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## CEO Replacement under Private Information

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PROF. DR. HELMUT SIEKMANN (HRSG.)

INSTITUTE FOR MONETARY AND FINANCIAL STABILITY  
PROFESSUR FÜR GELD-, WÄHRUNGS- UND NOTENBANKRECHT  
JOHANN WOLFGANG GOETHE-UNIVERSITÄT  
GRÜNEBURGPLATZ 1  
60629 FRANKFURT AM MAIN

TELEFON: (069) 798 – 34014  
TELEFAX: (069) 798 – 33913  
E-MAIL: [GELD-UND-WAEHRUNG@IMFS-FRANKFURT.DE](mailto:GELD-UND-WAEHRUNG@IMFS-FRANKFURT.DE)

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# CEO Replacement under Private Information\*

Roman Inderst<sup>†</sup>

Holger Müller<sup>‡</sup>

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## Abstract

We study a model of “information-based entrenchment” in which the CEO has private information that the board needs to make an efficient replacement decision. Eliciting the CEO’s private information is costly, as it implies that the board must pay the CEO both higher severance pay and higher on-the-job pay. While higher CEO pay is associated with higher turnover in our model, there is too little turnover in equilibrium. Our model makes novel empirical predictions relating CEO turnover, severance pay, and on-the-job pay to firm-level attributes such as size, corporate governance, and the quality of the firm’s accounting system.

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<sup>†</sup>University of Frankfurt, LSE, CEPR, and ECGI. E-mail: r.inderst@lse.ac.uk.

<sup>‡</sup>New York University, CEPR, and ECGI. Email: hmueller@stern.nyu.edu.

# 1 Introduction

The notion that top management is entrenched, leading to inefficient turnover at the top of the firm, is pervasive among both academics and practitioners.<sup>1</sup> Our model incorporates CEO entrenchment into a joint theory of CEO turnover and compensation. Taking CEO entrenchment into account when deriving hypotheses about CEO turnover is important, as it naturally creates a wedge between the firm’s efficient replacement decision and the actually observed level of turnover. Also, the firm will optimally design the CEO’s compensation to minimize distortions arising from entrenchment, thereby affecting the likelihood of future turnover.

Our model is one of endogenous entrenchment. Starting from a simple problem of moral hazard, we first show that the on-the-job pay that must be offered to the CEO to keep him from shirking biases him towards continuing with the firm even if his “match value” is lower than that of a potential replacement CEO. What keeps the board from implementing an efficient replacement policy is that the CEO has better, albeit private, information about the firm value under his continued leadership.<sup>2</sup> Inducing efficient CEO turnover is thus costly, as it requires to elicit the CEO’s private information by granting him informational rents.

The optimal way to reduce CEO entrenchment, and thus to induce more efficient turnover, is to increase both the CEO’s on-the-job pay and his severance pay. The need for higher severance pay is intuitive. After all, the CEO must find it attractive to leave the firm when the match value under a potential replacement CEO is higher. The need for higher on-the-job pay follows because otherwise the higher severance pay would undermine the CEO’s incentives to work hard. That the CEO’s on-the-job pay must increase works, however, *against* reducing CEO entrenchment: A CEO who expects higher on-the-job pay has more to gain from clinging to his job. A key insight of our analysis is that, through the careful optimal design of the CEO’s compensation package in the form of a combination of severance pay and high-powered incentive pay, it can be ensured that the joint increase in severance pay and on-the-job pay has indeed the desired effect of reducing

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<sup>1</sup>See Sonnenfeld (1991) and Shleifer and Vishny (1989).

<sup>2</sup>The notion that the CEO has information that the board needs for an efficient replacement policy is not new. For instance, Jensen (1993, p. 864) notes that “the CEO most always determines the agenda and the information given to the board. This limitation on information hinders the ability of even highly talented board members to contribute effectively to the monitoring and evaluation of the CEO.”

CEO entrenchment and thus inducing higher turnover.<sup>3</sup>

Due to the simplicity of the CEO's moral hazard problem in our model, high-powered incentive pay becomes optimal not for the purpose of inducing more effort, but because it accomplishes a given level of CEO turnover at least cost. Absent any further restrictions, the optimal on-the-job pay scheme is a high-powered (and discontinuous) bonus scheme. When we impose additional restrictions stemming from a cash-flow falsification problem à la Lacker and Weinberg (1989), we find that a continuous and piecewise linear "option-like" contract becomes optimal. The "steeper" the firm can make this contract, the lower are the (marginal) costs of reducing CEO entrenchment. More CEO entrenchment, and thus less turnover, would, however, result if the board faced a binding cap on the amount of severance pay it can pay, e.g., because of political pressure or "public outcry" (see Bebchuk and Fried 2004).

On the other hand, tying the board's hands by not allowing it to "top up" the CEO's severance pay *ex post* ("golden handshakes") benefits the firm. This is due to a commitment problem that the board, which is assumed to act in the firm's interest, faces when it must decide whether to replace the CEO. At that point, all that matters for the firm is to reduce CEO entrenchment. In contrast, the firm is *ex ante* additionally constrained by the need to keep the CEO from shirking, which makes the use of severance pay more costly as it must be accompanied by a simultaneous increase in on-the-job pay. In our model, the board's inability to commit not to "top up" the CEO's severance pay *ex post* would undermine his *ex-ante* incentives to work hard.

Our model gives rise to several comparative statics results relating CEO turnover, severance pay, and on-the job pay to firm-level characteristics. The board wants to ensure that the CEO becomes less entrenched, implying higher turnover, if entrenchment entails a larger reduction in firm value, as is likely the case for larger firms. Likewise, the board will offer higher severance pay and induce more subsequent turnover if it becomes less likely *ex ante* that the present CEO will also remain the best possible fit in the future. Importantly, in this case the CEO's higher pay does not constitute compensation for the higher probability that he may be replaced. Higher pay provides him with additional informational rents that are necessary to soften his entrenchment. Instead, if better corporate

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<sup>3</sup>That severance pay and on-the-job pay must move in the same direction distinguishes our argument from Bebchuk and Fried (2004), where severance pay is a substitute form of "stealth" compensation for more visible incentive pay.

governance makes it harder for the CEO to shirk, then this results in lower pay, both in terms of severance pay and on-the-job pay, as well as higher turnover.

In a variation of our basic model, we endow not the CEO but rather the board with better information about the match value. Following recent contributions that stress the complementary role of boards (e.g., Adams and Ferreira 2007), we wish to capture the notion that the board may have valuable (albeit private) information that affects how successful the CEO will be at the firm. Even though the information now resides with the board, the equilibrium level of CEO turnover is again inefficient, albeit now it is inefficiently high. In contrast to the case of a “weak board”, which has an informational disadvantage vis-à-vis the CEO, with a “strong board” we find that CEO turnover and pay may now be *negatively* correlated.

Severance pay plays a central role in our model. Lambert and Larcker (1985) and Harris (1990) are two early models in which severance pay (or golden parachutes) provides managers with insurance against the loss of their jobs. More recently, Almazan and Suarez (2003) consider the role of severance pay for renegotiations between the CEO and the board. While CEO replacement is always efficient in their model due to symmetric information between the CEO and the board, severance pay can provide stronger *ex-ante* incentives for the CEO than incentive pay. Our model of “information-based entrenchment” is also related to Eisfeldt and Rampini (2008), where managers who are privately informed about the productivity of assets under their control must be rewarded with a bonus to relinquish control of low-productivity assets.

More generally, the tension between truth-telling at the *interim* stage and the provision of *ex-ante* effort incentives has been previously analyzed in Levitt and Snyder (1997). The authors consider a model that is very similar to ours in that the agent must first exert effort, then he receives private information, and then the principal must decide whether to continue the project. In their model, the agent must be rewarded for giving an “early warning” when his information is unfavorable. Apart from having a different focus, what is novel in our model is the question of optimal contract design with a continuum of outcomes, leading to new insights regarding the optimality of non-linear compensation schemes. Moreover, we consider extensions in which the agent can falsify the outcome and in which the principal (here: the board) is better informed than the agent. Also, our model contains several novel comparative statics results.

In an extension of our model, we consider a simple variant of the costly state falsification model by Lacker and Weinberg (1989). While our falsification problem is a special case of theirs, our argument why in a costly state falsification setting (piecewise) linear schemes may be optimal is new and complementary to their argument, which is based on risk sharing. In our model, piecewise linear schemes are optimal because, next to ensuring that no falsification occurs in equilibrium, they shift as much as possible of the CEO’s pay into high cash-flow states, allowing the firm to implement a given level of CEO turnover with minimal informational rents.

The rest of this paper is organized as follows. Section 2 introduces the model. Section 3 characterizes the optimal contract implementing a given level of CEO turnover at least cost. Section 4 shows that under the optimal contract, CEO turnover, on-the-job pay, and severance pay are all positively related, while Section 5 makes use of this equilibrium relationship to provide further comparative statics results. Section 6 considers renegotiations (“golden handshakes”). In Section 7, we depart from our basic model by assuming that the (“strong”) board, not the CEO, has private information. Section 8 concludes. All proofs are in the Appendix.

## 2 Model

### Information-Based Entrenchment

In  $t = 0$ , the board hires a CEO to run the firm. While the CEO is the best available candidate at the time, there is uncertainty as to whether he is a good match for the firm. In  $t = 1$ , the CEO privately observes a signal indicating the quality of the match.<sup>4</sup> The board, on the other hand, does not observe this signal. Hence, the CEO can always avoid replacement by simply withholding unfavorable information from the board. The firm’s cash flow is realized in  $t = 2$ . Everybody is risk neutral.

The CEO’s ability to avoid replacement by withholding unfavorable information is an admittedly parsimonious way to model CEO entrenchment. One could think of a richer strategy space, e.g., one in which the CEO, after observing a private signal, can entrench himself by undertaking an irreversible action that makes it prohibitively costly for the

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<sup>4</sup>Hermalin and Weisbach (1998, p.100) also argue that what matters for the board’s replacement decision is the quality of the *match* between the CEO and the firm, not the CEO’s “ability” per se.



board to replace him, as in, e.g., Shleifer and Vishny (1989) and other models.<sup>5</sup>

### Technology and Beliefs

Let  $\theta \in \Theta := [\underline{\theta}, \bar{\theta}]$  denote the CEO's private signal and let  $s \in S := [\underline{s}, \bar{s}]$  denote the firm's cash flow under the CEO's leadership, where  $\underline{s} \geq 0$ . Each signal gives rise to a conditional distribution function over cash flows,  $G_\theta(s)$ , with associated density  $g_\theta(s)$ , where  $G_\theta(s)$  is continuously differentiable in both  $s$  and  $\theta$ . We assume that the signal is informative in the sense of the Monotone Likelihood Ratio Property (MLRP), implying  $g_{\theta''}(s)/g_{\theta'}(s)$  is strictly increasing in  $s$  for all  $\theta'' > \theta' > \underline{\theta}$ . Accordingly, the conditional expected cash flow  $E[s \mid \theta] := \int_S s g_\theta(s) ds$  is continuous and strictly increasing in  $\theta$ .

Realistically, whether the firm's cash flow under the CEO's leadership will be high depends not only on the quality of the match, but also on how dedicated the CEO is to his job. We consider the following simple effort problem. If the CEO puts in high effort, the signal  $\theta$  is distributed according to  $F(\theta)$  with associated density  $f(\theta) > 0$  for all  $\theta$ . Putting in high effort is costly, as it implies that the CEO must forgo private benefits  $B > 0$ . High effort is, however, essential to make the CEO's continued leadership valuable for the firm. If the CEO puts in low effort, we assume that the signal is  $\theta = \underline{\theta}$ . Denote by  $V > 0$  the firm's expected cash flow under a potential replacement CEO.<sup>6</sup> We assume that

$$\int_{\underline{\theta}}^{\bar{\theta}} E[s \mid \theta] f(\theta) d\theta - B > V > E[s \mid \underline{\theta}] = \underline{s}. \quad (1)$$

The second inequality implies that it is efficient to replace the CEO if the lowest signal  $\underline{\theta}$  is realized.<sup>7</sup> Note that, in particular, this implies that the CEO should be replaced if he exerts low effort. As we will argue below, the first inequality ensures that eliciting high effort is optimal.<sup>8</sup> Since the first inequality also implies that  $E[s \mid \bar{\theta}] > V$ , it follows from strict monotonicity and continuity of  $E[s \mid \theta]$  that there exists a unique interior cutoff

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<sup>5</sup>See, e.g., Bagwell and Zechner (1993), Edlin and Stiglitz (1995), and Fulghieri and Hodrick (2006).

<sup>6</sup>There is no need to make distributional assumptions about  $V$ . What matters is only the firm's *expected* cash flow under a potential replacement CEO. Note also that  $V$  is independent of  $\theta$ : The signal  $\theta$  is match-specific in the sense that it only indicates whether the incumbent CEO is a good match for the firm, but it contains no information as to how good a match a potential replacement CEO might be.

<sup>7</sup>In addition, that the entire probability mass is on the lowest cash flow  $\underline{s}$  in case  $\underline{\theta}$  is realized ensures that the shape of the optimal contract is driven by the problem of "information-based entrenchment," and not by a "standard" effort problem.

<sup>8</sup>This condition is admittedly stronger than needed as it only evaluates firm profits for the case where the CEO is never replaced. Making this stronger assumption allows us, however, to avoid further case distinctions in what follows.

signal  $\theta_{FB} \in (\underline{\theta}, \bar{\theta})$  given by  $E[s \mid \theta_{FB}] = V$  such that it is first-best optimal to replace the CEO if and only if  $\theta < \theta_{FB}$ .

### CEO Replacement Policy and Compensation Package

We will show later that we can restrict consideration to simple mechanisms that specify a single on-the-job pay scheme  $w(s)$  if the CEO is retained and a fixed severance pay  $W$  if the CEO is replaced.<sup>9</sup> (There we will also discuss our restriction to deterministic mechanisms.) Denote by  $\Theta_- \subset \Theta$  the set of signals for which the CEO is replaced and by  $\Theta_+ := \Theta \setminus \Theta_-$  the set of signals for which the CEO is retained. By incentive compatibility, we have that  $E[w(s) \mid \theta] \geq W$  for all  $\theta \in \Theta_+$  and  $E[w(s) \mid \theta] \leq W$  for all  $\theta \in \Theta_-$ .

We finally impose two constraints on the CEO's on-the-job pay scheme. The first constraint is that  $w(s) \leq s$ , i.e., the CEO's on-the-job pay cannot exceed the firm's cash flow. The second constraint is that  $w(s)$  must be nondecreasing. While this second constraint simplifies the analysis, it does not bind at the optimal solution.

## 3 Analysis

### 3.1 Preliminary Analysis

Before setting up the firm's maximization problem, it is useful to make some observations that allow us to shorten the subsequent analysis. Our specification of the effort problem ensures that, by itself, the effort problem is not a source of rent for the CEO. This is because low effort results in the lowest cash flow  $\underline{s}$  if the CEO is retained. If the CEO was always retained, the firm could thus induce him to exert high effort by paying him a wage equal to his effort cost  $B$  for all cash-flows  $s > \underline{s}$  (and a zero wage if  $s = \underline{s}$ ). This would leave the CEO with zero rent. Hence, by always retaining the CEO and inducing high effort, the firm can attain a payoff of

$$\int_{\underline{\theta}}^{\bar{\theta}} E[s \mid \theta] f(\theta) d\theta - B. \quad (2)$$

As (2) strictly exceeds  $V$  by condition (1), and as (2) constitutes a lower boundary of the firm's payoff from inducing high effort (always retaining the CEO may not be optimal), this implies that it is always optimal for the firm to induce high effort. To realize a payoff

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<sup>9</sup>That is, (non-degenerate) menus that condition  $w(s, \hat{\theta})$  and  $W(\hat{\theta})$  on the (truthfully) revealed signal  $\hat{\theta} = \theta$  are not optimal in our model.

that is higher than (2), however, the firm must make use of the CEO's private information about his "match value". For the time being, we assume that it is profitable for the firm to elicit the CEO's private information. Hence, we assume that both  $\Theta_+$  and  $\Theta_-$  have positive mass. We will subsequently (in Section 4) provide sufficient conditions under which this is indeed the case.

Note next that the CEO's conditional expected on-the-job pay  $E[w(s) \mid \theta]$  cannot be independent of  $\theta$ . In this case it would have to be equal to his severance pay  $W$  to ensure that both  $\Theta_+$  and  $\Theta_-$  are non-empty. But then the CEO would strictly prefer to exert low effort. Recall next that  $w(s)$  is nondecreasing and that  $G_\theta(s)$  has full support for all  $\theta > \underline{\theta}$ . From First-Order Stochastic Dominance (FOSD), which is implied by MLRP, and continuity of  $G_\theta(s)$ , it then follows that the CEO's conditional expected on-the-job pay  $E[w(s) \mid \theta]$  must be continuous and strictly increasing in  $\theta$ . Together with the assumption that  $\Theta_+$  and  $\Theta_-$  have positive mass, this implies that there exists a unique cutoff signal  $\theta^* \in (\underline{\theta}, \bar{\theta})$  satisfying

$$E[w(s) \mid \theta^*] = W. \quad (3)$$

Hence, by incentive compatibility, we have that  $\Theta_+ = [\theta^*, \bar{\theta}]$  and  $\Theta_- = [\underline{\theta}, \theta^*)$ .<sup>10</sup> For a given compensation scheme  $(W, w(s))$ , condition (3) will thus govern the firm's entrenchment problem.

If the CEO exerts low effort, his payoff will be  $W + B$ , given that low effort results in  $\theta = \underline{\theta} < \theta^*$  and thus in the CEO's replacement. By contrast, if the CEO exerts high effort, he will only be replaced with probability  $F(\theta^*)$ . Consequently, exerting high effort is optimal if

$$\int_{\theta^*}^{\bar{\theta}} E[w(s) \mid \theta] f(\theta) d\theta + F(\theta^*)W \geq W + B. \quad (4)$$

The board's problem is thus to design a compensation scheme  $(W, w(s))$  that maximizes the firm's residual payoff

$$\omega := F(\theta^*)(V - W) + \int_{\theta^*}^{\bar{\theta}} E[s - w(s) \mid \theta] f(\theta) d\theta, \quad (5)$$

subject to the truth-telling constraint (3) and the incentive constraint (4).

It is straightforward to show that, by optimality, the incentive constraint (4) must be binding. Inserting the binding IC constraint into (5), the board's objective function

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<sup>10</sup> Given that  $\theta = \theta^*$  is a zero-probability event, it is inconsequential how we break the CEO's indifference in this case.

becomes

$$\omega = \int_{\theta^*}^{\bar{\theta}} E[s | \theta] f(\theta) d\theta + F(\theta^*)V - B - W. \quad (6)$$

Equation (6) entails two insights. First, as the residual claimant to all cash flows, the firm's payoff is highest if the replacement decision (i.e., the choice of  $\theta^*$ ) is made efficiently. In fact, if the information captured by  $\theta$  about the match value between the firm and the current CEO was verifiable, the optimal replacement policy would specify  $\theta^* = \theta_{FB}$ . The second insight from (6) is that the expected compensation that the firm must pay the CEO is equal to  $W + B$ , implying that the CEO earns an (informational) rent of  $W$ . This is intuitive as the CEO could earn  $W$  also when he shirks (in which case he is subsequently replaced).

We conclude the preliminary analysis with an observation regarding the CEO's incentive constraint (4). After rewriting (4), we obtain the requirement that

$$\int_{\theta^*}^{\bar{\theta}} E[w(s) | \theta] \frac{f(\theta)}{1 - F(\theta^*)} d\theta - W \geq \frac{B}{1 - F(\theta^*)}. \quad (7)$$

Hence, to induce the CEO to exert high effort, his expected on-the-job pay (conditional on  $\theta \geq \theta^*$ ) must exceed his severance pay by a sufficient margin. This required wedge between the CEO's on-the-job pay and his severance pay will be the (endogenous) source for the CEO's entrenchment in our model, as it biases him towards continuing.<sup>11</sup>

### 3.2 Optimal Contract Design

According to the firm's objective function (6), which we obtained after substituting the CEO's binding incentive constraint, the board has two objectives when designing the optimal compensation scheme. First, it wants to make the replacement decision, as captured by the cutoff signal  $\theta^*$ , as efficient as possible. Second, it wants to minimize the CEO's severance pay, as it constitutes a source of rent for the CEO. What makes the board's problem non-trivial is that these two objectives are in conflict. In fact, without severance pay, and thus without paying the CEO a rent, there would never be any CEO replacement.<sup>12</sup> This follows immediately from the reformulated incentive constraint (7), which

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<sup>11</sup>The required wedge between the CEO's on-the-job pay and his payoff when leaving the firm is reminiscent of efficiency-wage models (e.g., Shapiro and Stiglitz, 1984; Yellen, 1994). As will become clear in what follows, our main results rely only on the fact that such a wedge must exist, but not on the particular reason for why it must exist.

<sup>12</sup>Given that  $E[s | \underline{\theta}] = \underline{s}$  this holds, more precisely, for all  $\theta > \underline{\theta}$ .

showed that the CEO is biased towards continuing (“entrenchment”). Severance pay is thus necessary to “bribe” the CEO towards leaving in case of a low match value. As this is costly, the firm wants to keep  $W$  as low as possible. This is achieved by the optimal design of the CEO’s on-the-job pay.<sup>13</sup>

**Proposition 1** *Suppose the firm wants to ensure that the CEO is replaced whenever  $\theta \leq \theta^*$ , where  $\underline{\theta} < \theta^* < \bar{\theta}$ . Then the uniquely optimal compensation package consists of severance pay  $W > 0$  and an on-the-job pay scheme  $w(s)$  satisfying  $w(s) = 0$  for  $s < \hat{s}$  and  $w(s) = s$  if  $s \geq \hat{s}$ , where  $\hat{s} \in (\underline{s}, \bar{s})$ .*

The uniquely optimal on-the-job pay scheme is a high-powered, discontinuous bonus scheme that shifts all of the CEO’s on-the-job pay into the highest cash-flow states. The intuition is as follows. As low cash flows are relatively more likely after low values of  $\theta$  (due to the fact that  $G_\theta(s)$  satisfies MLRP), a bonus scheme of the sort described in Proposition 1 minimizes the CEO’s conditional expected on-the-job pay  $E[w(s) | \theta]$  at low values of  $\theta$ . Since the cutoff signal  $\theta^*$  is determined by  $E[w(s) | \theta^*] = W$ , this in turn implies that relatively less severance pay is needed to implement a given cutoff signal  $\theta^*$ . In other words, a high-powered bonus scheme of the sort described in Proposition 1 minimizes the informational rent that must be granted to the CEO to achieve a given level of CEO replacement.

While the optimality of high-powered incentive schemes is not novel to the literature, our argument is different from previous models. In particular, it is different from models of moral hazard, such as Innes (1990). To see this, note first that while in our model the CEO must also be induced to exert effort, the incentive constraint (4) has no direct implication for the optimal functional form of  $w(s)$ , but only for the *expected value* of  $w(s)$ . (See also condition (7), which rephrases the incentive constraint in terms of a wedge between the CEO’s expected on-the-job pay and his severance pay.)<sup>14</sup> From this it follows that the optimal functional form of  $w(s)$  in Proposition 1 is not driven by the problem of motivating the CEO to work hard, but rather by the problem of inducing him to reveal his

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<sup>13</sup>For Proposition 1, we suppose that it is indeed feasible to implement the particular cutoff signal  $\theta^*$ . Both the question of feasibility and that of optimality of implementing a particular cutoff  $\theta^*$  will be addressed below.

<sup>14</sup>In fact, if the signal  $\theta$  was contractible, there would be many optimal contracts that solve the remaining effort problem, e.g., a contract paying a fixed wage of  $w = B/[1 - F(\theta_{FB})]$  if the CEO is retained and no severance pay.

private information at least cost to the firm (in terms of necessary severance pay). This is achieved by making the CEO’s conditional expected on-the-job pay  $E[w(s) | \theta]$  as steep as possible. By MLRP, this is in turn achieved by shifting the CEO’s on-the-job pay as much as possible into high cash-flow states.

While our argument is different from previous models, what it shares with some existing models is that it relies on MLRP (or related assumptions on the distribution of cash flows). In Innes (1990), for example, in order to reduce agency costs, the principal wants to maximize the expected payoff differential between low and high effort, which by MLRP is achieved by paying the agent only in high cash-flow states. A similar logic also applies to problems with *ex-ante* private information (in contrast to our case with *interim* private information). For example, Nachman and Noe (1994) show that a high-value firm prefers the pooling (financing) contract that allows the firm to retain cash flows for high realizations rather than low realizations. By maximizing the expected cash-flow differential between the high- and low-value firm, this reduces the differential for the investor’s stake, thereby minimizing the high-value firm’s underpricing problem.

Before we proceed, Proposition 1 requires a final comment. The obtained “live-or-die” contract with  $w(s) = 0$  for  $s < \hat{s}$  and  $w(s) = s$  for  $s \geq \hat{s}$  is optimal under the restriction that the CEO’s on-the-job pay cannot exceed the firm’s cash flow:  $w(s) \leq s$ . (Otherwise, any additional cash flow could be used to make the pay scheme even more high-powered.) This same restriction also limits the range of  $\theta^*$  values that can be implemented. To see this, note that as  $\theta^*$  approaches  $\bar{\theta}$ , the likelihood that the CEO will be retained approaches zero. To satisfy his incentive constraint (4), for any given  $\theta > \theta^*$ , the CEO’s expected “reward” if he is retained,  $E[w(s) | \theta] - W > 0$ , would then have to go to infinity, which is not feasible.<sup>15</sup> In what follows, the restriction on the range of feasible  $\theta^*$  values that this observation implies will, however, not be binding once we solve for the firm’s *optimal* choice of  $\theta^*$  (see also the discussion in Section 4, where this is made more precise).<sup>16</sup>

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<sup>15</sup>Formally, this follows immediately from rewriting (4) as  $\int_{\theta^*}^{\bar{\theta}} [E[w(s) | \theta] - W] f(\theta) d\theta \geq B$ .

<sup>16</sup>A similar comment also applies if the CEO is replaced. While imposing the requirement that  $W \leq V$  again limits the range of feasible  $W$  values (and thus on  $\theta^*$  values according to Proposition 5 below), by optimality for the firm, this restriction will not be binding in equilibrium.

### 3.3 Costly State Falsification

As the previous analysis has shown, the cheapest (i.e., information-rent minimizing) way to implement a given cutoff signal  $\theta^*$  is to shift all of the CEO's on-the-job pay into the highest cash-flow states. The resulting discontinuous bonus scheme entails problems of its own, however. For instance, if the firm's cash flow increases only slightly from  $\hat{s} - \varepsilon$  to  $\hat{s}$ , the CEO's pay "jumps" from  $w(s) = 0$  to  $w(s) = \hat{s}$ . To the extent that the CEO can manipulate the firm's cash flow, he will have strong incentives to do so.

We consider a simple variant of the "costly state falsification" (CSF) setting by Lacker and Weinberg (1989).<sup>17</sup> We assume the CEO can falsify the firm's cash flow at private cost  $h(\Delta)$ , where  $\Delta = |s' - s|$ , and where  $s'$  and  $s$  denote the falsified and true cash flow, respectively. The cost function  $h(\Delta)$  is assumed to be continuously differentiable, nondecreasing, and convex with  $h(0) = 0$  and  $h'(0) = \gamma > 0$ . For a given on-the-job pay scheme  $w(s)$ , the utility realized by the CEO is then  $U(s) := \max_{s'} [w(s') - h(|s' - s|)]$ .

While falsifying cash flows entails private costs for the CEO, the costs to the firm may be much larger. Such costs could arise from law suits or loss of reputation, in particular vis-à-vis providers of capital. If these costs are sufficiently large, the firm will optimally want to ensure that cash flows are never falsified in equilibrium. This imposes the additional restriction that  $w(s)$  must be everywhere continuous with  $w(s) \geq w(s + \Delta) - h(\Delta)$  for all  $\Delta \geq 0$ . At points where  $w(s)$  is differentiable, this implies that the slope of  $w(s)$  cannot exceed  $\gamma$ .<sup>18</sup>

**Proposition 2** *Suppose the firm wants to ensure that the CEO does not falsify cash flows, which he could do at private costs  $h(\Delta)$  with  $h'(0) = \gamma$ . Then the uniquely optimal compensation package consists of severance pay  $W > 0$  and an on-the-job pay scheme  $w(s)$  satisfying  $w(s) = 0$  if  $s < \hat{s}$  and  $w(s) = \gamma(s - \hat{s})$  if  $s \geq \hat{s}$ , where  $\hat{s} \in (\underline{s}, \bar{s})$ .*

Intuitively, Proposition 2 follows immediately from our previous results (in particular, Proposition 1) after incorporating the additional "no-falsification constraint". Given this constraint, the optimal contract shifts again as much as possible of the CEO's on-the-job pay into the highest cash-flow states. The resulting contract has the "hockey-stick" shape

<sup>17</sup>See also Dye (1988), Maggi and Rodríguez-Clare (1995), and Crocker and Morgan (1998).

<sup>18</sup>Clearly, Proposition 2 presumes that the board wants to implement some cutoff  $\theta^* > \underline{\theta}$  (instead of retaining the CEO for all realizations of  $\theta$ ). It is also presumed that a contract that allows to incentivize the CEO exists, which, as is shown in Section 4, is always the case if  $\gamma$  is not too small.

of a standard call option: The CEO obtains zero if the cash flow falls below some hurdle  $\widehat{s}$  and a share  $\gamma$  of the incremental cash flow  $s - \widehat{s}$  if the cash flow is above  $\widehat{s}$ .

Even if there are no *direct* costs to the firm (e.g., reputational costs), cash-flow falsification entails *indirect* costs. As the firm is the residual claimant, cash-flow falsification reduces the firm's *ex-ante* payoff even if the falsification costs are *ex post* borne by the CEO. Precisely, because the IC constraint binds, the falsification costs must be ultimately borne by the firm. We will now show that for the special case where the marginal falsification costs are constant with  $h'(\Delta) = \gamma$  for all  $\Delta \geq 0$ , there will be again no falsification in equilibrium.

The argument is as follows. With constant marginal falsification costs, it is possible to replace any on-the-job pay scheme  $w(s)$  that induces falsification with a scheme  $\tilde{w}(s) \equiv U(s)$  that gives the CEO the exact same utility for all  $s$  and under which the CEO does not falsify. (The scheme  $\tilde{w}(s)$  is “falsification-proof”.) That the CEO's utility is the same under  $w(s)$  and  $\tilde{w}(s)$  implies that i) if the IC constraint binds under  $w(s)$ , then it must also bind under  $\tilde{w}(s)$ , and ii)  $w(s)$  and  $\tilde{w}(s)$  both implement the same cutoff  $\theta^*$ . However, the firm's residual payoff (after inserting the binding IC constraint) is strictly higher under  $\tilde{w}(s)$  than under  $w(s)$ ; the difference is the expected falsification cost  $\int_{\theta^*}^{\bar{\theta}} E[w(s) - U(s) \mid \theta] f(\theta) d\theta$  that the firm must bear under  $w(s)$  but not under  $\tilde{w}(s)$ . It is thus uniquely optimal to make the contract falsification-proof, which in turn implies that the uniquely optimal contract is characterized by Proposition 2.

To complete the argument, it remains to prove that the CEO does not falsify under  $\tilde{w}(s)$ , so that his utility is indeed  $\tilde{w}(s) = U(s)$  for all  $s$ . The CEO does not falsify under  $\tilde{w}(s)$  if for all  $s$  and  $s''$  it holds that  $\tilde{w}(s) \geq \tilde{w}(s'') - h(|s'' - s|)$ . Substituting  $\tilde{w}(s) = U(s)$  and using the definition of  $U(s)$  from above, this transforms to

$$\max_{s'} [w(s') - h(|s' - s|)] \geq \max_{s'} [w(s') - h(|s' - s''|)] - h(|s'' - s|),$$

which is satisfied if for all  $s'$  it holds that

$$h(|s' - s|) \leq h(|s' - s''|) + h(|s'' - s|). \quad (8)$$

Condition (8) is surely satisfied for  $h(\Delta) = \gamma\Delta$ .

For other specifications of  $h(\Delta)$ , it may be optimal to allow falsification in equilibrium. To see this most clearly, note that in case of differentiability we have  $U'(s) = h'(|\tilde{s}(s) - s|)$ ,



where  $\tilde{s}(s)$  is the (possibly falsified) cash flow chosen by a CEO of “type”  $s$ . If  $h(\Delta)$  is strictly convex, then by allowing falsification in equilibrium (i.e.,  $\tilde{s}(s) > s$ ), the CEO’s utility  $U(s)$  can be made “steeper”. As this also implies that his expected payoff  $E[U(s) \mid \theta]$  becomes steeper, it follows from our previous argument that the board can implement a given cutoff  $\theta^*$  with lower severance pay and thus lower rents for the CEO. Whether these cost savings outweigh the expected falsification costs, which are ultimately borne by the firm as the residual claimant, depends on the underlying distribution functions  $G_\theta(s)$  and  $F(\theta)$ .

The ambiguity as to whether allowing falsification is optimal is in accord with the existing literature. Lacker and Weinberg (1989, Section V) derive sufficient conditions under which the optimal contract allows no falsification in equilibrium. Generally, this is the case when the marginal falsification costs increase sufficiently “slowly”, a special case of which is the technology with constant marginal falsification costs analyzed above. Interestingly, Lacker and Weinberg (1989, p. 1361) note that “the introduction of a binding falsification problem “linearizes” the optimal principal-agent contract for quite general utility functions, probability distributions, and falsification cost functions”. They construct examples in which the optimal contract is either a linear or a piecewise linear “option-like” contract, like that in Proposition 2. The difference between their argument and ours is the reason for why the optimal contract is (piecewise) linear. While Lacker and Weinberg consider a risk-sharing problem, in our model the objective is to implement a given replacement policy (i.e., a given  $\theta^*$ ) at least cost to the firm. That said, it is quite possible that in our model the linearity result would be overturned when introducing either risk aversion or embedding the problem into a dynamic setting.

Several authors have noted that the optimality of “no falsification” in Lacker and Weinberg (1989) hinges on the assumption that the marginal falsification cost at zero is positive.<sup>19</sup> Clearly, if  $h'(0) = 0$ , the only falsification-proof contract would be a contract in which  $w(s)$  is completely “flat”, which would not allow to incentivize the CEO. Whether the assumption that  $h'(0)$  is bounded away from zero is plausible depends on the context. In the present context, given that legal ramifications can arise from *any* cash-flow falsification, no matter how small, we believe this assumption is plausible.

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<sup>19</sup>See, for instance, Dye (1988, p. 200), Maggi and Rodríguez-Clare (1995, footnote 6), and Crocker and Morgan (1998, p. 367).

The optimal (falsification-proof) contract from Proposition 2 is characterized by an additional parameter,  $\gamma$ , representing the marginal falsification cost at  $\Delta = 0$ . The marginal cost of falsifying cash flows may depend on the quality of the firm’s accounting system. If it is easy for the CEO to falsify cash flows, meaning  $\gamma$  is low, then the quality of the firm’s accounting system is poor, and vice versa.

**Proposition 3** *Consider the falsification-proof contract from Proposition 2. As the marginal cost  $\gamma$  of falsifying cash flows increases, e.g., because of an improvement in the quality of the firm’s accounting system, the CEO’s optimal on-the-job pay scheme becomes “steeper”. As a result, the same replacement policy, namely for all  $\theta \leq \theta^*$ , can be accomplished with lower severance pay and thus lower informational rents for the CEO.*

### 3.4 Alternative Mechanisms

Thus far we have restricted consideration to simple mechanisms that specify a single on-the-job pay scheme  $w(s)$  and fixed severance pay  $W$ . We will now show that, as long as we restrict consideration to deterministic mechanisms, such simple mechanisms are indeed uniquely optimal in our model. Note first that by incentive compatibility, the CEO must obtain the same severance pay  $W(\theta) = W$  for all  $\theta \in \Theta_-$ . On the other hand, by standard arguments it is possible to device an incentive-compatible menu of on-the-job pay schemes  $w(s, \theta)$  such that the CEO prefers different pay schemes from the menu for different  $\theta \in \Theta_+$ . This is, however, strictly suboptimal.<sup>20</sup>

The intuition is straightforward. By construction, the “single” optimal on-the-job pay scheme from Proposition 1 (or, likewise, Proposition 2) minimizes the CEO’s expected on-the-job pay at low signals. If the CEO was offered a richer menu  $w(s, \theta)$ , he would for each  $\theta \in \Theta_+$  choose the respective contract from the menu that yields him the highest payoff. Relative to the “single” optimal on-the-job pay scheme, any richer menu must thus necessarily shift some of the CEO’s expected on-the-job pay “back” into low-signal states. By our previous arguments, this implies a lower cutoff  $\theta^*$  for a given level of severance pay  $W$  or, equivalently, it requires a higher severance pay to implement the same cutoff.

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<sup>20</sup>That there are no direct benefits to the firm from offering a menu follows immediately from the fact that the board’s action is binary, namely to either retain or replace the CEO. Hence, a finer partition of  $\Theta_-$  (or  $\Theta_+$  for that matter) is of no value here. See also Levitt and Snyder (1997), who consider a similar setting as we do (see Introduction), and who also obtain the result that both the contract under continuation and the payoff to the agent under cancellation are optimally made independent of the agent’s *interim* message (see Proposition 7 on p. 651 and especially Step 2 of the corresponding proof on p. 659).

**Proposition 4** *It is strictly suboptimal to make either the CEO's on-the-job pay or his severance pay contingent on his reported signal.*

Throughout the analysis, we have restricted consideration to deterministic mechanisms. If we allow for stochastic mechanisms, the firm can offer an incentive compatible menu  $\{w(s, \theta), W(\theta), p(\theta)\}$ , where  $p(\theta)$  denotes the probability with which the CEO is retained. When revealing his “type”  $\theta$ , the CEO thus receives the on-the-job pay scheme  $w(\cdot, \theta)$  with probability  $p(\theta)$  and severance pay  $W(\theta)$  with probability  $1 - p(\theta)$ . In what follows, we restrict ourselves to a short, informal discussion of the possible advantages of such stochastic mechanisms, given that we cannot obtain a general characterization.

Suppose the mechanism specified some (possibly different)  $p(\theta) < 1$  for all  $\theta < \theta_{FB}$ . In this case, the resulting *expected* inefficiency from (sometimes) retaining the CEO for all  $\theta \in [\theta^*, \theta_{FB})$  would clearly be strictly lower than if always  $p(\theta) = 1$  for these  $\theta$ . On the other hand, as the CEO's expected reward from non-shirking would then also be lower, the mechanism would have to adjust such that  $\theta^*$  decreases, which works in the opposite direction and reduces efficiency.<sup>21</sup>

In addition, a stochastic mechanism can allow to elicit effort at *zero* costs (in terms of rent for the CEO), while still ensuring truthful revelation of  $\theta$ . We illustrate this in the rest of this Section.

For this we assume for simplicity that  $\underline{s} = 0$  and specify two contracts:  $w_1(s) = \beta s$  and  $w_2(s)$  with  $w_2(s) = 0$  for  $s < \hat{s}$  and  $w_2(s) = \gamma(s - \hat{s})$  for  $s \geq \hat{s}$ . The mechanism prescribes  $W(\theta) = 0$  as well as, first, for  $\theta \geq \theta_{FB}$  that  $p(\theta) = 1$  and  $w(s, \theta) = w_2(s)$  and, second, for  $\theta < \theta_{FB}$  that  $p(\theta) = p < 1$  as well as  $w(s, \theta) = w_1(s)$ . It is immediate to show that if  $\theta = \theta_{FB}$  is indifferent between  $(p(\theta) = 1, w_2)$  and  $(p, w_1)$ , then all other types strictly prefer the contract that the mechanism prescribes. As long as  $\beta \leq \gamma$  the contract is also falsification-proof, while an adequate choice of  $\beta$  and  $\hat{s}$  ensures that effort is elicited. Note, in particular, that the CEO now only receives  $B$  from shirking and thus zero rent. The remaining inefficiency is furthermore only captured by  $p > 0$ .

In Levitt and Snyder (1997), who consider a similar problem (cf. the Introduction), such a stochastic mechanism is shown to implement the first best (in the limit) provided that, as is assumed in their model, the principal has unlimited liability and there is no

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<sup>21</sup>The optimal  $p(\theta)$  for types  $\theta^* \leq \theta \leq \theta_{FB}$  should depend on local characteristics (e.g., of the distribution function).

problem of falsification. This can also be seen in our illustrative mechanism once we allow for  $p \rightarrow 0$  next to specifying now  $\tilde{w}_1(s) = w_1(s) + d$  for  $s > \underline{s}$ , while leaving  $\tilde{w}_1(\underline{s}) = 0$ , and letting in turn  $d \rightarrow \infty$ . The constraint  $w(s) \leq s$  as well as that of falsification proofness put, however, a limit on the efficiency of such a stochastic mechanism. Generally, we can not say how the (remaining) inefficiency from  $p > 0$  compares to the rent saved with  $W = 0$ .

## 4 Optimal CEO Entrenchment

The remainder of our analysis is based on the contract that is optimal if the firm wants to prevent the CEO from falsifying cash flows (see Proposition 2). Thus far we have focused on the least-cost way to implement a *given* level of CEO replacement, as captured by the cutoff  $\theta^*$  below which the CEO will be replaced. In what follows, we examine what it takes to *change* the firm's level of CEO replacement.

**Proposition 5** *To induce a higher level of CEO replacement (higher  $\theta^*$ ), it is necessary to increase the CEO's severance pay (higher  $W$ ). To prevent the CEO from shirking, the board must, along with increasing his severance pay, simultaneously also increase the CEO's on-the-job pay (lower  $\hat{s}$ ).*

If the board increases the CEO's severance pay, then it must also increase his on-the-job pay. This is necessary to preserve the wedge between the expected on-the-job pay and the severance pay that is required to satisfy the CEO's incentive constraint (4). While an increase in  $W$  makes it more attractive for the CEO to leave, the simultaneous increase in his on-the-job pay has the opposite effect, making it more attractive for the CEO to stay. Under the optimal compensation scheme the first effect outweighs the second, implying that an increase in  $W$  indeed pushes  $\theta^*$  upward.

The intuition is as follows. Under the optimal compensation scheme, the increase in on-the-job pay that is necessary to match the increase in  $W$  occurs at relatively high cash flows. By MLRP, this implies that the CEO's expected on-the-job pay  $E[w(s) | \theta]$  increases mainly at high signals. On the other hand,  $E[w(s) | \theta]$  increases only little at low signals. Hence, while "on average"  $E[w(s) | \theta]$  increases along with  $W$  as required by (4), it increases by more than  $W$  at high signals and by less than  $W$  at low signals. At

low signals, the difference  $E[w(s) | \theta] - W$  thus *decreases*, implying that an increase in  $W$  pushes  $\theta^*$  upward and thus closer towards  $\theta_{FB}$ .

By Proposition 5, a higher level of CEO replacement (higher  $\theta^*$ ) is accompanied both by higher on-the-job pay and higher severance pay, implying a higher informational rent for the CEO. In equilibrium, the board chooses the level of CEO replacement that is *ex-ante* optimal for the firm. Differentiating the firm's expected payoff  $\omega$  in (6) with respect to  $W$ , we obtain

$$\frac{d\omega}{dW} = -\frac{d\theta^*}{dW} f(\theta^*) [E[s | \theta^*] - V] - 1, \quad (9)$$

where  $d\theta^*/dW > 0$  from Proposition 5. (See the Proof of Proposition 5 for an explicit characterization.)

For our subsequent comparative statics analysis, we will assume that the problem of maximizing  $\omega$  is strictly quasiconcave and gives rise to an optimal level of  $W$  that induces CEO replacement with positive probability:  $\theta^* > \underline{\theta}$ . A sufficient condition for  $\theta^*$  to have an interior solution is that, when starting at  $\theta^* = \underline{\theta}$ , a marginal increase in  $\theta^*$  allows the firm to increase its payoff beyond the maximum payoff it can achieve by implementing  $\theta^* = \underline{\theta}$ . We now formalize this condition with the help of expression (9). For this, we first choose the parameters  $W$  and  $\hat{s}$  of the contract in Proposition 2 so that this contract implements  $\theta^* = \underline{\theta}$  at least cost. Setting  $W = 0$ , we obtain, together with  $E[w(s) | \underline{\theta}] = 0$  (from  $w(s) = 0$  for all  $s < \hat{s}$  and (1)), that  $\theta^* = \underline{\theta}$ . To satisfy the incentive constraint (4), the “kink”  $\hat{s} = \hat{s}_0$  must (after integrating by parts) satisfy<sup>22</sup>

$$\gamma \int_{\underline{\theta}}^{\bar{\theta}} \left( \int_{\hat{s}_0}^{\bar{s}} [1 - G_{\theta}(s)] ds \right) f(\theta) d\theta = B. \quad (10)$$

Note that a value  $\hat{s}_0 > \underline{s}$  satisfying (10) exists if

$$\gamma \int_{\underline{\theta}}^{\bar{\theta}} [E[s | \theta] - \underline{s}] f(\theta) d\theta > B, \quad (11)$$

which by (1) is clearly the case if  $\gamma$  is not too small.<sup>23</sup> (Otherwise, it is not feasible at all to induce the CEO to exert effort.) We obtain from total differentiating the CEO's

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<sup>22</sup>The contract with  $W = 0$  and  $\hat{s} = \hat{s}_0$  is an optimal contract implementing  $\theta^* = \underline{\theta}$ . Any feasible contract with  $w(\underline{s}) = 0 = W$  and under which the IC constraint binds is an optimal contract in this case. Under any such optimal contract, the firm's expected payoff from implementing  $\theta^* = \underline{\theta}$  is  $\int_{\underline{\theta}}^{\bar{\theta}} E[s | \theta] f(\theta) d\theta - B$ .

<sup>23</sup>For this we simply substitute  $\hat{s}_0 = \underline{s}$  into (10).

incentive constraint (4) and (the truth-telling) condition (3) that at  $\theta^* = \underline{\theta}$  the marginal costs of raising  $\theta^*$  equal

$$\left. \frac{dW}{d\theta^*} \right|_{\theta^*=\underline{\theta}} = \gamma \int_{\widehat{s}_0}^{\bar{s}} \left. \frac{\partial G_{\theta^*}(s)}{\partial \theta^*} \right|_{\theta^*=\underline{\theta}} ds, \quad (12)$$

while the marginal benefits equal  $f(\underline{\theta})(V - \underline{s}) > 0$ . Hence, a sufficient condition for  $\theta^* > \underline{\theta}$  to be optimal is that<sup>24</sup>

$$\left. \frac{dW}{d\theta^*} \right|_{\theta^*=\underline{\theta}} < f(\underline{\theta})(V - \underline{s}). \quad (13)$$

Depending on the size of  $\gamma$ , there are now two cases that need to be distinguished. In the first case, the uniquely optimal (by strict quasiconcavity) value of  $W$  satisfies the first-order condition  $d\omega/dW = 0$ . Note here that, after substituting  $d\theta^*/dW > 0$  from Proposition 5, we have from (9) that  $E[s | \theta^*] < V$ , implying that  $\theta^* < \theta_{FB}$ . Hence, there is always some equilibrium entrenchment under the optimal contract.

In the second case, it holds at the (constrained) optimal solution that  $d\omega/dW > 0$ . While the board would like to raise  $W$  further to increase the cutoff  $\theta^*$ , it cannot do so, because the on-the-job pay scheme already specifies  $\widehat{s} = \underline{s}$ , i.e., the board cannot further increase the CEO's on-the-job pay along with his severance pay as required by the binding incentive constraint (4).<sup>25</sup> From  $d\omega/dW > 0$  and the previous argument for the unconstrained case, we then have also presently that there is entrenchment in equilibrium:  $E[s | \theta^*] < V$ . To simplify the exposition of our comparative statics results below, we would like to rule out this (corner) case. Intuitively, this can be done if  $\gamma$  is not too small. More precisely, note first that the highest value of  $\theta^*$  that can be implemented through setting  $\widehat{s} = \underline{s}$  while satisfying the binding incentive constraint (4) is given by some  $\bar{\theta}^* < \bar{\theta}$  solving

$$\gamma \int_{\bar{\theta}^*}^{\bar{\theta}} [E[s | \theta] - E[s | \bar{\theta}^*]] f(\theta) d\theta = B.$$

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<sup>24</sup>In terms of model primitives, from (12) we have that condition (13) is surely satisfied if  $\partial G_{\theta}(s)/\partial \theta|_{\theta=\underline{\theta}} = 0$  for all  $s$ , implying that a marginal increase in  $\theta$  at  $\theta = \underline{\theta}$  has only a second-order effect on cash flows, in the sense that the cash flow is almost certain to remain  $E[s | \underline{\theta}] = \underline{s}$  for  $\theta$  sufficiently close to  $\underline{\theta}$ .

<sup>25</sup>Note that if  $\underline{s} > 0$ , the firm could always raise the CEO's on-the-job pay by stipulating  $w(\underline{s}) > 0$ . To satisfy (4), this would, however, require to increase  $W$  by the same amount and would, in contrast to a shift in  $\widehat{s}$ , not lead to a change in  $\theta^*$ .

That  $\bar{\theta}^* > \underline{\theta}$  follows from (11). In analogy to condition (13), we can now rule out the corner solution where  $\hat{s} = \underline{s}$  binds by requiring that

$$\left. \frac{dW}{d\theta^*} \right|_{\theta^* = \bar{\theta}^*} > f(\bar{\theta}^*)(V - \underline{s}), \quad (14)$$

where

$$\left. \frac{dW}{d\theta^*} \right|_{\theta^* = \bar{\theta}^*} = \gamma \int_{\underline{s}}^{\bar{s}} \left. \frac{\partial G_{\theta^*}(s)}{\partial \theta^*} \right|_{\theta^* = \bar{\theta}^*} ds$$

in analogy to (12). The following proposition summarizes the preceding discussion.

**Proposition 6** *Suppose that  $\gamma$  is not too small so that (11) is satisfied, which, together with condition (1), ensures that it is both feasible and optimal to induce the CEO to exert effort. Then a sufficient condition for the optimal cutoff  $\underline{\theta} < \theta^* < \bar{\theta}$  to be characterized by the first-order condition  $d\omega/dW = 0$  is that (13) and (14) jointly hold. Moreover, there will always be some entrenchment in equilibrium as the optimal cutoff satisfies  $\theta^* < \theta_{FB}$ .*

In what follows, we restrict consideration to the case where the sufficient conditions from Proposition 6 hold so that  $\theta^*$  is determined by the first-order condition  $d\omega/dW = 0$ . It is useful to emphasize once more that  $\theta^* < \theta_{FB}$ . The first-order effect on firm value from a marginal decrease in  $\theta^*$  at  $\theta^* = \theta_{FB}$  is zero, while the reduction in the CEO's informational rent constitutes a first-order cost saving. For all  $\theta \in [\theta^*, \theta_{FB})$ , the CEO thus remains in office even though it is *ex-post* inefficient, because the match value under his leadership is smaller than the firm value under a replacement CEO. Hence, even under the optimal contract there will always be some (information-based) entrenchment.

An immediate implication of the preceding analysis is that there would be more entrenchment, i.e., a larger “inefficiency” gap  $\theta_{FB} - \theta^*$ , if the firm faces a binding cap on how much severance pay it can give the CEO. Such a cap could result either from policy intervention or fear of bad publicity, especially if the company is publicly listed. In fact, both policy makers and the wider public have become increasingly sensitive to high severance packages, as they are often regarded as “rewards for failure”.<sup>26</sup> This is also the case

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<sup>26</sup>A prominent example is the lawsuit by Walt Disney shareholders against the company for awarding Michael Ovitiz severance pay worth \$130 million after being only 14 months with Disney. Public pressure against high severance packages is not limited to the United States. The United Kingdom, for instance, had a public inquiry about “rewards for failure” (DTI, 2003), and it has witnessed substantial shareholder activity against high severance packages. As a result, listing rules were amended in 2002 to require firms to publish their directors' remuneration reports, which must be approved by shareholders.

in our model, where a CEO who shirks can assure himself a payoff equal to his severance pay  $W$ . On the other hand, our model shows that introducing a binding cap on severance pay may come at a high cost: While it reduces the CEO's informational rent, it pushes the cutoff signal  $\theta^*$  downward, thereby leading to more entrenchment.<sup>27</sup>

## 5 Comparative Statics Analysis

In the following, we invoke conditions (13) and (14) to ensure that the optimally chosen cutoff signal  $\theta^*$  is always interior. Recall now that  $E[s | \theta_{FB}] = V$ : At the first-best cutoff  $\theta_{FB}$ , the expected firm value under the incumbent CEO is the same as under a potential replacement CEO. The first-best efficient cutoff  $\theta_{FB}$  is thus higher if  $V$  increases, implying a higher expected level of CEO replacement. Intuitively, the same should also hold under the firm's (second-best) optimal replacement policy, once we take into account that  $\theta$  is privately observed by the incumbent CEO. As is shown in Proposition 5, to push up the second-best cutoff signal  $\theta^*$ , it is necessary to increase both the CEO's severance pay and his on-the-job pay.

**Proposition 7** *Suppose that, from an ex-ante perspective, it becomes less likely that it is (first-best) efficient to retain the incumbent CEO, given that the expected match value with a replacement CEO increases (higher  $V$ ). Then also in (the second-best) equilibrium, there will be more CEO turnover, which is accompanied by an increase in both severance pay and on-the-job pay.*

Though an increase in  $V$  is associated with both higher (severance and on-the-job) pay and higher CEO turnover, the former does not represent compensation for the latter. The existence of such a (compensation) link between higher CEO turnover and higher pay was suggested by Hermalin (2005). In this case, the required additional pay would depend on the CEO's difficulty to find a new, equally well-paying job. In our model, the entrenched CEO has to be "induced" not to withhold information that allows the board to implement a more efficient replacement policy (i.e., a higher cutoff  $\theta^*$ ). The required additional pay, in the form of both higher severance pay and higher on-the-job

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<sup>27</sup>As  $W$  is set optimally from the firm's perspective, any policy intervention would reduce firm value. On the other hand, as  $W$  represents a pure transfer from the firm to the CEO, a social planner who is interested in total welfare should push for a higher  $W$  until  $\theta^* = \theta_{FB}$ .



pay, represents thus additional *rent* for the CEO, rather than compensation for higher disutility and risk. Formally, rearranging (9), we find at the optimally chosen cutoff  $\theta^*$  that

$$\frac{dW}{d\theta^*} = -[E[s | \theta^*] - V] \frac{f(\theta^*)}{F(\theta^*)},$$

capturing the additional pay that is necessary to induce (marginally) higher turnover. Instead of CEO-specific attributes (e.g., his disutility from losing his job), the increase in pay is thus related to firm-specific attributes, e.g., through the firm's efficiency loss  $E[s | \theta^*] - V < 0$ . This may open up a new avenue for explaining the raise in CEO pay witnessed over the past decades, which has gone hand-in-hand with an increase in CEO turnover (cf. Hermalin 2005).<sup>28</sup>

More generally, the positive relation between  $w(s)$  and  $W$  in Proposition 7 is consistent with a number of recent empirical studies. Rusticus (2006), Schwab and Thomas (2006), and Lefanowicz, Robinson, and Smith (2000) all show that CEOs' severance pay and golden parachutes are positively related to CEOs' on-the-job pay.

In the comparative statics analysis in Proposition 7, the first-best benchmark  $\theta_{FB}$  changed due to an increase in  $V$ , which then made it optimal to also change the second-best replacement policy, as captured by the cutoff  $\theta^*$ . However, even if  $\theta_{FB}$  remains unchanged, the firm may want to implement a more efficient replacement policy if the cost to the firm from having an entrenched CEO is larger. This might be the case, for example, in larger firms, given that more firm value may be lost if the CEO turns out to be a poor match. To formalize this hypothesis, we scale both the firm value under a potential replacement CEO,  $V$ , and the cash-flow realization under the incumbent CEO,  $s$ , by some factor  $\alpha > 0$ .

**Proposition 8** *An increase in firm size,  $\alpha$ , is associated with higher CEO turnover, higher severance pay, and higher on-the-job pay.*

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<sup>28</sup>Hall and Liebman (1998) document that the mean value of CEO stock option grants has increased almost sevenfold between 1980 and 1994. Similarly, Bebchuk and Grinstein (2005) find that the average CEO pay among S&P 500 firms has increased almost threefold between 1993 and 2003. As for severance pay, Walker (2005) points to a surge in (contractual) severance pay, while Lefanowicz, Robinson, and Smith (2000) find that both the usage and the magnitude of golden parachutes has increased during the 1980s and 90s. For alternative arguments for why CEO pay has increased over the past decades, see Almazan and Suarez (2003), Bebchuk and Fried (2004), Murphy and Zábojník (2004) or Dow and Raposo (2005).

Proposition 8 follows immediately from our previous results together with the fact that value destruction due to CEO entrenchment is, for a given  $\theta^* < \theta_{FB}$ , proportional to firm size, as captured by  $\alpha$ . Consistent with our results, recent studies have documented that CEO pay indeed increases with firm size (e.g., Conyon 1997, Schwab and Thomas 2006, Bebchuk and Grinstein 2005, and Rusticus 2006). Moreover, Proposition 8 predicts that this positive relation between firm size and CEO pay should be additionally associated with higher CEO turnover.

While in Propositions 7 and 8 a higher turnover likelihood ensues because CEO entrenchment becomes more costly to the firm, the equilibrium level of CEO pay and turnover should also depend on the CEO's benefits from becoming entrenched in the first place. Recall that in our model the parameter  $B$  captures the private benefits that the CEO can extract if he shirks. We would expect, for instance, that a more tightly controlled company leaves its CEO with fewer “toys” (e.g., private jets) and fewer resources that he can divert for private use if he is no longer fully dedicated to his job. A lower value of  $B$  could thus capture a higher overall quality of corporate governance, which allows to decrease the CEO's on-the-job pay while preserving his incentives to exert effort. This reduces the CEO's benefits from staying on even if the match value is low. Under the optimal compensation contract, turnover will then be higher.

**Proposition 9** *A decrease in the CEO's private benefits from shirking, which may be the result of improved corporate governance, leads to less CEO entrenchment (lower  $\theta^*$ ) and thus more turnover.*

## 6 Renegotiations and “Golden Handshakes”

In our model, the board chooses the CEO's compensation scheme at the time when he is hired. The optimal choice trades off a more efficient replacement policy against higher rents for the CEO. This trade-off is formalized in the derivative of the board's objective function with respect to  $W$ , equation (9). A key term in this equation is the derivative  $d\theta^*/dW$ , which captures how responsive the cutoff  $\theta^*$  is to a change in the CEO's severance pay, and thus his informational rent. The larger  $d\theta^*/dW$  is, the cheaper it is for the firm to reduce CEO entrenchment and thus narrow the “inefficiency gap”  $\theta_{FB} - \theta^* > 0$ . Recall also that an increase in severance pay must be matched by a simultaneous increase in on-

the-job pay to preserve the CEO's incentives to exert effort. As an increase in on-the-job pay works, however, in the opposite direction, namely towards a lower cutoff  $\theta^*$ , this has a dampening effect on  $d\theta^*/dW$ .

The last observation gives rise to the following problem of renegotiations. Suppose that after the CEO has exerted effort and privately observed the signal  $\theta$ , the board could offer to replace the initial contract with a new one. Based on the (possibly) renegotiated contract, the CEO would then play the message game with the board, giving rise to a cutoff signal  $\theta^*$  that is given by condition (3). The crux is now that at this *interim* stage the board strictly benefits from offering the CEO higher severance pay. As this no longer necessitates a simultaneous increase in on-the-job pay, severance pay is, at this *interim* stage, more effective in pushing up  $\theta^*$ . (*Ceteris paribus*,  $d\theta^*/dW$  is higher if  $W$  is offered at the *interim* stage than at the *ex-ante* stage.)

**Proposition 10** *If the optimal contract under commitment (see Proposition 2) can be renegotiated after the CEO has exerted effort and observed his private signal  $\theta$ , then the board would want to offer the CEO additional severance pay (“golden handshake”) at this interim stage. Ex-ante, however, the firm is strictly better off if it can commit not to renegotiate the initial contract.*

The “golden handshake” that the CEO can expect at the *interim* stage undermines his incentives to work hard *ex ante*. In fact, as the incentive constraint was binding under the uniquely optimal (commitment) contract from Proposition 2, the CEO will strictly prefer to shirk if he can expect higher severance pay later.

A stricter corporate governance standard, in particular if backed up regulatory requirements, may shore up a board's commitment not to offer generous “golden handshakes” *ex post*. For instance, such commitment could become credible if changes in compensation must be approved by a compensation committee involving independent board members. Public pressure and fear of negative publicity, especially in the case of publicly listed companies, may provide additional commitment for the board not to sweeten the CEO's (early) departure.

If we restrict attention to the class of contracts characterized in Proposition 2, then it is straightforward to derive the equilibrium outcome under renegotiations. The optimal contract must satisfy both the incentive constraint (4) and, in addition, the requirement

that it will not be renegotiated later. As this leads to a level of severance pay that is too high from an *ex-ante* perspective, the firm will optimally make the contract “just” renegotiation-proof. Precisely, the optimal contract will satisfy the firm’s first-order condition (9) at the *interim* stage. Clearly, the firm’s profits in this case are strictly lower than under the optimal commitment contract.

However, we can no longer be certain that the optimal renegotiation-proof contract is indeed characterized by Proposition 2. While we know that the contract from Proposition 2 implements a given level of entrenchment at lowest cost, it is not clear that it also provides the best possible commitment against subsequently renegotiating (upwards) the CEO’s severance pay. As the contract from Proposition 2 makes the CEO’s on-the-job pay  $E[w(s) | \theta]$  as steep as possible, *ceteris paribus* a given change in  $W$  induces a relatively small change in  $\theta^*$ , given that the CEO’s benefits from staying in office increase “faster” in  $\theta$ . While this observation would suggest that this is also the optimal renegotiation-proof contract, this misses an additional effect. Recall that the contract from Proposition 2 implements a given cutoff  $\theta^*$  with the lowest feasible amount of severance pay and on-the-job pay. As is easy to show, a reduction in the level of pay reduces the sensitivity of  $E[w(s) | \theta]$  with respect to  $\theta$ , with the effect that a change in  $W$  now induces a larger change in  $\theta^*$ , making it thus more attractive for the firm to subsequently renegotiate  $W$  upwards. This “level effect” works against the contract from Proposition 2 by making it *more* prone to be renegotiated at the *interim* stage.<sup>29</sup> We are not able to generally characterize the optimal contract under renegotiations.

## 7 Better Informed Board

### Model Variation

Thus far we have assumed that the CEO has better information than the board about the match quality between him and the firm. This assumption is based on the natural notion that the CEO knows best his own strengths and weaknesses, especially what corporate environments his personality is best suited for (albeit it may take him some time to

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<sup>29</sup>By the same token, it can no longer be assured that the incentive constraint (4) binds under the optimal contract. This is because higher on-the-job pay makes it subsequently more costly to implement a higher cutoff  $\theta^*$  by raising  $W$ , given that  $E[w(s) | \theta]$  becomes more sensitive to  $\theta$ . Hence, the firm may end up paying the CEO a higher rent, which induces more entrenchment, than what would otherwise be “necessary” to induce high effort.

fully learn the firm’s environment.) Alternatively, it could be that the board, because it knows the firm’s environment better than the newly hired CEO, is better informed about the match quality between the CEO and the firm (albeit it may take the board some time to get to know the CEO’s personality.) To explore this latter possibility, we now consider the opposite case in which the board, instead of the CEO, privately observes  $\theta$ .<sup>30,31</sup> By implication, the choice for which values of  $\theta$  the CEO will be replaced now depends directly on the *board’s* preferences. In contrast, in our basic model where  $\theta$  was observed only by the CEO, the cutoff signal  $\theta^*$  was determined by the CEO’s preferences, as reflected in the requirement that  $E[w(s) | \theta^*] = W$  from (3).

### Board’s Replacement Policy

The board, acting in the firm’s best interest, will retain the CEO if the expected residual profit,  $E[s - w(s) | \theta]$ , exceeds the profit under a replacement CEO,  $V - W$ . In the following, we impose an additional, albeit fairly standard, constraint, namely, that  $s - w(s)$  must be nondecreasing (e.g., Innes 1990).<sup>32</sup> By the same logic as in the previous analysis, it then follows from MLRP and continuity of  $G_\theta(s)$  that  $E[s - w(s) | \theta]$  is strictly increasing  $\theta$ . Also, like before, we first assume that both  $\Theta_+$  and  $\Theta_-$  have positive mass and then show later under what conditions this will be the case. Accordingly, the board’s optimal replacement policy is characterized by a unique interior cutoff signal  $\theta_{Board}^*$  satisfying

$$E[s - w(s) | \theta_{Board}^*] = V - W. \tag{15}$$

Note that the CEO’s incentive constraint (4) remains unchanged, except that we need to substitute the board’s optimal cutoff  $\theta_{Board}^*$ . In what follows, it proves convenient to refer to the previously optimal cutoff when the CEO had private information by  $\theta_{CEO}^*$  (see condition (3)).

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<sup>30</sup>If both the board and the CEO could observe  $\theta$ , while assuming that  $\theta$  is non-verifiable, then the firm would benefit (also *ex-ante*) from allowing *interim* (re-)negotiations. If instead only the CEO observes  $\theta$ , we have shown in Proposition 10 that the firm would like to commit not to renegotiate. As we will show in this section, if only the board can observe  $\theta$ , then the optimal commitment contract is renegotiation-proof.

<sup>31</sup>In the Introduction we provide an alternative interpretation of the assumption that the board observes  $\theta$  based on the complementary role of boards as advisors to the CEO, as emphasized in Adams and Ferreira (2007).

<sup>32</sup>If we assume that  $\gamma \leq 1$ , then this constraint is already implied by our previous requirement that  $w(s)$  must be falsification-proof. Like the previous requirement that  $w(s)$  is nondecreasing, the requirement that  $s - w(s)$  is nondecreasing is only invoked to shorten the subsequent derivation of results and will not bind in equilibrium.

As the firm is the residual claimant, from an *ex-ante* perspective it would again be optimal to specify  $\theta_{Board}^* = \theta_{FB}$ . But this is not necessarily the board's *ex-post* optimal choice. To see this most clearly, suppose first that  $W = 0$ . In this case, it holds that  $E[w(s) | \theta] > W$  for all  $\theta > \underline{\theta}$ , and thus, in particular, that  $E[s - w(s) | \theta_{FB}] < V - W$ . Hence, the board would strictly prefer to replace the CEO at  $\theta = \theta_{FB}$ . Consequently, if  $W = 0$ , the equilibrium cutoff  $\theta_{Board}^*$  must be higher than the first-best cutoff  $\theta_{FB}$  for any contract  $w(s)$  that satisfies the CEO's incentive constraint (4).

This result provides the perfect mirror image to the corresponding result for the previously analyzed case where the CEO observes  $\theta$ . The intuition is, however, the same. It rests on the notion that, in order to induce the CEO to exert effort, he must receive (*ex-post*) rents when he stays in office. While this biases the CEO towards staying, it creates the opposite bias for the board.

### On-the-Job Pay

Based on the preceding argument, it follows intuitively that the optimal on-the-job pay scheme must be again characterized by Proposition 2. Since  $\theta_{Board}^*$  is too high (relative to the first-best cutoff  $\theta_{FB}$ ), the goal of the optimal contract design is now to reduce  $\theta_{Board}^*$ . For a given level of severance pay  $W$ , if the optimal on-the-job pay scheme did not follow the characterization in Proposition 2, then it would be possible to shift the CEO's on-the-job pay  $w(s)$  further into high cash-flow states, thus shifting his expected on-the-job pay  $E[w(s) | \theta]$  further into high signal (i.e.,  $\theta$ ) states. This would reduce the board's optimal cutoff  $\theta_{Board}^*$  and push it closer to  $\theta_{FB}$ .

### (Optimal) Severance Pay

As for severance pay, there is an interesting difference compared to the previous case where the CEO had private information. In the previous case, there was a strictly positive relation between severance pay  $W$  and the optimal cutoff  $\theta_{CEO}^*$ . While now a given cutoff  $\theta_{Board}^*$  is still associated with a unique compensation package  $(W, \hat{s})$ , provided that  $w(s)$  follows the characterization in Proposition 2, the relation between  $\theta_{Board}^*$  and  $W$  may now no longer be everywhere monotonic. Condition (15), which pins down  $\theta_{Board}^*$ , would suggest that to implement a lower cutoff  $W$  must increase. But this leaves the on-the-job pay  $w(s)$  constant. Crucially, as long as  $\theta_{Board}^* > \theta_{FB}$  and thus  $E[w(s) | \theta_{Board}^*] > W$  holds, a reduction in  $\theta_{Board}^*$  relaxes the CEO's incentive constraint (4). If this effect is

sufficiently strong, then a lower  $\theta_{Board}^*$  may be compatible with both lower on-the-job pay *and* lower severance pay. Note, however, that as severance pay is costly, at the firm's *optimal* choice of  $W$ , provided that this is interior with  $W > 0$ , the more “direct” channel must be stronger such that  $d\theta_{Board}^*/dW < 0$ . As the first-order effect of a marginal change of  $\theta_{Board}^*$  at  $\theta_{Board}^* = \theta_{FB}$  on the firm's profits is zero, it then follows that also if  $W > 0$  is optimal, there is still entrenchment in equilibrium:  $\theta_{Board}^* > \theta_{FB}$ . (Recall that we have already shown that  $\theta_{Board}^* > \theta_{FB}$  holds for  $W = 0$ .)<sup>33</sup>

## Equilibrium

Note that these observations all presume that a solution to the board's program exists. Unlike previously, condition (1) is, however, no longer sufficient to ensure that it is indeed optimal to elicit the CEO's effort. To obtain a lower boundary for the firm's expected profit if the CEO exerts effort, suppose that the board chooses  $W$  so as to implement  $\theta_{Board}^* = \theta_{FB}$ . In this case, the “kink”  $\hat{s}_0$  that characterizes the CEO's optimal on-the-job pay must solve

$$\gamma \int_{\theta_{FB}}^{\bar{\theta}} \int_{\hat{s}_0}^{\bar{s}} [G_{\theta_{FB}}(s) - G_{\theta}(s)] ds f(\theta) d\theta = B, \quad (16)$$

while the corresponding severance pay  $W_0$  is given by

$$W_0 = E[w(s) | \theta_{FB}] = \gamma \int_{\hat{s}_0}^{\bar{s}} [1 - G_{\theta_{FB}}(s)] ds.$$

The requirement that the firm's expected profits  $\omega$  exceed  $V$  is then given by<sup>34</sup>

$$\int_{\theta^*}^{\bar{\theta}} E[s | \theta] f(\theta) d\theta + F(\theta^*)V - B - W_0 > V. \quad (17)$$

Note that this assumes that such a contract is indeed feasible, i.e., that a solution  $\hat{s}_0 > \underline{s}$  for (16) indeed exists. From (16) this is the case if

$$\gamma \int_{\theta_{FB}}^{\bar{\theta}} \int_{\underline{s}}^{\bar{s}} [G_{\theta_{FB}}(s) - G_{\theta}(s)] ds f(\theta) d\theta > B. \quad (18)$$

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<sup>33</sup>Admittedly, these observations hide some further technicalities. Note that the firm chooses  $W$ , which together with some  $w(s)$  pins down the unobserved chosen cutoff  $\theta_{Board}^*$ . However, for given  $W$  multiple choices of  $w$  and thus  $\theta_{Board}^*$  may be compatible with the binding constraint (4). (As  $\theta_{Board}^*$  changes continuously in  $W$  and  $\hat{s}$ , note that it is again immediate that (4) binds by optimality.) If all compatible choices of  $w$  lead to values  $\theta_{Board}^* \geq \theta_{FB}$ , then by optimality the board will, for given  $W$ , choose the (lowest) on-the-job pay scheme, corresponding also to the lowest cutoff, in which case we can talk of a functional relationship between  $W$  and  $\theta_{Board}^*$ . The argument in the main text is then further restricted to the case where at an interior optimum  $W > 0$  this function is continuously differentiable.

<sup>34</sup>Clearly, condition (17) is satisfied if  $B$  is sufficiently small as this affects  $\omega$  both directly and indirectly via a reduction of  $W_0$  (with  $W_0 \rightarrow 0$  and  $B \rightarrow 0$ ).

**Proposition 11** *Suppose instead of the CEO it is now the board who privately observes  $\theta$ . Suppose also that  $\gamma$  is not too small such that (18) is satisfied in addition to (17), ensuring that it is both feasible and optimal to induce the CEO to exert effort. Then we have the following results:*

- i) The optimal on-the-job pay scheme  $w(s)$  (still) follows the characterization in Proposition 2.*
- ii) The board optimally chooses the CEO's compensation package such that  $\theta_{Board}^* > \theta_{FB}$ , implying that there is inefficiently high CEO turnover.*
- iii) If it is optimal to offer a strictly positive severance pay  $W > 0$ , then at the thereby implemented cutoff it holds that  $dW/d\theta_{Board}^* < 0$ : To (locally) narrow the inefficiency gap  $\theta_{Board}^* - \theta_{FB} > 0$ , the board would have to increase the CEO's severance pay.*

Note that Proposition 11 does not assert that  $W > 0$  holds generally under the optimal contract. Whether  $W$  has an interior solution will depend on how the marginal efficiency gain from a decrease in  $\theta_{Board}^*$  (recall that  $\theta_{Board}^* < \theta_{FB}$ ) compares with the marginally higher rent that must be left to the CEO.<sup>35</sup>

## Discussion

By Proposition 11, for the case where the board privately observes  $\theta$ , implying that the CEO is replaced inefficiently often, the use of severance pay makes it credible that the CEO is replaced less frequently, thus improving efficiency. As noted in the Introduction, in Almazan and Suarez (2003) severance pay also benefits the CEO, albeit in their model symmetric information ensures that the board's replacement decision is always first-best efficient, in contrast to our model. However, by affecting the renegotiation outcome between the CEO and the board, severance pay can provide the CEO with stronger *ex-ante* effort incentives than incentive pay.<sup>36</sup> Closer to our setting, in Berkovitch, Israel, and Spiegel (2000) severance pay also commits against inefficient replacement. In their model, a replacement CEO, whose ability is unknown, makes firm value more uncertain, which is beneficial to shareholders if the firm is levered.

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<sup>35</sup>A sufficient condition for  $W > 0$  can be derived in analogy to condition (13), albeit now the corresponding condition  $-dW/d\theta^* < f(\theta^*) [E[w(s) | \theta^*] - V]$  must hold at  $\theta^* = \theta_{Board}^* > \theta_{FB}$  that applies for  $W = 0$ .

<sup>36</sup>Though they do not focus on severance pay, Fisman, Khurana, and Rhodes-Kropf (2005) also consider a model in which the board may replace the CEO inefficiently often. In their model, however, this is because the board gives in to the misguided activism of misinformed and biased shareholders.



## Comparative Analysis

We next compare the outcome with a “weak board”, where the board needs to elicit the CEO’s private information, to that with a “strong board”, where this information lies with the board.

**Corollary 1** *Comparing the two regimes where either the CEO or the board observes  $\theta$ , we have the following results:*

- i) Under the optimal compensation package, there is strictly more CEO turnover if the board observes  $\theta$ , i.e., it holds that  $\theta_{Board}^* > \theta_{FB} > \theta_{CEO}^*$ .*
- ii) If the CEO observes  $\theta$ , then higher severance pay is associated with higher CEO turnover. If the board observes  $\theta$ , then, at least locally at an interior solution, higher severance pay is associated with lower CEO turnover.*

There are thus two key distinctions between the two regimes. First, *ceteris paribus*, there is strictly more CEO turnover if the board observes  $\theta$ . Second, the relationship between severance pay and CEO turnover, which is always positive if the CEO observes  $\theta$ , may have the opposite sign if the board is “informationally” strong. A brief caveat is in order. Any comparison between the two regimes is based on the assumption that all primitives of the model remain fixed. In a richer model, however, the question of who has private information about the match value might itself be endogenous (depending, for instance, on the model’s primitives such as  $V$  or  $F(\theta)$ ).<sup>37</sup>

We conclude the comparison between the two regimes with the following result.

**Proposition 12** *Suppose instead of the CEO it is now the board who privately observes  $\theta$ . Then the optimal (commitment) contract from Proposition 11 will not be renegotiated at the interim stage.*

This result stands in contrast to the discussion in Section 6. If the board has private information, the firm thus no longer benefits from tying the board’s hands to prevent it from renegotiating the contract with the CEO. To see why this holds, suppose that the

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<sup>37</sup>A drawback of our approach with a continuum of signals  $\theta$  and a continuum of cash-flow realizations  $s$  is that we cannot explicitly compare the firm’s profits under the two regimes. Given that the optimal choice of  $W$  depends on “local” conditions such as the densities  $f(\theta)$  or  $G_\theta(s)$  to the left and right of  $\theta = \theta_{FB}$ , it is generally not possible to compare the respective optimal levels of  $W$  (or, for that matter, the remaining inefficiencies).

CEO could make a new offer at the *interim* stage, i.e., after he exerted effort and after the board observed  $\theta$ .<sup>38</sup> Though from  $\theta_{Board}^* > \theta_{FB}$  there would be strict gains from renegotiating as long as  $\theta \in [\theta_{Board}^*, \theta_{FB})$ , this is not feasible as  $\theta$  is the boards’s private information. Any “wage cut” that the CEO offered so as to push down  $\theta_{Board}^*$  would also be preferred by all “board types”  $\theta > \theta_{Board}^*$ . This follows in turn as by construction the initial contract from Proposition 2 makes the CEO’s compensation as steep as possible, implying that if any other contract that is offered at the renegotiation stage was preferred by some type  $\theta'$ , it would be strictly preferred by all higher types  $\theta > \theta'$ .<sup>39</sup> However, if the CEO preferred an on-the-job compensation that was less attractive but that would implement a lower cutoff  $\theta_{Board}^*$ , then this would contradict optimality of the initial (commitment) contract.

## 8 Conclusion

This paper develops a new theory of “information based” entrenchment. The on-the-job pay that the CEO must be offered to keep him from shirking biases him towards staying on even if his “match value” with the firm is strictly below that of a potential replacement CEO. If the CEO has private information about this match value, then this bias will lead to entrenchment: The CEO is replaced less often than he should be. We showed that CEO entrenchment can be reduced with severance pay, albeit higher severance pay has to go hand-in-hand with higher on-the-job pay. Absent any further restrictions, the optimal on-the-job pay scheme is a high-powered, discontinuous bonus scheme. We showed, however, that if the CEO can (at private costs) falsify cash flows, then under some circumstances the optimal on-the-job pay becomes a piecewise linear (option-type) contract.

We derived several implications from this model. In terms of public policy as well as corporate governance, we showed that while imposing a cap on the *ex-ante* negotiated severance pay is against the firm’s interest as it inefficiently reduces turnover, a commitment not to pay *ex-post* “golden handshakes” enhances firm value. In our model, the expectation of “golden handshakes” undermines the CEO’s incentives to work hard.

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<sup>38</sup>As this is only “cheap talk”, we may also suppose that this is preceded by the board’s announcement whether it intends to replace the CEO or not. However, the board only makes its final decision after it accepted or rejected the CEO’s new offer. In addition, the subsequent arguments extend to the case where the board can make a new offer at the *interim* stage, which leads to a game of signaling.

<sup>39</sup>From  $\theta_{Board}^* > \theta_{FB}$  there are clearly no mutual gains from renegotiating severance pay.

Our model also predicts a positive correlation between CEO turnover and pay. In contrast to extant theory, however, the increase in pay does not represent compensation for the CEO's higher risk of being fired, but represents additional rent. As we argued, in our theory the respective pay level (or pay rise) would thus be linked rather to firm characteristics than to characteristics of the CEO's job market. Other predictions that we obtained from the model included a positive correlation between firm size and both pay and CEO turnover.

Our analysis thus enriches the extant theory on (optimal) CEO turnover. CEO entrenchment creates a wedge between the firm's efficient replacement decision and observed turnover. This should be taken into consideration when forming hypotheses about the factors that affect CEO turnover. Also, our analysis showed how the risk of entrenchment and thus inefficient turnover should influence the optimal design of CEO compensation, i.e., both the level of severance pay and on-the-job pay as well as the optimal form of on-the-job pay.

## 9 Appendix

**Proof of Proposition 1.** The fact that  $W > 0$  follows from the argument in the main text. We next prove that it is uniquely optimal to give the CEO an on-the-job pay scheme of the form  $w(s) = 0$  if  $s < \hat{s}$  and  $w(s) = s$  if  $s \geq \hat{s}$  for some  $\hat{s} \in (\underline{s}, \bar{s})$ .

We argue to a contradiction. Suppose it was optimal to implement a given cutoff signal  $\theta^*$  with a different on-the-job pay scheme  $\tilde{w}(s)$ , and denote the corresponding severance pay by  $\tilde{W}$ . We show that there then exists some on-the-job pay scheme  $w(s)$  such that (i) the incentive constraint (4) remains binding and (ii) we can still implement the same  $\theta^*$ —though now with a lower severance pay  $W$ . That is, in a slight abuse of notation, we show that the new on-the-job pay scheme satisfies  $\theta^*(w, W) = \theta^*(\tilde{w}, \tilde{W}) = \theta^*$  and  $W < \tilde{W}$ , which by inspection of (6), contradicts the optimality of  $\tilde{w}(s)$ .

We proceed in two steps. We first choose  $\bar{W} = \tilde{W}$  and  $\bar{w}(s)$  with  $\bar{w}(s) = 0$  for  $s < \hat{s}'$  and  $\bar{w}(s) = s$  for  $s \geq \hat{s}'$  such that  $\theta^*(\bar{w}, \bar{W}) = \theta^*$ . That is, defining  $\Delta(s) := \tilde{w}(s) - \bar{w}(s)$ , we have that

$$\int_{\underline{s}}^{\bar{s}} \Delta(s) g_{\theta^*}(s) ds = 0. \quad (19)$$

Given the construction of  $\bar{w}(s)$ , there exists a value  $\tilde{s} \in (\underline{s}, \bar{s})$  such that  $\Delta(s) \geq 0$  for all

$s < \tilde{s}$  and  $\Delta(s) \leq 0$  for all  $s > \tilde{s}$ , where both inequalities are strict over sets of positive measure. Take now any signal  $\hat{\theta} > \theta^*$ . By MLRP of  $G_\theta(s)$  and (19), it then holds that

$$\begin{aligned} \int_{\underline{s}}^{\tilde{s}} \Delta(s) g_{\hat{\theta}}(s) ds &= \int_{\underline{s}}^{\tilde{s}} \Delta(s) g_{\theta^*}(s) \frac{g_{\hat{\theta}}(s)}{g_{\theta^*}(s)} ds + \int_{\tilde{s}}^{\bar{s}} \Delta(s) g_{\theta^*}(s) \frac{g_{\hat{\theta}}(s)}{g_{\theta^*}(s)} ds \\ &< \frac{g_{\hat{\theta}}(\tilde{s})}{g_{\theta^*}(\tilde{s})} \int_{\underline{s}}^{\tilde{s}} \Delta(s) g_{\theta^*}(s) ds = 0, \end{aligned} \quad (20)$$

which implies the incentive constraint (4) is slack under  $\bar{w}(s)$  and  $\bar{W}$ .

In a second step, we can now construct the asserted pay scheme with  $w(s) = 0$  for  $s < \hat{s}$  and  $w(s) = s$  for  $s \geq \hat{s}$  and  $W < \bar{W} = \tilde{W}$ . In order to do this, we continuously increase the threshold  $\hat{s}'$  in  $\bar{w}(s)$  and decrease  $\bar{W}$ , while still satisfying  $\theta^*(\bar{w}, \bar{W}) = \theta^*$ , until (4) again binds. Here, existence of a solution to the respective two equations (namely, the binding constraint (4) and the requirement that  $E[w(s) | \theta^*] = W$ ) is ensured from continuity of all payoffs in  $\hat{s}'$  as well as  $\bar{W}$  and the fact that (4) is violated as  $\hat{s}' \rightarrow \bar{s}$ .<sup>40</sup> Q.E.D.

**Proof of Proposition 2.** By the argument in the main text, the manipulation problem adds one additional constraint to the maximization problem: The slope of  $w(s)$  must not exceed  $\gamma$ .<sup>41</sup> As in the proof of Proposition 1 we argue to a contradiction. Suppose thus that to implement a given cutoff signal  $\theta^*$  a different on-the-job pay scheme  $\tilde{w}(s)$  was chosen. Like in the proof of Proposition 1, we can then again construct  $\bar{w}(s)$  with  $\bar{w}(s) = 0$  for  $s < \tilde{s}'$  and  $\bar{w}(s) = \gamma(s - \tilde{s}')$  for  $s \geq \tilde{s}'$  satisfying the following conditions. First, (19) must be satisfied. Second, as  $\tilde{w}(s)$  must be continuous and as (where differentiable) the slope of  $\tilde{w}(s)$  cannot exceed  $\gamma$ , we have again a value  $\tilde{s} \in (\underline{s}, \bar{s})$  such that  $\Delta(s) \geq 0$  for all  $s < \tilde{s}$  and  $\Delta(s) \leq 0$  for all  $s > \tilde{s}$ , where both inequalities are strict over sets of positive measure.

We can now fully apply the final steps from the proof of Proposition 1. To see this, note that the step in (20) only relies on the just described properties of the function  $\Delta(s)$ . Hence, we have again that the incentive constraint (4) is slack under  $(\bar{w}(s), \bar{W})$ , which then allows to construct a more profitable contract with a lower severance pay.

Uniqueness of  $(W, \hat{s})$  follows as from substituting (3) into the binding constraint (4) it must hold that

$$\gamma \int_{\theta^*}^{\bar{\theta}} \left[ \int_{\hat{s}}^{\bar{s}} [G_{\theta^*}(s) - G_\theta(s)] ds \right] f(\theta) d\theta = 0, \quad (21)$$

<sup>40</sup>The equation system may have more than one solution. In this case, the firm strictly prefers the one with the lowest value of  $W$ .

<sup>41</sup>From convexity of  $h(\cdot)$  this will also ensure that the resulting (piecewise linear) compensation scheme is indeed falsification-proof.

where we used that  $E[w(s) | \theta] = \gamma \int_{\hat{s}}^{\bar{s}} [1 - G_{\theta}(s)] ds$ . Condition (21) gives thus indeed rise to a unique value  $\hat{s}$ , which from (3) leads to a unique value  $W$ .<sup>42</sup> Q.E.D.

**Proof of Proposition 3.** By Proposition 2, an increase in  $\gamma$  increases the slope of the optimal on-the-job pay scheme to the right of the (adjusted) threshold  $\hat{s}$ . It remains to prove that as  $\gamma$  increases, implementing a given cutoff signal  $\theta^*$  requires a lower amount of severance pay.

To prove this, we totally differentiate (3), which pins down  $\theta^*$ , and the binding constraint (4) to obtain (holding  $\theta^*$  fixed)

$$\frac{dW}{d\gamma} = \frac{\int_{\theta^*}^{\bar{\theta}} \left[ \int_{\hat{s}}^{\bar{s}} [[1 - G_{\theta}(\hat{s})][1 - G_{\theta^*}(s)] - [1 - G_{\theta^*}(\hat{s})][1 - G_{\theta}(s)]] ds \right] f(\theta) d\theta}{\int_{\theta^*}^{\bar{\theta}} [G_{\theta^*}(\hat{s}) - G_{\theta}(\hat{s})] f(\theta) d\theta}. \quad (22)$$

The denominator of (22) is positive as  $G_{\theta}(s)$  satisfies FOSD, which is implied by MLRP. That the numerator is negative follows finally as  $[1 - G_{\theta}(s)] / [1 - G_{\theta^*}(s)]$  is strictly increasing in  $s$  for all  $\theta > \theta^*$ . To see that this indeed implied by MLRP, note that as  $G_{\theta}(s)$  is differentiable, this is equivalent to requiring that  $g_{\theta}(s) / [1 - G_{\theta}(s)]$  is strictly decreasing in  $\theta$  for any given  $s \in (\underline{s}, \bar{s})$ . It is well known that this condition (the Monotone Hazard Rate Property), is indeed implied by MLRP. Q.E.D.

**Proof of Proposition 4.** Note first that we can again restrict consideration to on-the-job pay schemes  $w(s, \theta)$  that are strictly increasing in  $s$  on a set of positive measure. In conjunction with the fact that  $G_{\theta}(s)$  satisfies MLRP, truthtelling then implies that  $\Theta_- = [\underline{\theta}, \theta^*)$  and  $\Theta_+ = [\theta^*, \bar{\theta}]$  with  $E[w(s, \theta^*) | \theta^*] = W$ . The following auxiliary result follows now immediately from the Proof of Proposition 1.

**Claim 1.** *Take two different feasible on-the-job pay schemes  $\tilde{w}(s)$  and  $\hat{w}(s)$  such that  $\hat{w}(s) = 0$  for  $s < \hat{s}$  and  $\hat{w}(s) = s$  for  $s \geq \hat{s}$ . If  $E[\hat{w}(s) | \theta'] \geq E[\tilde{w}(s) | \theta']$  for some  $\theta' < \bar{\theta}$ , then  $E[\hat{w}(s) | \theta'] > E[\tilde{w}(s) | \theta']$  for all  $\theta > \theta'$ .*

To complete the proof, we must distinguish between two cases. If  $w(s, \theta^*)$  satisfies  $w(s, \theta^*) = 0$  for  $s < \hat{s}$  and  $w(s, \theta^*) = s$  for  $s \geq \hat{s}$ , Claim 1 and truthtelling imply that the same on-the-job pay scheme is also chosen for all  $\theta \geq \theta^*$ . That is, the optimal menu is

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<sup>42</sup>It is useful to point here to a difference to the proof of Proposition 1. There, the respective system of equations (namely, the binding constraint (4) and  $E[w(s) | \theta^*] = W$ ) may still have multiple solutions, of which only that with the lowest  $W$  is optimal.

degenerate with  $w(s, \theta) = w(s, \theta^*)$ . Suppose next that  $w(s, \theta^*)$  takes a different form as above. As in the Proof of Proposition 1, we can then construct a single on-the-job pay scheme  $\widehat{w}(s)$  satisfying  $\widehat{w}(s) = 0$  for  $s < \widehat{s}$  and  $\widehat{w}(s) = s$  for  $s \geq \widehat{s}$  such that the same cutoff signal  $\theta^*$  is implemented while the effort constraint is relaxed. This follows from the fact that  $E[\widehat{w}(s) | \theta] > E[w(s, \theta) | \theta]$  for all  $\theta > \theta^*$ , which in turn follows from Claim 1 and the truth-telling requirement for the original menu. As in Proposition 1, we can finally adjust the new (single) on-the-job pay scheme  $\widehat{w}(s)$  so as to implement  $\theta^*$  with a lower severance pay. Q.E.D.

**Proof of Proposition 5.** Totally differentiating (3), which pins down  $\theta^*$ , and the constraint (4) while substituting the optimal on-the-job compensation scheme from Proposition 2 yields

$$\frac{d\theta^*}{dW} = -\frac{1}{\gamma} \frac{\int_{\theta^*}^{\bar{\theta}} [G_{\theta^*}(\widehat{s}) - G_{\theta}(\widehat{s})] f(\theta) d\theta}{\left[ \int_{\widehat{s}}^{\bar{s}} \frac{\partial G_{\theta^*}(s)}{\partial \theta^*} ds \right] \left[ \int_{\theta^*}^{\bar{\theta}} [1 - G_{\theta}(\widehat{s})] f(\theta) d\theta \right]}. \quad (23)$$

To evaluate the sign of (23), note that MLRP implies that  $G_{\theta}(s)$  is decreasing in  $\theta$  for all  $s \in (\underline{s}, \bar{s})$ , implying that  $d\theta^*/dW > 0$ . That on-the-job pay must then increase as well, through a reduction of  $\widehat{s}$ , follows immediately from (4). (Note for this also that from  $E[w(s) | \theta^*] = W$  the first-order effect of the initiated change in  $\theta^*$  on  $\int_{\theta^*}^{\bar{\theta}} E[w(s) | \theta] f(\theta) d\theta$  is zero.) Q.E.D.

**Proof of Proposition 7.** We show that the optimal choice of  $W$  is strictly increasing in  $V$ . By the argument in Proposition 5 this implies that the corresponding optimal choice of  $\theta^*$  is also strictly increasing, together with the value of on-the-job pay (through a reduction in  $\widehat{s}$ ). Writing out explicitly the first-order condition from (9), we have that

$$-\frac{d\theta^*}{dW} f(\theta^*) [E[s | \theta^*] - V] - 1 = 0. \quad (24)$$

Implicit differentiation of (24) gives

$$\frac{dW}{dV} = -\frac{d\theta^*}{dW} f(\theta^*) \frac{1}{d^2\omega/dW^2} > 0,$$

where  $d^2\omega/dW^2 < 0$  must hold at an interior optimum. (Note that we also use strict quasiconcavity of  $\omega$  for uniqueness of the optimal  $W$  and thus  $\theta^*$ .) Q.E.D.

**Proof of Proposition 8.** In analogy to the proof of Proposition 7 we only have to show that the optimal choice of  $W$  is strictly increasing in  $\alpha$ . For this note first that the

first-order condition (24) now becomes

$$-\frac{d\theta^*}{dW}f(\theta^*)\alpha[E[s|\theta^*]-V]-1=0, \quad (25)$$

while we can still substitute  $d\theta^*/dW$  from (23). Implicit differentiation of (25) gives

$$\frac{dW}{d\alpha}=\frac{d\theta^*}{dW}f(\theta^*)[E[s|\theta^*]-V]\frac{1}{d^2\omega/dW^2}>0,$$

where we now used from Proposition 6 that  $E[s|\theta^*]<V$  must hold from  $\theta^*<\theta_{FB}$ . Q.E.D.

**Proof of Proposition 9.** We show first that in order to implement a given cutoff signal  $\theta^*$ , the higher is  $B$  the higher must also be the severance pay  $W$ . We totally differentiate (3), which determines  $\theta^*$ , and the constraint (4) to obtain

$$\frac{dW}{dB}=\frac{1-G_{\theta^*}(\hat{s})}{\int_{\theta^*}^{\bar{\theta}}[G_{\theta^*}(\hat{s})-G_{\theta}(\hat{s})]f(\theta)d\theta}>0, \quad (26)$$

where the sign follows again from MLRP of  $G_{\theta}(s)$ , which implies FOSD.

Take now some value  $B=\hat{B}$ . The optimal compensation package specifies an amount of severance pay  $W=\hat{W}$  and some on-the-job pay scheme  $w(s)=\hat{w}(s)$ , which is in turn characterized by a unique threshold  $\hat{s}=\hat{s}'$ . Denote the corresponding cutoff signal by  $\theta^*=\hat{\theta}^*$ . If  $B=\tilde{B}>\hat{B}$ , we know from (26) that in order to implement the same cutoff signal  $\theta^*=\hat{\theta}^*$ , the severance pay would have to increase to some value  $W=\tilde{W}$  satisfying  $\tilde{W}>\hat{W}$ . To still satisfy (4), the CEO's expected on-the-job pay must also increase, i.e., the new threshold  $\hat{s}=\hat{s}''$  must satisfy  $\hat{s}''<\hat{s}'$ .

Consider next  $d\omega/dW$  from (9). By construction, we have for  $B=\hat{B}$ ,  $\hat{s}=\hat{s}'$ ,  $W=\hat{W}$ , and  $\theta^*=\hat{\theta}^*$  that the derivative is just zero. (This is just the first-order condition.) We now want to evaluate the sign of the derivative when we substitute  $B=\tilde{B}$ ,  $\hat{s}=\hat{s}''$ ,  $W=\tilde{W}$ , and  $\theta^*=\hat{\theta}^*$ , i.e., we want to evaluate the sign of the derivative at the point where with higher private benefits the same cutoff signal is implemented, albeit with higher severance pay and a higher expected on-the-job pay. We show that the derivative (9) is then negative.

This is the case if at  $\theta^*=\hat{\theta}^*$  the derivative  $d\theta^*/dW$  is strictly lower when  $B=\tilde{B}$  and thus  $W=\tilde{W}$  and  $\hat{s}=\hat{s}''$ . Given that  $\hat{s}''<\hat{s}'$ , this in turn holds if the derivative (23) is strictly increasing in  $\hat{s}$ . To show that this is the case, we rearrange (23) to obtain

$$\frac{d\theta^*}{dW}=\frac{1}{\gamma}\left(\frac{-1}{\int_{\hat{s}}^{\bar{s}}\frac{\partial G_{\theta^*}(s)}{\partial\theta^*}ds}\right)\left(\frac{\int_{\theta^*}^{\bar{\theta}}[G_{\theta^*}(\hat{s})-G_{\theta}(\hat{s})]f(\theta)d\theta}{\int_{\theta^*}^{\bar{\theta}}[1-G_{\theta}(\hat{s})]f(\theta)d\theta}\right). \quad (27)$$

The first expression in parentheses is positive by  $dG_{\theta^*}(\hat{s})/d\theta^* < 0$ , which is implied by FOSD and thus by MLRP, strictly increasing in  $\hat{s}$ . Next, after some transformations, we have that the sign of the derivative of the last term in (27) with respect to  $\hat{s}$  is given by the expression

$$\int_{\theta^*}^{\bar{\theta}} [g_{\theta^*}(\hat{s}) [1 - G_{\theta}(\hat{s})] - g_{\theta}(\hat{s}) [1 - G_{\theta^*}(\hat{s})]] f(\theta) d\theta > 0. \quad (28)$$

The fact that (28) is also strictly positive follows again from MLRP, which implies the Monotone Hazard Rate Property:  $g_{\theta}(s)/[1 - G_{\theta}(s)]$  must be strictly decreasing in  $\theta$  for all  $s \in (\underline{s}, \bar{s})$ . Hence, we have shown that given  $B = \tilde{B}$ , if we evaluate (9) at the value  $W = \tilde{W}$  where  $\theta^* = \hat{\theta}^*$ , then the derivative is strictly negative. Given strict quasiconcavity of the objective function,  $\omega$ , and the fact that  $\theta^*$  (and thus, in particular,  $\hat{\theta}^*$ ) is interior, we thus have that for  $B = \tilde{B}$  the optimal severance pay must be strictly lower than  $W = \tilde{W}$ . As  $\tilde{W}$  was constructed to ensure that the cutoff stays unchanged after an increase to  $\tilde{B} > \hat{B}$ , this implies from Proposition 5 that under the optimal compensation package there is more entrenchment if  $B = \tilde{B}$  than if  $B = \hat{B} < \tilde{B}$ . Q.E.D.

**Proof of Proposition 10.** It is straightforward from  $\theta^* < \theta_{FB}$  that at the *interim* stage the firm could only benefit from offering a still higher severance pay. (Any other offer would, if accepted, only result in a windfall profit for the CEO.) At the *interim* stage the derivative of the firm's profits  $\omega$  with respect to  $W$  is given by

$$-\frac{d\theta^*}{dW} f(\theta^*) [E[s | \theta^*] - V] - F(\theta^*),$$

where we used that  $E[w(s) | \theta^*] = W$ . This is clearly strictly higher than (9) if the respective function  $d\theta^*/dW > 0$  is strictly larger at the *interim* stage than *ex-ante* (i.e., as used for (9)).

At the *interim* stage we obtain from implicit differentiation of the requirement that  $E[w(s) | \theta^*] = W$  (cf. condition (3))

$$\frac{d\theta^*}{dW} = -\frac{1}{\gamma} \frac{1}{\int_{\underline{s}}^{\bar{s}} \frac{\partial G_{\theta^*}(s)}{\partial \theta^*} ds} > 0, \quad (29)$$

where we have further substituted the optimal contract (cf. Proposition 2) and integrated by parts to transform  $E[w(s) | \theta^*]$ . Comparing this with the respective expression for the



*ex-ante* stage (cf. (23)), we find that the latter is equal to (29) multiplied by

$$\frac{\int_{\theta^*}^{\bar{\theta}} [G_{\theta^*}(\hat{s}) - G_{\theta}(\hat{s})] f(\theta) d\theta}{\int_{\theta^*}^{\bar{\theta}} [1 - G_{\theta}(\hat{s})] f(\theta) d\theta}.$$

The assertion thus follows as this expression is indeed always strictly smaller than one.

The preceding argument also implies that the *unique* optimal commitment contract is not renegotiation-proof. This immediately implies that the firm *strictly* benefits from commitment. Q.E.D.

**Proof of Proposition 11.** It is helpful to first recall the following observations. As by optimality the incentive constraint (4) still binds, the firm's objective is again to maximize  $\omega$ . In addition, for  $W = 0$  we have always  $\theta^* > \theta_{FB}$  (where we abbreviate  $\theta^* = \theta_{Board}^*$ ). Note also that from the arguments in the main text it remains to prove the assertion on the optimal on-the-job pay. We now obtain, in contrast to the case with CEO private information, an interior cutoff  $\theta^* > \underline{\theta}$  also if  $W = 0$ . To prove the assertion on the optimal on-the-job pay scheme we thus proceed somewhat differently than in the proof of Proposition 2 (respectively, that of Proposition 1). It is convenient to first suppose that the on-the-job pay takes on the asserted form and to make several observations for this case. For all  $\theta^*$  where the respective contract is feasible (given that  $\hat{s} \geq \underline{s}$ ) we have from substituting (15) into the binding constraint (4) the requirement that

$$\int_{\theta^*}^{\bar{\theta}} \left[ \gamma \int_{\hat{s}}^{\bar{s}} [G_{\theta^*}(s) - G_{\theta}(s)] ds + [E[s | \theta^*] - V] \right] f(\theta) d\theta = B. \quad (30)$$

As the left-hand side is strictly decreasing in  $\hat{s}$ , this pins down a unique value and thus also a corresponding unique value  $W$ . As noted in the main text, however, the thereby defined (continuously differentiable) function  $W$  of  $\theta^*$  may now no longer be monotonic. For what follows, we will only need monotonicity over the range of values  $\theta^* \leq \theta_{FB}$  (though the respective cutoff will clearly not arise in equilibrium).

**Claim 1.** *For all feasible  $\theta^* \leq \theta_{FB}$  and corresponding compensation contract  $(w, W)$  that satisfies the characterization of Proposition 11 we have that  $\theta^*$  represents a continuous and strictly decreasing function of  $W$  (with corresponding adjustment of  $w$ ).*

**Proof.** It is convenient to rewrite the binding constraint (4) and (15) as follows:

$$\begin{aligned}\psi_1 & : = \int_{\theta^*}^{\bar{\theta}} \left[ \gamma \int_{\hat{s}}^{\bar{s}} [1 - G_{\theta}(s)] ds - W \right] f(\theta) d\theta - B = 0, \\ \psi_2 & : = \left[ \gamma \int_{\hat{s}}^{\bar{s}} [1 - G_{\theta^*}(s)] ds - W \right] - \left[ \underline{s} + \int_{\underline{s}}^{\bar{s}} [1 - G_{\theta^*}(s)] ds - V \right] = 0,\end{aligned}\tag{31}$$

which has the determinant  $D := \frac{\partial \psi_1}{\partial \theta^*} \frac{\partial \psi_2}{\partial \hat{s}} - \frac{\partial \psi_1}{\partial \hat{s}} \frac{\partial \psi_2}{\partial \theta^*} < 0$ , given that for  $\theta^* \leq \theta_{FB}$  we have that

$$\begin{aligned}\frac{\partial \psi_1}{\partial \theta^*} & = - \left[ \gamma \int_{\hat{s}}^{\bar{s}} [1 - G_{\theta^*}(s)] ds - W \right] f(\theta^*) > 0, \\ \frac{\partial \psi_1}{\partial \hat{s}} & = -\gamma \int_{\theta^*}^{\bar{\theta}} [1 - G_{\theta}(\hat{s})] f(\theta) d\theta < 0, \\ \frac{\partial \psi_2}{\partial \theta^*} & = -\gamma \int_{\hat{s}}^{\bar{s}} \frac{\partial G_{\theta^*}(s)}{\partial \theta} ds + \int_{\underline{s}}^{\bar{s}} \frac{\partial G_{\theta^*}(s)}{\partial \theta} ds < 0, \\ \frac{\partial \psi_2}{\partial \hat{s}} & = -\gamma [1 - G_{\theta^*}(\hat{s})] < 0.\end{aligned}$$

With

$$D_W = [1 - F(\theta^*)] \frac{\partial \psi_2}{\partial \hat{s}} - \frac{\partial \psi_1}{\partial \hat{s}} = \gamma \int_{\theta^*}^{\bar{\theta}} [G_{\theta^*}(\hat{s}) - G_{\theta}(\hat{s})] f(\theta) d\theta < 0,$$

we have from Cramer's rule that  $d\theta^*/dW = -D_W/D < 0$ . Q.E.D.

To prove the assertion on optimal on-the-job pay, we argue again to a contradiction and suppose that it was optimal to specify some  $\widetilde{W} \geq 0$  together with some different on-the-job pay scheme  $\widetilde{w}(s)$ . The argument is now largely analogous to that in the proof of Proposition 2 and thus kept short. Like in the proof of Proposition 2, we can then again construct  $\overline{w}(s)$  with  $\overline{w}(s) = 0$  for  $s < \widetilde{s}'$  and  $\overline{w}(s) = \gamma(s - \widetilde{s}')$  for  $s \geq \widetilde{s}'$  satisfying the following conditions. First, (19) must be satisfied, which implies that  $(\overline{w}(s), \widetilde{W})$  implement the same cutoff  $\theta^*$  (though now this is decided by the board). Recall that in the proof of Proposition 2 this was made more explicit by writing  $\theta^*(\widetilde{w}, \widetilde{W}) = \theta^*(\overline{w}, \widetilde{W})$ .

Second, as  $\widetilde{w}(s)$  must be continuous and as (where differentiable) the slope of  $\widetilde{w}(s)$  cannot exceed  $\gamma$  so as to be everywhere falsification-proof, we have again a value  $\widetilde{s} \in (\underline{s}, \bar{s})$  such that  $\Delta(s) \geq 0$  for all  $s < \widetilde{s}$  and  $\Delta(s) \leq 0$  for all  $s > \widetilde{s}$ , where both inequalities are strict over sets of positive measure. By the arguments from the proof of Propositions 1 and 2, where step (20) only relies on the properties of  $\Delta(s)$ , we know again that the incentive constraint (4) is slack under  $(\overline{w}(s), \widetilde{W})$ . As we now increase the respective ‘‘kink’’

$\widehat{s}'$ , note that this (continuously) pushes down  $\theta^*$ . As this relaxes (4), while the increase in  $\widehat{s}'$  has the opposite effect, the overall effect from a marginal increase in  $\widehat{s}'$  on (4) may be ambiguous. Still, from inspection of (4) (and using continuity) it is immediate that there exists a highest value for  $\widehat{s}'$  where (4) is just binding. We denote the respective value by  $\widehat{s}$  and the corresponding on-the-job pay by  $w(s)$ .

For a final step in the proof of Claim 2, we now have to conduct an additional case distinction. If the new cutoff  $\theta^*(\overline{w}, \widetilde{W}) < \theta^*(\widetilde{w}, \widetilde{W})$  satisfies  $\theta^*(\overline{w}, \widetilde{W}) \geq \theta_{FB}$ , then we are clearly done: We can set  $w(s) = \overline{w}(s)$  and  $W = \overline{W}$  such that  $(w(s), W)$  clearly generates higher profits  $\omega$  and satisfies the incentive constraint (4). If, instead,  $\theta^*(\overline{w}, \widetilde{W}) < \theta_{FB}$ , then we still have to adjust the contract. We do so by reducing  $\overline{W}$  (and, respectively,  $\overline{w}(s)$  to satisfy (4)), which from Claim 1 (continuously) pushes up the cutoff. (Note again that we use here that  $\theta^*(\overline{w}, \widetilde{W}) < \theta_{FB}$ .) As always  $\theta^*(w, 0) > \theta_{FB}$ , we know that there exists  $(w(s), W)$  with  $W < \widetilde{W}$  and  $\theta^*(w, W) = \theta_{FB}$ , which is thus again strictly more profitable than the original contract  $(\widetilde{w}, \widetilde{W})$ .<sup>43</sup> Q.E.D.

**Proof of Proposition 12.** Starting from the optimal (commitment) contract  $(w, W)$  from Proposition 11 we can restrict attention to different on-the-job pay offers  $\widetilde{w}$  at the renegotiation stage. If the CEO offers  $\widetilde{w}$ , then this can clearly only be mutually beneficial if  $\theta^*(w, W) > \theta^*(\widetilde{w}, W)$ , while from optimality for the CEO we can also restrict consideration to  $\theta^*(\widetilde{w}, W) \geq \theta_{FB}$ . Note that the new offer is then accepted by *all* "types"  $\theta \geq \theta^*(\widetilde{w}, W)$ , i.e., including types  $\theta \geq \theta^*(w, W)$  who would not have replaced the CEO also under the initial contract.<sup>44</sup> This follows from the observation that if some  $\theta' < \overline{\theta}$  prefers  $\widetilde{w}$  over  $w$ , i.e., if  $E[s - \widetilde{w}(s) \mid \theta'] \geq E[s - w(s) \mid \theta']$ , then this holds strictly for all higher types  $\theta > \theta'$  (Claim 1 in the proof of Proposition 4). If the CEO preferred the new offer, i.e., if

$$\int_{\theta^*(\widetilde{w}, W)}^{\overline{\theta}} E[\widetilde{w}(s) \mid \theta] f(\theta) d\theta + F(\theta^*(\widetilde{w}, W))W > \int_{\theta^*(w, W)}^{\overline{\theta}} E[w(s) \mid \theta] f(\theta) d\theta + F(\theta^*(w, W))W,$$

then this would also have satisfied the incentive constraint (4). Given that the firm's profits would be strictly higher, this contradicts optimality of  $(w, W)$ . Q.E.D.

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<sup>43</sup>It should be noted that in this proof we do not have to consider whether the constructed contracts are indeed feasible (with  $\widehat{s} \geq \underline{s}$ ). As is immediate, this follows as the original contract  $\widetilde{w}$  that implemented the fixed cutoff  $\theta^*$  was assumed to be feasible.

<sup>44</sup>Likewise, if we introduced such an additional "cheap talk" stage, all  $\theta > \theta^*(\widetilde{w}, W)$  would strictly prefer to pretend to otherwise replace the CEO, provided that this statement leads to the offer of  $\widetilde{w}$ .

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