τ is common across all candidates). Beyond the differences in their estimated abilities, type-0 and type-1 CEO candidates differ in terms of their market power: The former have no market power and command a wage given by (12); while the latter have complete market power, which means they can capture all the surplus that a board could gain by employing a type-1 CEO rather than a 0-type. Hence, the wage of a 1-type is determined by

$$\begin{aligned}\delta(P_1^*V_1 + (1 - P_1^*)\mu_1 - w_1) - c(P_1^*) &= \delta(P_0^*V_0 + (1 - P_0^*)\mu_0 - w_0) - c(P_0^*) \\ &= \delta(P_0^*V_0 + (1 - P_0^*)\mu_0 - \underline{U} + b(P_0^*\Phi_0 + (1 - P_0^*))) - c(P_0^*),\end{aligned} \tag{14}$$

where subscripts 0 and 1 denote whether the variable pertains to a 0-type or 1-type CEO candidate. Differentiating (14) with respect to δ, utilizing the envelope theorem, and using (14) to simplify yields

$$\frac{\partial w_1}{\partial \delta} = \frac{1}{\delta^2}\underbrace{(c(P_1^*) - c(P_0^*))}_{\text{negative by Prop. 1}} - \delta\underbrace{b(\Phi_0 - 1)\frac{\partial P_0^*}{\partial \delta}}_{\text{negative by (13)}}. \tag{15}$$

As (15) makes clear, the wage of a superstar CEO (i.e., type 1) varies in an *in*determinant way with the diligence of the board. On the one hand, board diligence is a substitute for managerial ability (this is what, after substitution, the difference in the $c(\cdot)$s represents in (15)). Hence, the marginal value of a superstar CEO over a run-of-the-mill CEO is less, the more vigilant the board is. On the other hand, a more diligent board is already a high-paying board, hence the incremental cost of a superstar is less than for a less diligent board

(this is what the second term of (15) represents). Hence, the marginal cost of a superstar CEO over a run-of-the-mill CEO is less, the more diligent the board is. On net, there is no reason to expect one of the two marginal effects to be dominant and, in fact, one can find examples in which either one is dominant.[23]

In those cases in which (15) is negative, the following situation exists. Let $\bar{w}_\kappa$ denote the wage of a type-κ CEO dealing with a more diligent board, and let $\underline{w}_\kappa$ denote the wage of a type-κ CEO dealing with a less diligent board (assume, for convenience, two levels of diligence). Then $\underline{w}_1 > \bar{w}_1 > \bar{w}_0$. That is, the highest wages in cross-section will be paid by the less diligent board. Depending on the relative frequency of the two kinds of boards relative to the two types of CEO candidates, it is also possible that the less diligent boards pay more on average than do the more diligent boards.

Indeed, the same conclusion about the cross-section can still be reached even if $\bar{w}_1 > \underline{w}_1 > \bar{w}_0$: Because a firm with a more diligent board is a less attractive workplace for a CEO, it is possible that, even if the more diligent board is willing to pay more for a superstar CEO, the superstar's expected utility is higher at a firm with a less diligent board. So, again, the highest wages in cross-section are paid by the less diligent board. Hence, again, it is possible that average CEO compensation is higher at firms with less diligent boards.

While cross-sectionally, one can, thus, find an inverse relation between board diligence and CEO compensation, it is still likely that the time-series effect of a secular trend toward greater board diligence is to lead to an increase in CEO compensation: As boards become more diligent, the compensation of the run-of-the-mill (type-0) CEOs increases, because they require compensation for the greater disutility they suffer from working for more diligent boards. Because the run-of-the-mill CEOs are the majority, the consequence for average CEO compensation across all firms is that it increases as board diligence increases on average across firms. To summarize this discussion:

OBSERVATION 1: *With heterogenous CEOs, the following scenario is feasible within the model developed in this article. In a cross-section of firms, at any moment in time, CEO compensation can vary inversely with the diligence of the board (measured, e.g., by the proportion of outsiders on the board). However, over time, as boards on average become more diligent, the trend should be toward an increase in CEO compensation; that is, across time, CEO compensation should co-vary positively with the diligence of the board.*

VI. Other Views and Interpretations

While this article has developed a model that offers a way to tie together a number of trends in corporate governance, it is worth briefly considering alternative hypotheses and interpretations.

[23] For example, let $c(p) = p^2/2$, $\tau = 1$, $s = 1$, $\mu_1 = 1$, $\mu_0 = 1/2$. Then (15) is negative if $b = 1$, but positive if $b = 2$, when evaluated at $\delta = 1/2$.

One issue is the relation between greater board diligence, δ, and an increased tendency to hire external candidates to be the CEO. To the extent greater diligence captures an increased proportion of outside directors on the board, an alternative explanation might be that outside directors simply have better expertise in choosing external candidates than do insider directors. The trend toward more external hiring is, then, a reflection of the increased ability of boards to do so. This alternative explanation suffers, however, on a number of grounds:

- It leaves unexplained the trend toward shorter CEO tenures and does not directly relate to the trend toward greater CEO compensation.
- It is unclear why this expertise could not be gained by employing "head hunting" firms.
- If, as seems reasonable, "better expertise" means an ability to estimate ability with greater precision, then, from the analysis above, a trend toward more outsiders should lead to *less* external hiring because, as shown in Propositions 1 and 2, an increase in τ_E reduces the desirability of hiring externally ceteris paribus because it reduces the option value that an external candidate offers.

A counter-objection to this last point could be that the better expertise matters because the board actually cares about the risk of a new CEO. This, however, would require that the board be risk averse (it has heretofore been assumed to be risk neutral). While director risk aversion might not be an unwarranted assumption, it does not necessarily reverse the predictions of the model; in particular, the option-value effect still exists, but, now, is offset to some degree by the directors' distaste for risk. A full analysis of director risk aversion would make this article too long and is, therefore, a subject for future work.

A more plausible variant of the "better-expertise" alternative is that outside directors are more likely to want to take the company in new directions and new directions require new, external, management. But this variant, however, can be seen as essentially the same as the model presented above. Now, μ_I is the expected return from following the incumbent strategy and μ_E is the expected return offered by a new strategy. Not surprisingly, there is less uncertainty about the incumbent strategy than a new strategy, so $\tau_I > \tau_E$. So, with α reinterpreted as the quality of the strategy rather than the ability of the CEO and an added assumption that a (radical) change in strategy requires a change in CEO, the model put forth above continues to work and is consistent with the trends discussed above.

Another board-composition hypothesis is that inside-dominated boards naturally favor fellow insiders for the CEO position and are uninterested in monitoring one of their own when he becomes CEO. To an extent, such a hypothesis is already captured in the model; inside-dominated boards have lower diligence, δ, so monitor less intensely and, thus, weight the additional option value of an external candidate less in their hiring decisions. Another point is that it is not necessarily obvious that an inside-dominated board would have a bias toward appointing an internal candidate. In many instances there is a "horse

race" among leading internal candidates to become CEO, with the losers typically leaving the company.[24] It is possible, therefore, that insiders might wish to avoid such a conflict and go outside for a new CEO.

Another aspect to "horse racing" is the following: It is claimed that a motive for having insiders on the board (besides the CEO) is that board experience is important should they become the CEO (see Mace (1971) or Vancil (1987)). Hence, a firm with a lot of internal talent would be more likely to have an inside-heavy board than a firm that was less well endowed. Because μ_I can be seen as the maximum-order statistic from a pool of internal candidates, μ_I will tend to be greater, on average, for firms with larger pools than firms with smaller pools. Hence, ceteris paribus, such large-pool firms will be more inclined to hire internally than externally (see Proposition 2). Pool size, therefore, offers a way to explain differences in board composition and, thus, δ across firms.

Another issue stemming from pool size is the following: Rajan and Wulf (2003) offer evidence that U.S. firms have been flattening their hierarchies. In particular, the middle layer between the CEO and division heads appears to be shrinking. A likely consequence is that the pool of potential internal candidates for the CEO position is shrinking, pushing down the average μ_I across firms. This, in turn, implies a reduction in the average estimated ability of CEOs appointed. If, on average, CEOs are of lesser ability, then the desirability of monitoring increases, which, in turn, could increase the demand for more diligent boards.[25] In other words, trends toward flatter hierarchies could be another trend leading to greater board diligence (higher δ).

Murphy and Zábojník (2003) posit that there has been a decline in the value of managers' firm-specific knowledge relative to the value of their general knowledge. This has increased the willingness of firms to hire CEOs externally. Given the way Murphy and Zábojník model the CEO labor market, this greater willingness to go outside translates into a rise in CEO compensation. As formulated, their model is silent with respect to trends in CEO tenure. Moreover, in their model, the trend toward greater outsider representation on boards is essentially orthogonal to the trend toward greater external hiring of CEOs.

On the other hand, the Murphy and Zábojník model can, to an extent, be folded into the model presented here: Let $\alpha_I = \tilde{\alpha} + \gamma$, where the constant $\gamma, \gamma > 0$, is the value of an internal candidate's firm-specific knowledge and $\tilde{\alpha} \sim \mathrm{N}[\tilde{\mu}, 1/\tau_I]$ (so $\mu_I = \tilde{\mu} + \gamma$). Then, as shown above, a decline in γ will lead to an increase in the hiring of external candidates. Because the μ of the initially

[24] See Vancil (1987) for a discussion of such horse races. Hermalin and Weisbach (1988) offer statistical evidence consistent with internal candidates leaving, at least, the board.

[25] Assume there is a cost to shareholders of putting in place a more diligent board—a not unreasonable assumption, because otherwise would not every board be maximally diligent? Then, if

$$\frac{\partial^2 P^*}{\partial \mu \partial \delta} \leq 0,$$

a secular decline in μ will lead shareholders to insist on more diligent boards. Details available from the author upon request.

hired CEO will be lower on average, monitoring will be greater; so average CEO tenure should fall. To the extent the demand for greater monitoring increases the demand for board diligence (see note 25 supra), then a decline in γ could lead to more independent boards (e.g., more outside directors).

Another view put forth about the role of boards is that their job is not to collect information about the CEO but to interpret information.[26] That is, the board *always* gets a signal y, but its ability to interpret it depends on its effort. This interpretative function can be seen as a statement about the precision of the signal. That is, with more effort, the board raises the signal's precision. To a degree, the current model can be reinterpreted in this light: By expending effort p, the board will be able to raise the precision of the signal from 0 to a fixed $s > 0$ with probability p. With probability $1 - p$, the precision remains at 0.[27]

A better way, however, to capture this view would be to let s be both the precision of the signal and the effort board expends on interpreting the available information; that is, the board's utility is $\delta x - c(s)$.[28] The board, therefore, seeks to solve

$$\max_s \delta V - c(s) \tag{16}$$

(V, recall, is a function of s). However, the comparative statics of this maximization program with respect to s are essentially the same as they were with respect to p (i.e., with respect to program (4)):

PROPOSITION 8: *Consider the modified model in which the board's objective is to solve* (16). *Then the intensity with which the board monitors the CEO, S^* (the solution to* (16)*), is*

(i) decreasing with the prior estimate of his ability, μ;
(ii) decreasing with the precision of the prior estimate, τ, if $\mu^2\tau \geq 1$; but
(iii) increasing with the board's diligence or independence, δ.

Because Proposition 1 was essential for the analysis in the previous sections of the paper, Proposition 8, the analog of Proposition 1, makes clear that the same analysis will hold if s is the board's decision variable instead of p (at least when $\mu^2\tau \geq 1$).

Making signal precision the board's decision variable (the "s-version" of the model) allows us to consider the question of how boards appear to react to public information.[29] Suppose that the public (investors) see $\xi = q + \varepsilon$, where $q \sim \mathrm{N}[\alpha, \sigma_q^2]$, $\varepsilon \sim \mathrm{N}[0, \sigma_\varepsilon^2]$ and $\mathrm{cov}(q, \varepsilon) = 0$, while the board sees

[26] I thank Bengt Holmstrom for suggesting this view.

[27] Observe that if $s = 0$, then $\hat{\mu} = \mu$ and, from expression (2), the CEO would never be dismissed (the cutoff, Y, is $-\infty$ in that case).

[28] Provided the precision of the signal is monotonic in the board's effort, there is no loss of generality in letting s do double duty because the inverse mapping from s back into effort can be built into the function $c(\cdot)$.

[29] I am grateful to an anonymous associate editor for comments that led to this extension.

$$y = q + \varepsilon\sqrt{\frac{1 - s\sigma_q^2}{s\sigma_\varepsilon^2}}.$$

By construction, the precision of y will be s. The board's choice of s is constrained to be in the interval

$$\left[\frac{1}{\sigma_q^2 + \sigma_\varepsilon^2}, \frac{1}{\sigma_q^2}\right] \equiv \mathcal{S}.$$

Observe that $\text{Var}(\xi) > \text{Var}(y)$ for all s except the smallest $s \in \mathcal{S}$; the board has more precise information. Observe $\text{corr}(y, \xi) > 0$. Because the probability that the CEO retains his job is decreasing in s ceteris paribus,[30] it follows that, if σ_ε^2 is large, then boards that tend not to monitor (expend effort) will appear unresponsive to ξ in their firing decisions. In contrast, boards that monitor more (expend more effort) will appear more responsive to ξ on average. Given that S^* increases with δ, this result is consistent with Weisbach (1988), which found that more independent boards were more responsive to firm performance (i.e., ξ) than less independent boards with respect to firing the CEO.

Of course, it could be the case the board is directly concerned with public signals, such as ξ, independent of their informativeness. If, for instance, bad public signals could trigger a shareholders' suit, then a board might want to be more vigilant. This increased vigilance out of concern for litigation or other reactions to bad public signals translates in this model to a higher δ.

Another issue is that a *series* of rapid CEO turnovers could be very hard on a firm.[31] This could, therefore, translate to an increasing *marginal* cost of turnover. In terms of the model, this would correspond to a declining μ_R, the value of a replacement CEO net of disruption costs. Because this is not a dynamic model, it is difficult to capture this increasing marginal cost issue fully. It can be shown (details upon request) that switching from $\mu_R = 0$ to $\mu_R = -\Delta$ (i.e., an increase in disruption costs of Δ) changes V to $\hat{V}$, where the latter is

$$\hat{V} = (\mu + \Delta)\Phi\left(\frac{\tau}{\sqrt{H}}(\mu + \Delta)\right) + \frac{\sqrt{H}}{\tau}\phi\left(-\frac{\tau}{\sqrt{H}}(\mu + \Delta)\right) - \Delta. \tag{17}$$

Because V can be written as

$$V = \mu\Phi\left(\frac{\tau}{\sqrt{H}}\mu\right) + \frac{\sqrt{H}}{\tau}\phi\left(-\frac{\tau}{\sqrt{H}}\mu\right),$$

it is readily apparent that all the comparative statics previously considered continue to hold for a *fixed* value of Δ (i.e., given that $d(\mu + \Delta)/d\mu = d\mu/d\mu = 1$). Utilizing expression (A2) from the Appendix,

$$\frac{\partial \hat{V}}{\partial \Delta} = \Phi - 1 < 0,$$

[30] Differentiating (3) with respect to s yields $-\frac{1}{2}\tau\phi(-(Y - \mu)\sqrt{H})\sqrt{H}/s^2 < 0$.

[31] I am grateful to an anonymous associate editor for this observation.

that is, the board's marginal benefit of monitoring is decreasing in disruption costs. This, in turn, means that an increase in Δ results in less monitoring. In other words, there could be a tendency for boards to be more forgiving toward the current incumbent if there has been a lot of turnover in the recent past.

A way to interpret this decrease in monitoring is as follows: As disruption costs go up, the probability that the board will exercise its replacement option goes down, which lowers the value of that option. Since it is the value of that option that motivates the board to monitor, a decrease in its value must lead to less monitoring. That same intuition explains the following result.

PROPOSITION 9: *Suppose that at a given level of disruption cost* ($\Delta = 0$), *a board would be indifferent between a given internal CEO candidate and a given external candidate. Then if disruption costs increase* ($\Delta > 0$), *the board will strictly prefer the internal candidate.*

Proposition 9 indicates that an increase in disruption costs should push firms toward hiring CEOs from the inside all else equal. Hence, the trend toward greater *external* hiring could, in part, be due to a fall in disruption costs. Such a view would, for instance, be consistent with Murphy and Zábojník (2003): they argue that managers are becoming better trained (e.g., more have MBAs), which might make it easier—less costly—for a replacement CEO to step into the job. On the other hand, to the extent that externally hired CEOs could have shorter tenures on average, an increase in external hiring could, if disruption costs have an increasing margin, lead to a future slowing in external hiring. Firms could, for instance, have a tendency to cycle between internal and external hiring for this reason. A rigorous dynamic analysis is, however, beyond the scope of the current article.

VII. Final Thoughts

This paper has set forth a plausible model of board behavior—specifically that, to varying degrees, boards seek to determine whether they should keep the CEO they have or replace him, where replacement is a costly option. It has also shown how the model can tie together a number of trends in corporate governance. In particular, if there is a secular trend toward more vigilant governance, then the model predicts the following trends should also be observed: (i) the frequency with which external candidates are the winning candidates to become CEO should increase; (ii) the average tenure of CEOs should fall; (iii) CEO effort should increase; and (iv) average CEO compensation should increase. The model also offers an insight (v) into how board vigilance and CEO compensation can co-vary inversely in cross-sectional data, but co-vary positively in time-series data. Finally, if one is willing to assume the underlying distributions of estimated abilities for internal and external candidates are not too dissimilar or the distribution of the external candidates is degenerate,

then the model predicts that (vi) external candidates appointed CEO will have shorter tenures on average than internal candidates who are appointed CEO.

Moreover, these linkages among trends are often the consequences or reinforced by subtle or indirect mechanisms. For instance, greater CEO effort occurs even though the board is *not* monitoring effort, but seeking to assess ability. Or, for instance, greater board diligence raises the option value of a new CEO and, thus, makes boards more willing to hire CEOs with lower mean ability if their ability is less precisely known—which, in turn, reinforces the trend toward shorter CEO tenures.

While the model is quite successful in tying together various trends in corporate governance, there is more work that can be done. Some of it is primarily technical, such as working out the mixed-strategy equilibrium that can exist in the effort model (Section IV). Other remaining work is more substantive. For instance, the CEO labor market has largely been ignored or, as in Section V, modeled in a highly stylized manner. A richer model of this market should offer more definitive insights into patterns to be expected in the cross-sectional data.

A related issue is CEO compensation. Although the analysis presented here addresses issues connected with total compensation—particularly why its overall expected value should increase—the paper says little about the components of compensation. As boards become more diligent, should we expect the use of incentive pay to increase or decrease? Can the trend in greater board diligence be tied to the apparent trend toward greater use of stock options in executive compensation?

Another issue is to tie this model into the CEO-life-cycle model of Hermalin and Weisbach (1998). In their model, over a CEO's tenure in office, more is learned about him. Because only able CEOs are retained, this means that CEOs with long tenures will generally have proved themselves to be considerably better than the expected value of replacements. This makes them "rare commodities," which in turn gives them bargaining power against the board. One objective they will bargain for is greater pay, but another is less scrutiny. Less scrutiny can be achieved only by getting a less diligent board. (Note this model, thus, offers another explanation for an inverse relation between CEO compensation and board diligence in cross-sectional data—high-paying firms are those with a proven CEO, who is thus able to bargain for high pay and a less diligent board.) The mechanics of the Hermalin and Weisbach (1998) model are such that there is a trend *during* a CEO's tenure toward *less* board diligence (a prediction—if the proportion of outsiders is a proxy for board diligence—borne out in the data; see Hermalin and Weisbach (1988)). A question not fully addressed by either Hermalin and Weisbach (1998) or this article is how an overall trend to increased board diligence can be reconciled with this tendency, within any given firm over the CEO life-cycle, toward less diligence? What are the mechanics by which boards become more diligent?

Despite these open issues, the analysis presented here demonstrates that starting from a simple model of board monitoring, one can tie together a number of trends in corporate governance. Moreover, this analysis provides a framework

whereby one can consider the consequences of various reforms; for instance, that pressure to have boards that are tougher and more independent of management can have the, perhaps undesirable, feature of leading to greater executive compensation.

Appendix

Proof of Proposition 1: Some preliminaries. First, recall that $\phi'(z) = -z\phi(z)$. Second, observe that

$$\begin{aligned}\frac{\partial V}{\partial Y} &= -\mu\phi\big(-(Y-\mu)\sqrt{H}\big)\sqrt{H} - \frac{H}{\tau}\phi\big((Y-\mu)\sqrt{H}\big)[Y-\mu]\sqrt{H} \\ &= \phi\big((Y-\mu)\sqrt{H}\big)\sqrt{H}\left(-\mu + \frac{s}{s+\tau}\left[\frac{\tau\mu}{s} + \mu\right]\right) \\ &= 0. \end{aligned} \tag{A1}$$

Third, observe that (using expression (A1) to eliminate $\partial V/\partial Y \times \partial Y/\partial\mu$ terms):

$$\begin{aligned}\frac{\partial V}{\partial \mu} &= \Phi + \mu\phi\sqrt{H} + \frac{H\sqrt{H}}{\tau}(Y-\mu)\phi \\ &= \Phi + \phi\sqrt{H}\left(\mu - \frac{s}{s+\tau}\left[\frac{\tau\mu}{s} + \mu\right]\right) \\ &= \Phi. \end{aligned} \tag{A2}$$

Turning to claims (i)–(iii): let Ω be the objective function in expression (4). Consider claim (i):

$$\begin{aligned}\frac{\partial^2\Omega}{\partial\mu\partial p} &= \frac{\partial[V-\mu]}{\partial\mu} \\ &= \Phi - 1 \qquad \text{(from expression (A2))} \\ &< 0, \end{aligned}$$

so, by the usual comparative statics, $\partial P^*/\partial\mu < 0$. Similarly,

$$\begin{aligned}\frac{\partial^2\Omega}{\partial\delta\partial p} &= V - \mu > 0 \quad \text{and} \\ \frac{\partial^2\Omega}{\partial\tau\partial p} &= \frac{\partial V}{\partial\tau} \\ &= \left(-1 + \frac{1}{2}\frac{s}{s+\tau}\right)\frac{\sqrt{H}}{\tau^2}\phi < 0 \end{aligned} \tag{A3}$$

(where (A3) relies on (A1)). Hence, $\partial P^*/\partial\delta > 0$ and $\partial P^*/\partial\tau < 0$. Q.E.D.

Proof of Proposition 2: Define

$$W_E = \delta\big(P_E^* V_E + (1 - P_E^*)\mu_E\big) - c\big(P_E^*\big) \quad \text{and}$$
$$W_I = \delta\big(P_I^* V_I + (1 - P_I^*)\mu_I\big) - c\big(P_I^*\big).$$

The value W_E (alt. W_I) is the board's expected value from hiring an external (alt. internal) candidate. Observe that W_I can be written as

$$W_I(\Delta) = \delta P_I^*\Big[(\mu_E + \Delta)\Phi\big(-(Y_I - [\mu_E + \Delta])\sqrt{H_I}\big) + \frac{\sqrt{H_I}}{\tau_I}\phi\big((Y_I - [\mu_E + \Delta])\sqrt{H_I}\big)\Big]$$
$$+ \delta\big(1 - P_I^*\big)(\mu_E + \Delta) - c\big(P_I^*\big).$$

Next, differentiate $W_I(\Delta)$, recalling, from the proof of Proposition 1, that $\partial V/\partial Y = 0$ (expression (A1)) and $\partial V/\partial \mu = \Phi$ (expression (A2)) and utilizing the envelope theorem:

$$W_I'(\Delta) = \delta\big(P_I^*\Phi + \big(1 - P_I^*\big)\big) > 0. \tag{A4}$$

If it can be shown both that $W_I(0) < W_E$ and there is a Δ such that $W_I(\Delta) > W_E$, then the existence of a Δ_m with the properties stated in the proposition follows from (A4). To see that $W_I(0) < W_E$, observe that

$$\frac{\partial W}{\partial \tau} = \delta P^* \frac{\partial V}{\partial \tau}$$
$$= \delta P^*\left(-1 + \frac{1}{2}\frac{s}{s+\tau}\right)\frac{\sqrt{H}}{\tau^2}\phi < 0, \tag{A5}$$

where (A5) follows from the envelope theorem. Hence,

$$W_I(0) < W_E, \tag{A6}$$

because $\tau_I > \tau_E$. To show that there is a Δ such that $W_I(\Delta) > W_E$, observe that

$$W_I(\Delta) \geq \delta(\mu_E + \Delta) - c(0).$$

Hence,

$$\lim_{\Delta \uparrow \infty} W_I(\Delta) = \infty. \tag{A7}$$

This establishes the first part of the proposition.

To show the "moreover" part, start from the identity:

$$0 \equiv W_I(\Delta_m) - W_E. \tag{A8}$$

Differentiate this with respect to δ, utilizing the envelope theorem:

$$
\begin{aligned}
0 &= \frac{\partial(W_I(\Delta_m) - W_E)}{\partial\delta} \\
&= \underbrace{\delta\left(P_I^*\Phi + (1 - P_I^*)\right)}_{W_I'(\Delta_m)} \frac{\partial\Delta_m}{\partial\delta} + \left(P_I^*V_I + (1 - P_I^*)\mu_I\right) - \left(P_E^*V_E + (1 - P_E^*)\mu_E\right) \\
&= \delta\left(P_I^*\Phi + (1 - P_I^*)\right)\frac{\partial\Delta_m}{\partial\delta} + \frac{1}{\delta}\left(c(P_I^*) - c(P_E^*)\right), \qquad \text{(A9)}
\end{aligned}
$$

where $W_I'(\Delta_m)$ comes from (A4) and the third equality follows because (A8) can rewritten as

$$\delta\left(P_I^*V_I + (1 - P_I^*)\mu_I\right) - \delta\left(P_E^*V_E + (1 - P_E^*)\mu_E\right) = c(P_I^*) - c(P_E^*).$$

Because $\Delta_m > 0$, $\mu_I > \mu_E$. By assumption, $\tau_I > \tau_E$. Results (i) and (ii) of Proposition 1 therefore imply that $P_E^* > P_I^*$; hence

$$c(P_I^*) - c(P_E^*) < 0.$$

But, then, (A9) holds if and only if $\partial\Delta_m/\partial\delta > 0$, which establishes the "moreover" part. Q.E.D.

Proof of Proposition 3: By assumption, $\tau_I > \tau_E$. From Corollary 1, for the board to be indifferent, it must be that $\mu_I > \mu_E$. Hence, result (i) of this proposition follows immediately from results (i) and (ii) of Proposition 1. To show result (ii) of this proposition it is sufficient to show that

$$-(Y - \mu)\sqrt{H} = \frac{s + \tau}{s}\mu\sqrt{H} = \frac{\tau}{\sqrt{H}}\mu$$

is increasing in both μ and τ. Clearly that expression is increasing in μ. Differentiating that expression with respect to τ yields:

$$
\begin{aligned}
\frac{\partial}{\partial\tau}\frac{\tau}{\sqrt{H}}\mu &= \frac{\sqrt{H} - \frac{1}{2}\tau\frac{1}{\sqrt{H}}\frac{s^2}{(s+\tau)^2}}{H}\mu \\
&= \frac{\sqrt{H} - \frac{1}{2}\frac{1}{\tau\sqrt{H}}H^2}{H}\mu,
\end{aligned}
$$

which has the same sign as

$$1 - \frac{1}{2}\frac{H}{\tau} = 1 - \frac{1}{2}\frac{s}{s+\tau} > 0.$$

Hence, the probability of *retaining* a position as CEO is increasing in both μ and τ, which means the probability of *dismissal* is greater for an external candidate

than an internal candidate. Result (iii) of this proposition follows immediately from results (i) and (ii) of this proposition. Q.E.D.

Proof of Corollary 2: From Proposition 2, any internal candidate who is hired must have an estimated ability greater than μ_E. That is, in the population of *hired* CEOs, $\mu_I > \mu_E$. The proof of Proposition 3 is readily seen as being valid for any μ_I and μ_E pair such that $\mu_I > \mu_E$. The corollary follows as it is just a restatement of result (iii) from Proposition 3. Q.E.D.

Proof of Proposition 4: Result (i) follows immediately from the second half of Proposition 2. To show result (ii), observe the probability of dismissal conditional on employment is

$$\Pr\{\text{dismissal}\} = P^*\Phi\big((Y-\mu)\sqrt{H}\big).$$

Hence,

$$\begin{aligned}\frac{\partial \Pr\{\text{dismissal}\}}{\partial \delta} &= \frac{\partial P^*}{\partial \delta}\Phi\big((Y-\mu)\sqrt{H}\big)\\ &> 0,\end{aligned}$$

where the second line follows from result (iii) of Proposition 1. Hence, result (ii) follows provided the change in δ does not change the choice of candidate (internal vs. external). If the change in δ does change the choice of candidate, then, from Proposition 2, an increase in δ causes a "switch" from the internal to the external candidate. By Corollary 1, if the internal candidate is hirable under any circumstances, $\mu_I > \mu_E$. Consequently, this external candidate would receive more scrutiny ceteris paribus than the internal candidate by results (i) and (ii) of Proposition 1. Because an increase in δ also increases the level of scrutiny (result (iii) of Proposition 1), the overall effect of an increase in the board's δ is to increase the probability that any CEO it employs gets fired. Q.E.D.

Proof of Lemma 1: When $k(e) = e^2/2$, expression (9) becomes

$$e^* = bP^*\phi\left(\frac{s+\tau}{s}\mu\sqrt{H}\right)\sqrt{H}.$$

Substituting that into the first-order condition, expression (8), yields

$$bP^*\phi\left(\left[\frac{s+\tau}{s}\mu + e - bP^*\phi\left(\frac{s+\tau}{s}\mu\sqrt{H}\right)\sqrt{H}\right]\sqrt{H}\right)\sqrt{H} - e = 0. \qquad \text{(A10)}$$

Letting $Z = \mu(s+\tau)/s$ and $Q = bP^*$, the second-order condition (the derivative of the left-hand side of (A10) with respect to e) can be written as

$$-QH[Z + e - Q\phi(Z\sqrt{H})\sqrt{H}]$$
$$\times \phi([Z + e - Q\phi(Z\sqrt{H})\sqrt{H}]\sqrt{H})\sqrt{H} - 1. \tag{A11}$$

The only way in which (A11) could ever be positive (i.e., expression (7) is not *globally* concave) is if the product term in (A11) is big enough. Observe the product term can be written as

$$-QHA\phi(A), \tag{A12}$$

where

$$A = (Z + e - Q\phi(Z\sqrt{H})\sqrt{H})\sqrt{H}.$$

Maximizing (A12) with respect to A yields the first-order condition

$$-QH\phi(A) + QHA^2\phi(A) = 0,$$

which has two solutions $A = -1$ and $A = 1$. Only the former, however, satisfies the second-order condition:

$$3QHA\phi(A) - QHA^3\phi(A) = -3QH\phi(A) - QH\phi(A) < 0.$$

Substituting $A = -1$ into (11) yields

$$QH\phi(-1) - 1 \leq bH\phi(-1) - 1$$
$$= bH\phi(1) - 1,$$

which is negative if $bH < 1/\phi(1)$ as assumed. Hence, expression (7) is globally concave, so the local maximum at $e = e^*$ is the only (and, thus, global) maximum. A pure-strategy equilibrium thus exists. The discussion in the text showed that if a pure-strategy equilibrium exists, then it is unique. Q.E.D.

Proof of Proposition 5: From (9), equilibrium effort is greater the greater is

$$bP^*\phi(-(Y - \mu)\sqrt{H})\sqrt{H} = bP^*\phi\left(\frac{\tau}{\sqrt{H}}\mu\right)\sqrt{H}. \tag{A13}$$

Because $\mu > 0$, a small decrease in μ pulls the argument of ϕ from the right tail of the normal distribution toward its mode, which, thus, means ϕ is increasing as μ decreases. From Proposition 1, P^* also increases as μ falls. Hence (A13) increases as μ falls, which establishes result (i).

The only term in (A13) that depends on δ is P^*, which is increasing in δ (recall Proposition 1). This establishes result (ii). Q.E.D.

Proof of Proposition 8: For future reference, observe that

$$\frac{\partial V}{\partial s} = \frac{\tau}{2(s + \tau)^2\sqrt{H}} \times \phi\left(-\frac{\tau + s}{s}\mu\sqrt{H}\right) > 0. \tag{A14}$$

Let $\Omega = \delta V - c(s)$. It is sufficient to prove the three parts of the proposition to consider the appropriate cross-partial derivatives of Ω.

(i) $\frac{\partial^2 \Omega}{\partial \mu \partial s} = \delta \frac{\partial^2 V}{\partial \mu \partial s}$, which is negative from (A14) (recall

$$d\phi(f(x))/dx = -f(x)f'(x)\phi(x),$$

where here $-f(x) > 0$ and $f'(x) = -(\tau + s)\sqrt{H}/s < 0$). Hence, an increase in μ leads to a decrease in S^*.

(ii) $\frac{\partial^2 \Omega}{\partial \tau \partial s} = \delta \frac{\partial^2 V}{\partial \tau \partial s}$. Calculations reveal

$$\frac{\partial^2 V}{\partial \tau \partial s} = \frac{-2\mu^2\tau^4 + s^2\tau(1 - \mu^2\tau) - s\tau^2(2 + \mu^2\tau)}{4H^{3/2}(s + \tau)^4} \times \phi\left(-\frac{\tau + s}{s}\mu\sqrt{H}\right),$$

which must be negative if $1 \leq \mu^2\tau$. Hence, an increase in τ leads to a decrease in S^*.

(iii) $\frac{\partial^2 \Omega}{\partial \delta \partial s} = \frac{\partial V}{\partial s}$, which is positive from (A14). Hence, an increase in δ leads to an increase in S^*. Q.E.D.

Proof of Proposition 9: Define W_E and W_I as in the proof of Proposition 2. By Corollary 1, the fact that the board is indifferent when $\Delta = 0$ means $\mu_I > \mu_E$. By assumption, $\tau_I > \tau_E$. Differentiate $W_I - W_E$ with respect to Δ using expression (17) to write V:

$$\frac{\partial[W_I - W_E]}{\partial \Delta} = \delta\big(P_E^*(1 - \Phi_E) - P_I^*(1 - \Phi_I)\big), \tag{A15}$$

where the envelope theorem has been invoked; where Φ_E is the survival probability of an externally hired CEO who is monitored; and where Φ_I is the survival probability of an internally hired CEO who is monitored. From Proposition 3, part (i), $P_E^* > P_I^*$; and from part (ii) of that proposition, $\Phi_E < \Phi_I$. Hence, expression (A15) is positive, which means the value of the internal candidate increases more when Δ increases than does the value of the external candidate. Q.E.D.

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