When Less is More: The Benefits of Limits on Executive Pay[*]

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Abstract

We derive conditions under which limits on executive compensation can enhance efficiency and benefit shareholders (but not executives). Having its hands tied in the future allows a board of directors to credibly enter into relational contracts with executives that are more efficient than performance-contingent contracts. This has implications for the ideal composition of the board. The analysis also offers insights into the political economy of executive-compensation reform.

Keywords: Executive compensation, boards of directors, relational vs. performance-based contracting.

Executive compensation engenders endless controversy. Resentment, rightly or wrongly, about high pay has fueled political action: for instance, "say-on-pay" provisions in the Dodd-Frank law in the US or a recent Swiss referendum on executive pay.[1] Although a few scholars have applauded restrictions on executive compensation (see, *e.g.,* Bebchuk, 2007, and Bebchuk and Fried, 2004, 2005), many have opposed them (see, *e.g.,* Bainbridge, 2011, Jensen and Murphy, 1990, Kaplan, 2007, and Larcker et al., 2012). Opposition—or at least suspicion—by economists is not surprising: most economic textbooks caution against limiting prices. Moreover, a large economic literature has made a strong case for freedom of contract (see Hermalin, Katz, and Craswell, 2007, especially §2.2, for a survey).

Yet the literature also acknowledges that restricting private contracts can sometimes enhance welfare (see Hermalin, Katz, and Craswell, §2.3). In particular, parties sometimes benefit by "lashing themselves to the mast": they can write better contracts today if their options tomorrow are limited. In this paper, we show this logic could extend to executive compensation. To be sure, demonstrating, as we do, that circumstances exist in which restrictions on executive compensation can benefit shareholders and enhance welfare does not prove such restrictions are always beneficial; but it at least indicates that the issue is more complex and less straightforward than textbook-economic intuition might otherwise suggest.

Restrictions can benefit the shareholders—*even when they possess all the bargaining power*—for the following reason: ideally, as in most agency models,[2] the shareholders (or their representatives, the firm's directors) want to pay executives based on their actions, not those actions' stochastic outcomes. We assume, however, an informational friction prevents that: although the directors can observe the executives' actions, that information cannot be verified and, thus, cannot serve as a

[1]Say-on-pay provisions are requirements that shareholders vote on executive compensation plans. These laws vary across jurisdictions, in particular with respect to the consequences if shareholders vote against plans. In addition to the US and Switzerland, there are say-on-pay laws in Australia (Corporations Amendment Act 2011) and the UK (Companies Act 2006).

[2]As true, *e.g.,* of Grossman and Hart (1983), Holmstrom (1979), Sappington (1983), and Shavell (1979).

contractual contingency in a *formal* contract.[3] Yet, because the board of directors plays repeatedly, it may be able to overcome this problem via reputation: the board promises to honor the terms of such an agreement and, even though not legally enforceable, that promise is credible because there is a net loss from reneging; a board that reneges today can't enter into similar agreements in the future—and thus forfeits the benefits from doing so—because future executives will no longer see such agreements as credible. Such agreements are known as relational or informal contracts (see Malcomson, 2013, for a survey of the literature).

The cost of losing credibility—and hence how deterred the board is from reneging—depends on how good the next-best alternative to informal contracting is. Here, the next-best alternative is a series of future formal contracts in which the executives' compensation is tied to firm performance, a noisy signal of their actions. The greater the firm's profits from formal contracts, the greater the board's temptation to renege on an informal contract. If formal contracting is too attractive, a fully efficient or profit-maximizing relational contract is impossible: the temptation to renege will simply be too great and, because executives would anticipate the board will renege, such a contract fails to provide them incentives. In such a situation, state-imposed restrictions on formal contracts can be beneficial: by making formal contracting less profitable, the temptation to cheat on a relational contract is reduced, which permits the use of better relational contracts.

That it could be infeasible to utilize the optimal relational contract absent state-imposed restrictions helps explain the prevalence of formal incentive (*e.g.,* stock-price-contingent) contracts despite the many criticisms that they are not as effective as desired, or overly reward managers given what they achieve.[4] In principle, improvements are possible but unless the board is capable (see Section 6) and can commit, they cannot be realized.[5]

[3]The literature distinguishes between observable information, known to the contracting parties only, and verifiable information, which the party who adjudicates contractual disputes can learn. A formal contract cannot be contingent on unverifiable information because there is no way for the adjudicating party to enforce such a contingency.

[4]See, *e.g.,* Jensen and Murphy (1990), Bebchuk and Fried (2004, 2005), or Bertrand and Mullainathan (2001, 2003).

[5]As the Editor, Itay Goldstein, remarked, this also provides a rational-actor explanation for less-than-desired

It has long been known that relational contracting becomes more precarious as formal contracts become more attractive.[6] We note, in this regard, Baker, Gibbons, and Murphy (1994), which, in many ways, is the work closest to ours. Those authors assume the agent's action generates two signals: a "subjective performance measure," which is observable, but unverifiable, and an "objective performance measure," which is verifiable. The former is also the agent's contribution to firm profit. The authors consider what happens as the objective measure becomes, on average, a better estimator of the subjective measure (their notion of formal contracting improving). They show that a cutoff exists, which, once reached, renders relational contracting based on the subjective measure infeasible. Because, for high enough discount factors, the first-best outcome would otherwise be achieved under a relational contract, the principal is made worse off by improved formal contracting (*i.e.,* contracting on the objective measure): unless the objective measure is *perfectly* correlated with the subjective measure, having to rely only on a formal contract means the first-best outcome is unattainable.

Although closer to us than other work in the literature, there are critical differences between our work and Baker, Gibbons, and Murphy One is that we consider restrictions on compensation and they do not. This leads to implications, absent from their analysis, that are critical to issues of executive compensation.

Second, in Baker, Gibbons, and Murphy, unlike here, the parties are assumed *unable* to contract directly on the principal's payoff. Although a reasonable assumption in their context, such an assumption is unrealistic here, as it would rule out contracts contingent on corporate profits. Hence, their model is ill-suited to the issues of executive compensation that we address.

Third, unlike Baker, Gibbons, and Murphy, we allow for an efficiency-wage effect under *formal* contracting: the board can induce greater effort from the executive than it could in a one-period

governance, in contrast to explanations that rely on mistakes (*e.g.,* Kerr, 1975) or psychological factors (*e.g.,* Fehr and Gächter, 2002).

[6] Schmidt and Schnitzer (1995) show that, as the cost of formal contracting falls, the harder it will be to sustain relational contracts. A related literature considers improvements in the legal system or other formal institutions: see, *e.g.,* Kranton (1996), Kranton and Swamy (1999), and McMillan and Woodruff (1999a,b).

model because it can threaten the executive with the loss of future rents. Unlike Baker, Gibbons, and Murphy, we are allowing for maximally efficient *formal* contracting. This is critical in assessing the value of restricting formal contracts as, otherwise, the deck would be stacked against formal contracting.

Yet another difference concerns the sources of the relevant agency problems: in our model, a key friction is the executive's limited liability—all payments to him must be non-negative[7]—whereas in Baker, Gibbons, and Murphy the friction is asymmetric information about a key parameter.[8] Although this might seem a minor, technical detail, it is important for understanding the political economy surrounding executive compensation: specifically, the shareholders prefer relational contracting and, therefore, favor caps on contingent compensation; while the executive prefers formal contracts, which allow him to earn a rent, and thus he is strictly opposed to caps. These opposing preferences are reflected in the actual public policy debate over restrictions on pay, with shareholder advocates on one side and executives on the other. In contrast, to the best of our knowledge, the previous literature has found either that both sides of the contract are better off if relational contracting is sustainable or one side is better off and the other completely indifferent (as in Baker, Gibbons, and Murphy).

Two of our model's assumptions warrant discussion upfront: one, that the board is a perfect agent for the shareholders and, two, that the directors (hence, shareholders) possess all bargaining power *vis-à-vis* the executives. Together, these mean we can consider limits on executive pay independent of a need to correct any agency problem that may exist between shareholders and their boards (an argument advanced by Bebchuk, 2007, among others). That is, the benefits shareholders derive from limits on compensation in our model are *not* simply legislated redistribution to compensate for shareholders' lacking control over their boards or their boards' lacking bargaining power.

[7]In keeping with the literature's convention that an agent is a he, we use masculine pronouns for the executive; were there a single principal, she would be a she.

[8]Baker, Gibbons, and Murphy assume the correlation, μ, between the objective and subjective measures varies randomly across periods and the agent privately learns each period's μ before he acts.

Put differently, it is not that our shareholders have too little discretion in setting compensation; rather, they have too much and, so, can benefit from being lashed to the mast.

Notwithstanding, we briefly consider, in Section 7, what happens if the executive possesses the bargaining power. In contrast to most models, in which contract restrictions hold no value for the party without bargaining power, given it is always held to its reservation payoff, here shareholders strictly benefit (at least if the executive is sufficiently impatient): severe enough restrictions mean, if the CEO is to maximize his compensation, he must offer a contract that concedes rents to the shareholders (see Proposition 8 below).

In Section 1.2, we show that a board limited to formal contracts only will never achieve full efficiency: with a formal contract, the board must tradeoff inducing greater effort from the executive and paying him a greater rent. Consequently, the board's most-preferred formal contract is less than fully efficient. In contrast, as we show, the board can avoid paying the executive a rent under an informal (relational) contract. A sufficiently patient board can and will achieve full efficiency, with all surplus going to the shareholders.

Nothing prevents the board offering "hybrid" contracts that contain elements of both formal and relational contracts, and we analyze such contracts in depth in Section 3, where we derive conditions under which limits on contingent compensation enhance efficiency and firm profits. Our results are nuanced: in some circumstances, a prohibition on contingent compensation would be beneficial, but in others, caps, rather than outright bans, would be optimal. Further, limits on contingent compensation can sometimes be unnecessary, as there are situations in which formal contracting poses no "threat" to informal contracting.

Sections 4–6 address important extensions of the model. One is the fear that public policy might limit *overall* executive compensation and not just, as our model indicates would be optimal, performance-contingent compensation. Although a limit on overall compensation is a blunter instrument than ideal, we show that it can nevertheless be superior to no limit; that is, an overall limit can help support optimal informal contracting, to the benefit of shareholders.

Another extension addresses why boards (shareholders) can't lash themselves to the mast (*i.e.,* why is state action necessary)? As discussed in Section 5, it is difficult, as a matter of law, for parties to bind themselves via contract or corporate charter to future courses of action that they would mutually wish to alter subsequently. Putting restrictions on compensation into the corporate charter, thus, won't tie the ropes tightly. On the other hand, the costs associated with amending a corporate charter (or contract generally) can bind the parties partially. The extent to which private action can substitute for state-imposed limits will, therefore, depend on the magnitude of such costs.

In Section 6, we relax our assumption that the board is a perfect monitor. Instead, how good a monitor—how capable—it is reflects an investment decision. If the cost of having a board able to monitor the CEO's actions is too great, then the shareholders optimally forgo having such a board. In this case, they are necessarily reliant on formal contracting and, thus, can only be harmed by restrictions on contracts. On the other hand, the benefit of having a capable board can be a function of whether contingent compensation is capped. If it is capped, then the value of a capable board is greater than if it is not. This particular relation between board quality and executive compensation is, we believe, novel and serves to complement other recent work that has examined the relation between board quality and executive pay (see, *e.g.,* Hermalin, 2005, and Kumar and Sivaramakrishnan, 2008). Among the implications of our analysis is that, if board quality is *endogenous*, we should expect to see higher board quality when contingent compensation is capped; or, somewhat conversely, a negative correlation between board quality and levels of contingent pay. In Section 8, we discuss the many other implications our model holds for understanding trends in governance and for empirical research.

Proofs that do not disrupt the paper's flow are in the main text, the rest in the appendix.

1. Basic Model

1.1 Structure and Preferences

There are two parties: a board of directors and a chief executive officer (CEO). We treat the board as if it were a single actor, which seeks to maximize profit (firm value); as such, the board is a perfect agent for the shareholders (we reconsider this assumption in Section 7).

Our model supposes the infinite repetition of the following stage game. At the beginning of each period (stage), the board and CEO agree on the contract governing that period; next, the CEO takes an action, p, from a set of available actions, $\mathcal{P}$; then the board obtains information about that action and, additionally, a verifiable outcome, success or failure, is realized.

The CEO's per-period utility is zero if *not* employed by the firm (this is his reservation utility) and it is $y - c(p)$ if he is, where y is his compensation and $c : \mathcal{P} \to \mathbb{R}_+$ his disutility-of-action function. The firm's (board's) payoff is $g - y$ if success occurs and $-y$ otherwise (*i.e.,* g is the firm's gain from success relative to failure). Note all actors are risk neutral.

Because the firm's payoff is a function of the verifiable outcome only, it is without loss of generality to equate the CEO's action with the probability of success. That is, success is realized with probability p, failure with probability $1 - p$, and $\mathcal{P} = [0, 1]$.

To avoid corner solutions and multiple best responses for the CEO, assume: the disutility-of-action function, $c(\cdot)$, is twice continuously differentiable; the null action ($p = 0$) is costless (*i.e.,* $c(0) = 0$); *marginal* disutility of action is increasing (*i.e.,* $c''(p) > 0 \ \forall p \in [0, 1]$); and $0 = c'(0) < g < c'(1)$.[9] *Inter alia*, the last assumption implies that there is a positive action ($p > 0$) that is welfare superior to the null action, but that guaranteed success ($p = 1$) is *not* welfare (surplus) maximizing. Because $c'(0) = 0$, integrating c'' establishes that the disutility of action is increasing: $c'(p) > 0$ for all $p \in (0, 1]$.

[9] Setting $c'(0) = 0$ entails some loss of generality, but greatly simplifies the analysis. An earlier version—available from the corresponding author upon request—allowed for the possibility that $c'(0) > 0$.

Lemma 1. A unique surplus-maximizing action, $p^*(g)$, exists, $0 < p^*(g) < 1$.[10]

Both CEO and board discount the future: let $\gamma \in [0, 1)$ and $\delta \in (0, 1)$ denote their respective discount factors. These discount factors reflect financial discounting, as well as any exogenous uncertainty about the game's continuation. In particular, because the CEO likely has a higher exit rate than the firm,[11] it is reasonable to assume, as we do, that $\gamma \leq \delta$.[12] If $\gamma = 0$, the CEO is either wholly myopic or a short-run player (*i.e.,* the firm hires a new CEO each period). Throughout, we assume the board is a long-lived player (*i.e.,* $\delta > 0$).[13]

1.2 Information and Contracts

Except in Section 7, we assume that the board possesses the bargaining power: each period, it offers the CEO a contract on a take-it-or-leave-it basis. There are, however, limits as to what the board can propose: consistent with reality, as well as limited liability and other protections, we assume the CEO cannot be compelled to make payments to the firm.

Because the outcome, success or failure, is verifiable, it can serve as a contractual contingency. Let $b \in \mathbb{R}_+$ denote the additional compensation (bonus) the contract promises the CEO for achieving success.[14] Payments are also verifiable. Hence, the board can promise a non-contingent level of compensation, $w \in \mathbb{R}_+$ (the base wage or salary).

Recall that the board also obtains other information about the CEO's action beyond whether the outcome is a success or not. We assume that this other information is not verifiable: no third party, who might be called upon to adjudicate a contractual dispute between board and CEO,

[10] The rationale for labeling the surplus-maximizing action $p^*(g)$ will become clear shortly.

[11] By exit rate, we include incapacitation, retirement, and simply death.

[12] As will be evident, often the analysis requires no condition on γ versus δ—we highlight below where use is made of $\gamma \leq \delta$.

[13] See Kreps (1990) for an analysis of how long-lived institutions can maintain long-term reputations even when composed of short-lived members (*e.g.,* individual directors).

[14] Although we refer to b as a bonus, it should be understood that it could be stock-based compensation (*e.g.,* stock options). The critical feature is that it is compensation contractually linked to a verifiable measure of performance.

can learn it. Hence, direct enforcement of a promised payment contingent on this information is impossible. Enforcement must be indirect: a broken promise today can be punished in the future only.[15] Specifically, we assume grim-trigger strategies: if the firm (board) reneges on a promised payment to the CEO, neither that CEO nor any subsequently hired CEO will ever trust such a promise in the future.[16]

We assume this other, unverifiable, information is perfect; that is, the board observes the CEO's action, p. Let $\tau : \mathcal{P} \to \mathbb{R}_+$ denote the transfer (payment) schedule that the board promises to follow. We refer to this as the *informal component* of compensation. Because payments themselves are verifiable, the board is contractually obligated to pay $\min_{p\in[0,1]} \tau(p)$; that is, the board has discretion only over the portion of $\tau(p)$ in excess of the minimum possible transfer. On the other hand, there is no loss of generality in folding $\min_{p\in[0,1]} \tau(p)$ into w, the base wage; that is, we can and will set $\min_{p\in[0,1]} \tau(p) = 0$.

To summarize, a contract, $\langle w, b, \tau(\cdot)\rangle$, is a triple containing a non-contingent payment, w; a bonus, b, paid if a successful outcome is realized; and an informal component, $\tau(\cdot)$, a function of the CEO's observable, but unverifiable, action, p. Call a contract of the form $\langle w, b, 0\rangle$ (*i.e.,* where $\tau(p) = 0\ \forall p$) a *formal contract*.[17] When confusion is unlikely, we sometimes omit the zero and

[15] In light of Hermalin and Katz (1991), could renegotiation be another means for the parties to contract effectively on this other information? The answer is no: the reason being that, in Hermalin and Katz, the value of renegotiation is that it eliminates the insurance-incentive tradeoff that arises in agency models with risk-averse agents. Here the agent (the CEO) is risk neutral and the contractual friction is, instead, due to his limited liability; that is, the impossibility of making him pay the firm. Note this also explains why we do not use a standard moral-hazard model with a risk-averse agent (*i.e.,* as in Grossman and Hart, 1983, Holmstrom, 1979, or Shavell, 1979): given our assumption that the board observes the CEO's action, the first best would be attainable via renegotiation; see Hermalin and Katz for details.

[16] A subtle issue is how might a subsequently hired CEO learns that the board reneged given that information is unverifiable. Some possibilities are that, once on the job, a new CEO would receive evidence that indicated his predecessor had been cheated (this is especially plausible if the new CEO comes from within the firm). Another is that industry insiders—such as a new CEO—would know, but such knowledge is so difficult and expensive to communicate to outsiders—such as judges—that it is infeasible to contract directly on it (this is a standard assumption in the incomplete-contracts literature—see, *e.g.,* Hermalin, Katz, and Craswell, 2007, §4 for discussion). Finally, if the CEO is long-lived but wholly myopic (*i.e.,* $\gamma = 0$), then this issue disappears: the efficiency-wage effect, discussed *infra* and which relies on the threat of dismissal, doesn't arise and, therefore, one could assume the same board and CEO play against each other every period regardless of past play.

[17] As will become evident, even with a *formal* contract, the board might use its knowledge of p when deciding

write a formal contract as $\langle w, b\rangle$. Call a contract of the form $\langle w, 0, \tau(\cdot)\rangle$ (*i.e.,* with no bonus) an *informal contract*. Analogously, when confusion is unlikely, we omit the zero and write an informal contract as $\langle w, \tau(\cdot)\rangle$. It is worth briefly analyzing these two contractual extremes before proceeding to a more complete analysis.

Formal Contracts. Suppose the board uses a formal contract only. Given the game's stationarity, it is without loss to assume that the same contract is offered in every period. We begin with a somewhat naïve analysis of such contracts—one that ignores the repeated-game aspect of the situation—then turn to a more sophisticated analysis.

Consider a wholly myopic CEO (*i.e.,* one for whom $\gamma = 0$). Only the current period matters to him, so his response to contract $\langle w, b\rangle$ maximizes his current expected utility. His choice of action thus solves

$$\max_{p\in[0,1]} w + bp - c(p)\,. \tag{1}$$

Previously made assumptions imply (1) has a unique solution, which we denote as $p^*(b)$.[18] It can be shown, via well-known comparative statics results (see Lemma A.1 in the Appendix), that $p^*(\cdot)$ is strictly increasing. In addition, because $c'(0) = 0$, $p^*(0) = 0$. These last two points entail that the firm is always able to earn a positive expected profit if it can set $b > 0$: for $b \in (0, g)$ and with $w = 0$, expected profit is $p^*(b)(g - b) > 0$.

Because the CEO cannot be made to pay the firm, the firm cannot profit from a contract in which $b \geq g$. Consequently, there is no loss to restricting $b < g$ and that should be understood going forward. This entails $p^*(b) < p^*(g)$.

Lemma 2. A *myopic* CEO takes a positive action ($p > 0$) under a formal contract if and only if the bonus is positive ($b > 0$). If the bonus is positive, he earns a rent (expected utility in excess of his reservation utility); in particular, $bp^*(b) - c\big(p^*(b)\big) > 0$ if $b > 0$.

whether to retain or fire the CEO.

[18]It is straightforward to prove this by redoing the proof of Lemma 1 with b in place of g.

Let $R(b) = bp^*(b) - c\big(p^*(b)\big)$ denote the CEO's expected rent. Observe that the CEO can guarantee himself an expected utility of at least $R(b)$ if his contract promises a bonus b in the event of success. From Lemma 2, $R(0) = 0$ and $R(b) > 0$ if $b > 0$. The envelope theorem implies $R'(b) = p^*(b) \geq 0$.

The CEO is not necessarily myopic; that is, we wish to allow for the possibility that $\gamma > 0$. This, in turn, gives the board an additional instrument in its contract design: it can threaten the CEO with the loss of future rents should he fail to take (or exceed) a target action $\widetilde{p}$.[19] Specifically, suppose the board offers the CEO the contract $\langle w, b \rangle$, informing him it expects him to meet the target $\widetilde{p}$, $\widetilde{p} > p^*(b)$. If he fails to meet the target, he will be dismissed. Given the game's stationarity, if it is optimal for the board to offer that contract and target today, it will be optimal for it to do so in every period. Because $\widetilde{p} > p^*(b)$ and $bp - c(p)$ is strictly concave in p, the CEO won't exceed the target. He will meet the target if

$$\sum_{t=0}^{\infty} \gamma^t \big(w + b\widetilde{p} - c(\widetilde{p})\big) \geq w + bp^*(b) - c\big(p^*(b)\big) = w + R(b)\,,$$

where the lefthand side is the present discounted value of his utility if he meets the target every period and the righthand side is the best he can do if he decides not to meet it. This condition can be rewritten as

$$w + b\widetilde{p} - c(\widetilde{p}) \geq (1 - \gamma)\big(w + R(b)\big)\,. \tag{2}$$

Lemma 3. Consider a board, limited to using a formal contract, which seeks to maximize expected profit. The contract it offers in equilibrium is such that (2) holds as an equality.

Intuitively, were (2) not binding, then the firm could profitably reduce the CEO's compensation without destroying his incentive to choose target action $\widetilde{p}$.

The next lemma considers the composition of the optimal formal contract.

Lemma 4. Suppose there is no limit or cap on bonuses, then a board limited to formal contracts

[19] This logic is similar to that of efficiency wages (see, *e.g.,* Shapiro and Stiglitz, 1984).

only will offer a contract of the form $\langle 0, b \rangle$ in equilibrium; that is, the non-contingent portion of compensation will be zero.

Intuitively, consider a dollar reduction in the non-contingent portion of compensation, w, and a corresponding increase in the bonus rate of $1/\widetilde{p}$. This is income neutral (*i.e.,* the lefthand side of (2) is unchanged), but it *reduces* the CEO's rent by $1 - p^*(b)/\widetilde{p} > 0$ (*i.e.,* lowers the righthand side of (2)). By the logic of Lemma 3, this would benefit the firm: the optimal w for the unconstrained firm is, thus, zero.

A functional relation holds between a formal contract's terms and the target action:

Lemma 5. Consider a firm limited to offering formal contracts only. For any $\langle w, b \rangle$ that could be offered in equilibrium, there is a unique $\widetilde{p} > p^*(b)$ that solves expression (2) as an equality. Let $\widehat{p}(w, b)$ denote that unique $\widetilde{p}$. The function $\widehat{p}(\cdot, \cdot)$ is increasing and differentiable in each argument.

Given Lemma 4, we will often be concerned with $\widehat{p}(0, b)$, which we write as $\widehat{p}(b)$.

There is a friction with formal contracting: the firm (board) cannot avoid paying the CEO a rent. This will lead to inefficiencies:

Proposition 1. A firm limited to formal contracts will choose to implement an action strictly less than the surplus-maximizing action, $p^*(g)$. Such a firm's expected equilibrium profit increases with the CEO's patience (*i.e.,* with γ).[20]

The firm faces a tradeoff: a higher bonus supports a greater probability of success (*i.e.,* greater $\widetilde{p}$), but also increases the CEO's rent. In the neighborhood of the profit-maximizing action, $p^*(g)$, an increase in $\widetilde{p}$ has only a second-order benefit in terms of surplus, but is a first-order cost *vis-à-vis* the CEO's rent. Hence, $\widetilde{p} < p^*(g)$. From (2), that rent is diminishing in γ, which is why the firm does better the more patient the CEO is.

[20]An earlier version of this paper showed that the first best can be obtained with *formal* contracts in the limit as $\gamma \to 1$. Details available from the corresponding author upon request.

As discussed in the Introduction, we are interested in restrictions on formal contracts. Let π_{FC} to be the equilibrium per-period expected profit of a firm limited to using only formal contracts given whatever restrictions exist. Let π^*_{FC} be the equilibrium per-period expected profit absent binding restrictions. Finally, let π^0_{FC} be the equilibrium per-period expected profit when bonuses are forbidden (*i.e.*, when $b \equiv 0$). From Lemma 4, it follows that $\pi^*_{\text{FC}} \geq \pi_{\text{FC}} \geq \pi^0_{\text{FC}}$, with at least one inequality holding strictly.

Define

$$\pi^* \equiv p^*(g)g - c\big(p^*(g)\big)\,. \tag{3}$$

That is maximum feasible expected per-period profit because the right side is maximum expected surplus (Lemma 1) and the CEO's reservation utility is zero.

A corollary to Proposition 1 is

Corollary 1. A firm limited to using only formal contracts earns, in equilibrium, an expected per-period profit less than the maximum feasible expected per-period profit; that is, $\pi_{\text{FC}} < \pi^*$.

Proof: From Lemma 1, $p^*(g)$ is the unique maximizer of surplus. From Proposition 1, the board implements an action less than $p^*(g)$; hence, surplus is not maximized. Because the firm's expected profit cannot exceed surplus, it follows that $\pi_{\text{FC}} < \pi^*$. ■

As a last result concerning formal contracts: if bonuses are forbidden, then Lemma 3 implies $\gamma w = c(\widetilde{p})$. Therefore

$$\pi^0_{\text{FC}} = \max_p pg - \frac{1}{\gamma}c(p)\,.$$

That optimization program is equivalent to maximizing $p \times (\gamma g) - c(p)$; hence,

$$\pi^0_{\text{FC}} = gp^*(\gamma g) - \frac{1}{\gamma}c\big(p^*(\gamma g)\big)\,.$$

Informal Contracts. Suppose the board uses an informal contract only; that is, $\langle w, \tau(\cdot)\rangle$. As before, start with a wholly myopic CEO. If he is confident the contract will be honored, then, to maximize his utility, he will choose his action, p, to maximize $\tau(p) - c(p)$.

Suppose the components of the contract are $w = 0$ and

$$\tau(p) = \begin{cases} 0\,, \text{ if } p < \widetilde{p} \\ c(\widetilde{p})\,, \text{ if } p \geq \widetilde{p} \end{cases} . \tag{4}$$

If the CEO expects the board to honor the contract (*i.e.,* pay $c(\widetilde{p})$ if $p \geq \widetilde{p}$), then a best response is clearly for him to take action $\widetilde{p}$.

Because the board can never expect to pay less than $c(\widetilde{p})$ to induce a target action $\widetilde{p}$, it follows that the contract given by (4) is the cheapest way for the board to induce $\widetilde{p}$. Moreover, the CEO is earning no rent. Consequently, provided an informal contract is credible, the efficiency-wage-like issues that arose with formal contracts do not apply here. In other words, there was no loss in beginning the analysis by supposing a wholly myopic CEO. Note expected profit under the contract given by (4) is $\widetilde{p}g - c(\widetilde{p})$.

As previously assumed, should the board renege on its promise to pay $\tau(p)$ when the CEO has taken action p, all future play will be governed by formal contracts only; that is, the firm's expected per-period profit will be π_{FC} going forward should it renege today. Given the stationarity of the game, it makes sense for the board to offer contract (4) every period if it makes sense for it to offer it today. Hence, the condition for the board not to renege is

$$-\tau(\widetilde{p}) + \sum_{t=1}^{\infty} \delta^t \big(\widetilde{p}g - \tau(\widetilde{p})\big) \geq \sum_{t=1}^{\infty} \delta^t \pi_{\text{FC}}\,.$$

Or rewriting, using (4), provided that

$$\delta\big(\widetilde{p}g - c(\widetilde{p})\big) \geq (1-\delta)c(\widetilde{p}) + \delta\pi_{\text{FC}}\,. \tag{5}$$

If there exists a $\widetilde{p} > 0$ satisfying (5), then the firm's expected per-period profit from using just an informal contract exceeds π_{FC} by at least $(1-\delta)c(\widetilde{p})/\delta$ given (5) entails

$$\widetilde{p}g - c(\widetilde{p}) \geq \frac{1-\delta}{\delta}c(\widetilde{p}) + \pi_{\text{FC}}\,.$$

A particularly important case of when an informal contract is credible is the following:

Proposition 2. Consider a regime in which bonuses are prohibited. Then there is a *credible* informal contract that yields greater expected per-period profit than achievable with formal contracting given the restriction (*i.e.,* yields expected per-period profit in excess of π_{FC}^0).

Proof: Recall the board is at least as patient as the CEO (*i.e.,* $\delta \geq \gamma$). The chain

$$\delta g p^*(\delta g) - c\big(p^*(\delta g)\big) \geq \delta g p^*(\gamma g) - c\big(p^*(\gamma g)\big) \geq \delta g p^*(\gamma g) - \frac{\delta}{\gamma}c\big(p^*(\gamma g)\big) = \delta\pi_{\text{FC}}^0$$

is valid by the definition of an optimum (the first inequality) and because $\delta \geq \gamma$ (the second).[21] Considering only the ends of the chain, that expression implies

$$\delta\Big(g p^*(\delta g) - c\big(p^*(\delta g)\big)\Big) \geq (1-\delta)c\big(p^*(\delta g)\big) + \delta\pi_{\text{FC}}^0\,; \tag{6}$$

hence, the informal contract with $w = 0$ and informal component

$$\tau(p) = \begin{cases} c\big(p^*(\delta g)\big)\,, \text{ if } p \geq p^*(\delta g) \\ 0, \text{ otherwise} \end{cases}$$

is credible (*i.e.,* satisfies (5)). Moreover, because $c\big(p^*(\delta g)\big) > 0$, expression (6) implies $g p^*(\delta g) - c\big(p^*(\delta g)\big) > \pi_{\text{FC}}^0$: expected per-period profit is greater with the informal contract than the optimal

[21] If $\gamma = 0$, then $\pi_{\text{FC}}^0 = 0$ and it directly follows that $\delta g p^*(\delta g) - c\big(p^*(\delta g)\big) \geq \delta\pi_{\text{FC}}^0$ because, by the definition of an optimum, $\delta g p^*(\delta g) - c\big(p^*(\delta g)\big) \geq \delta g \times 0 - c(0) = 0$.

formal contract. ■

2. Achieving the First Best with Informal Contracts

We begin by deriving conditions under which the board can achieve the maximum feasible expected per-period profit, π^*, defined earlier by expression (3).

The condition for the board to honor an informal contract is given by (5) above. Substituting $p^*(g)$ for $\widetilde{p}$, that expression becomes:

$$\delta\pi^* \geq (1-\delta)c\big(p^*(g)\big) + \delta\pi_{\mathrm{FC}}\,.$$

Solving for δ, there is an equilibrium in which the firm obtains maximum expected profit if

$$\delta \geq \frac{c\big(p^*(g)\big)}{c\big(p^*(g)\big)+\pi^*-\pi_{\mathrm{FC}}} = \frac{p^*(g)g-\pi^*}{p^*(g)g-\pi_{\mathrm{FC}}}\,, \tag{7}$$

where the second equality derives from $c\big(p^*(g)\big) = p^*(g)g-\pi^*$. Because $\pi^* > \pi_{\mathrm{FC}}$ (Corollary 1), the cutoff (minimum) discount factor for sustaining the first best lies strictly between 0 and 1. Observe the ratios in expression (7) increase in π_{FC}. Consequently:

Proposition 3. Consider the minimum discount factor for the board such that the maximum expected profit is sustainable in equilibrium (*i.e.,* the lower bound given in expression (7) above). The lower is the profit obtainable under formal contracting, π_{FC}, the lower is that minimum discount factor.

This can be restated as the first-best outcome is more readily sustained (*i.e.,* for a larger set of discount factors) the lower is expected profit under formal contracting, *ceteris paribus*.

Recall that π_{FC} increases in γ (Proposition 1); hence, a corollary of Proposition 3 is:

Corollary 2. The less patient is the CEO (*i.e.,* the less is γ), the less patient the board needs to be to achieve maximum expected profit in equilibrium.

Corollary 2 shows that whereas a more patient CEO is a plus for a firm limited to formal contracting, it could prove a negative for a firm seeking to rely on informal contracting. The intuition is that a more patient CEO makes formal contracting more effective because of the efficiency-wage effect, thereby making the board's commitment to an informal contract less credible *ceteris paribus*.

In light of Lemma 4, the profit obtainable under formal contracting, π_{FC}, is a non-decreasing function of the maximum bonus that can permissibly be paid. It is increasing in that cap when the cap binds; otherwise, it does not depend on the cap. Hence, lowering the cap can reduce the profit obtainable under formal contracting. This suggests the following: if the board's discount factor is too low to sustain the first best absent a cap (*i.e.,* inequality (7) is reversed), then restricting bonuses might permit the achievement of the first best.

That hypothesis is correct in the following sense: suppose that

$$\delta \geq \frac{c\big(p^*(g)\big)}{c\big(p^*(g)\big) + \pi^* - \pi_{\text{FC}}^0}\,; \tag{8}$$

that is, the board's discount factor is sufficiently great that the first best would obtain if bonuses were prohibited. Consequently, expression (8) implies condition (7) holds for some cap or limit on bonuses, $\bar{b}$. To summarize:

Corollary 3. If the credibility condition (7) fails to hold, but condition (8) does, then there exists a cap on bonuses such that the first best is achievable in equilibrium under that cap, but not absent that cap.

What Corollary 3 does *not* show is that a cap on bonuses is *necessary* to achieve the first best. The reason is that if (7) fails to hold, then the board might choose to employ a contract with both a bonus and an informal component. If such a hybrid can achieve the first best and the board will choose to offer it, then there is no justification for limiting bonuses. Hence, we need to consider the use of hybrid contracts, the topic of the next section.

3. Analysis with Bonus and Informal Components

Suppose the CEO has accepted the contract $\langle w, b, \tau(\cdot)\rangle$ with target action, $\widetilde{p}$. Suppose the CEO expects the informal component to be honored and the same contract to be offered him if he remains employed. The CEO will, then, choose the target $\widetilde{p}$ provided, for all $p \neq \widetilde{p}$,

$$\frac{1}{1-\gamma}\big(w + \tau(\widetilde{p}) + b\widetilde{p} - c(\widetilde{p})\big) \geq w + \tau(p) + bp - c(p)\,. \tag{9}$$

A useful lemma for what follows is:

Lemma 6. Suppose the board wishes to induce action $\widetilde{p}$. It is without loss of generality to limit the board to offering contracts that have an informal component of the form

$$\tau(p) = \begin{cases} \widehat{\tau}\,, & \text{if } p = \widetilde{p} \\ 0\,, & \text{if } p \neq \widetilde{p} \end{cases}.$$

Intuitively, the board wants constraint (9) to be as relaxed as possible; hence, it may as well set $\tau(p) = 0$ for $p \neq \widetilde{p}$.

Given Lemma 6, if the CEO were *not* to choose the target action, $\widetilde{p}$, he does best to choose the action that maximizes $bp - c(p)$; that is, $p^*(b)$. Consequently, (9) holds if

$$w + \tau(\widetilde{p}) + b\widetilde{p} - c(\widetilde{p}) \geq (1-\gamma)\big(w + R(b)\big)\,. \tag{10}$$

If the inequality in (10) were strict, then the board could, without violating (10), reduce the CEO's compensation and make the informal component more credible by lowering $\tau(\widetilde{p})$. Hence, (10) is an equality in equilibrium. Per-period expected CEO compensation is, thus,

$$w + \tau(\widetilde{p}) + b\widetilde{p} = c(\widetilde{p}) + (1-\gamma)\big(w + R(b)\big)\,. \tag{11}$$

The firm's per-period expected profit is, therefore,

$$g\widetilde{p} - c(\widetilde{p}) - (1-\gamma)\big(w + R(b)\big)\,. \tag{12}$$

Lemma 2 means $R(b) > 0$ for $b > 0$; hence, for any $\widetilde{p}$, the board does best to set $b = 0$ and $w = 0$. It further follows that if (7) holds, then the board will only offer an informal contract in equilibrium. If (7) holds for $\pi_{\text{FC}} = \pi^*_{\text{FC}}$, then the board is indifferent to constraints on bonuses—they are simply irrelevant.[22] If (7) fails for $\pi_{\text{FC}} = \pi^*_{\text{FC}}$, but (8) holds, then there is a restriction on the bonuses that would necessarily benefit the board. To summarize:

Proposition 4. For any given action it wishes to induce, the board would prefer—if credible—to induce it via a contract with no bonus or base wage (*i.e.,* one in which $b = w = 0$). If the credibility condition (7) holds for the first-best action regardless of the maximum expected profit possible under a formal contract, then the board is indifferent to restrictions on bonuses. If that is not true, but condition (8) holds, then there is a restriction on bonuses that would enhance efficiency and benefit the firm.

What if the conditions of Proposition 4 are not met (*i.e.,* what if credibility conditions (7) and (8) both fail to hold)? Would the firm (board) still be better off with some restrictions on bonuses? We explore that question now. To that end, the condition for the board not to renege on the informal component is, from (11) and (12),

$$\underbrace{b\widetilde{p} - c(\widetilde{p}) - (1-\gamma)R(b) + \gamma w}_{-\tau(\widetilde{p})} + \sum_{t=1}^{\infty}\delta^t\Big(g\widetilde{p} - c(\widetilde{p}) - (1-\gamma)\big(w + R(b)\big)\Big) \geq \sum_{t=1}^{\infty}\delta^t \pi_{\text{FC}}\,;$$

[22]Recall π^*_{FC} is maximum expected profit using a formal contract only (*i.e.,* without restriction on bonuses).

or, rearranging,

$$g\widetilde{p} - \big(c(\widetilde{p}) + (1-\gamma)R(b)\big) \geq (\delta - \gamma)w + (1-\delta)(g-b)\widetilde{p} + \delta\pi_{\text{FC}}\,. \tag{13}$$

Recall the board is at least as patient as the CEO ($\delta \geq \gamma$); hence, constraint (13) is more readily satisfied if $w = 0$. Because the firm's expected per-period profit is maximized if $w = 0$, it follows that the firm will set $w = 0$. Given that, the lefthand side of (13) is, therefore, expected per-period profit. We can now establish the following.

Proposition 5. Assume that bonuses are permitted and the first best is not attainable given the permitted level of bonuses (*i.e.,* credibility condition (7) does *not* hold). Let b^e denote the bonus the board offers in equilibrium (using a hybrid contract). Let b_{FC} be the smallest bonus the board would rationally offer were it limited to formal contracts only.[23] If $b^e < b_{\text{FC}}$, then there exists a cap on bonuses $\bar{b}$, $\bar{b} \leq b^e$ (and equal only if $b^e = 0$), such that imposing that cap would raise the firm's expected equilibrium profit; that is, the firm would benefit if bonuses were capped *below* their equilibrium level (assuming the equilibrium level is positive).

Proof: The logic of Lemma 4 implies $b_{\text{FC}} > 0$. By hypothesis, it is true for all $b'' \leq b^e$ that

$$\widehat{\pi}(b'') \equiv \max_{\substack{b' \in [0,b''] \\ w \in [0,g]}} \widehat{p}(w,b')(g-b') - w < \pi_{\text{FC}}\,.$$

Let $\widetilde{p}$ be the action the board induces in equilibrium. Recall the lefthand side of (13) is equilibrium per-period expected profit. Because condition (7) is not satisfied, expression (13) must bind in

[23] The board's optimization program when limited to formal contracts, expression (29) in the Appendix, is not necessarily concave in b and w; hence, it is conceivable that more than one expected-profit-maximizing contract exists. Even if the optimal contract is not unique, by appeal to the Maximum Theorem (see, *e.g.,* Sundaram, 1996, p. 235), b_{FC} is well defined (*i.e.,* a minimum—as opposed to just an infimum—optimal bonus must exist).

equilibrium. Consequently,

$$g\widetilde{p} - \big(c(\widetilde{p}) + (1-\gamma)R(b^e)\big) > (1-\delta)(g-b^e)\widetilde{p} + \delta\widehat{\pi}(b^e)\,. \tag{14}$$

If $b^e = 0$, then (14) means a ban on bonuses strictly benefits the firm (it could increase $\widetilde{p}$).

Suppose $b^e > 0$. By continuity, (14) entails a $\hat{b} \in [0, b^e)$ such that

$$g\widetilde{p} - \big(c(\widetilde{p}) + (1-\gamma)R(\hat{b})\big) \geq (1-\delta)(g-\hat{b})\widetilde{p} + \delta\widehat{\pi}(\hat{b})\,. \tag{15}$$

Expression (15) shows that if the cap on bonuses were $\hat{b}$, then a hybrid contract with bonus $\hat{b}$ could credibly achieve a per-period profit of

$$g\widetilde{p} - \big(c(\widetilde{p}) + (1-\gamma)R(\hat{b})\big)\,,$$

which exceeds the original equilibrium's expected per-period profit (the lefthand side of (14)) because $R(\cdot)$ is an increasing function. ∎

As an example, suppose $c(p) = p^2/2$, $g = 3/4$, $\delta = 13/25$, $\gamma = 1/4$, and there is no cap on bonuses. It is readily shown that $b_{\text{FC}} = 3/8 = .375$, $\widehat{p}(b_{\text{FC}}) = 9/16 = .5625$, $\pi_{\text{FC}} = 27/128 \approx .211$, and that expression (8) fails (*i.e.,* Proposition 4 is not applicable). Solving for the equilibrium, it can be shown that the board would induce $\widetilde{p} \approx .564$ using a hybrid contract with bonus $b \approx .346$, for an expected per-period profit of approximately .219.[24] If a cap on bonuses of $\bar{b} = 1/4$ were imposed, then it can be shown that the board would induce $\widetilde{p} \approx .609$ using a hybrid contract with a bonus $b \approx .214$ for an expected per-period profit of approximately .254 (a 16% increase in expected profit).

Noting, for this example, that the bonus the board would wish to offer *after* the imposition of

[24] Calculations for all examples are available from the corresponding author upon request.

a cap is less than the cap, Proposition 5 implies that an even lower cap would raise expected firm profit even higher. It is tempting to imagine that this iterative process would lead to an optimal cap of zero. That proves not to be true, however: calculations reveal that expected equilibrium profits are maximized if the cap (*i.e.,* $\bar{b}$) is approximately .1033.

4. Limits on Overall Compensation

As noted in the Introduction, restrictions on executive compensation set by legislatures or referenda could fail to be as nuanced as the analysis to this point assumes. In particular, there could simply be a cap on *overall* compensation, $\bar{y}$; that is, regardless of circumstances, the CEO's *realized* compensation cannot exceed $\bar{y}$. Under such a restriction, a contract $\langle w, b, \tau(\cdot)\rangle$ is permissible only if

$$w + b + \max_p \tau(p) \leq \bar{y}\,.$$

Although a limit on realized compensation is a blunter instrument than a limit on bonuses, it can still benefit shareholders. To see this, consider the following example: $c(p) = p^2/2$, $g = 1/2$, $\gamma = 16/25$, and $\delta = 4/5$. It is readily verified that $p^*(g) = 1/2$, $c\big(p^*(g)\big) = 1/8$, and $\pi^* = 10/80$. Barring any limitations on contracts, $\pi^*_{\text{FC}} = 9/80$ (with $b = 1/4$ and $w = 0$). The first best is unattainable absent restrictions because expression (7) fails:

$$\frac{1/8}{1/8 + 10/80 - 9/80} = \frac{10}{11} > \frac{4}{5}\,.$$

Suppose that the limit $\bar{y} = 1/8$ is imposed. This doesn't impinge on the first-best *informal* contract:

$$w = 0 \text{ and } \tau(p) = \begin{cases} 0\,, & \text{if } p < p^*(g) = 1/2 \\ 1/8\,, & \text{if } p \geq p^*(g) = 1/2 \end{cases}\,.$$

It does, though, impinge on the optimal formal contract (since $1/4 > 1/8$). Given that limit, the best formal contract is $w \approx .0317$ and $b \approx .0933$. Under that contract, $\pi_{\text{FC}} \approx .0936 < 3/32$. Because

$$\frac{1/8}{1/8 + 10/80 - \pi_{\text{FC}}} < \frac{1/8}{1/8 + 10/80 - 3/32} = \frac{4}{5}\,,$$

the first best is sustainable in equilibrium given this limit (*i.e.,* expression (7) holds).

This example can be generalized in the following way:

Proposition 6. Assume no restrictions on pay and that the credibility condition (7) does *not* hold. Let b^e denote the bonus the board offers in equilibrium (using a hybrid contract) and $\widetilde{p}$ the action it induces in equilibrium. Let b_{FC} be the smallest bonus the board would rationally offer were it limited to formal contracts only. If $b^e + c(\widetilde{p}) < b_{\text{FC}}$, then there exists a limit on *realized* compensation, $\bar{y}$, such that imposing that limit would raise the firm's expected equilibrium profit; that is, the firm would benefit if compensation were limited.

Proof: Fix a limit satisfying $b^e + c(\widetilde{p}) < \bar{y} < b_{\text{FC}}$. Given Lemma 4, this limit binds when formal contracts are used. Hence, expected profit under a formal contract with this limit, π_{FC}, is strictly less than expected profit absent the limit, π^*_{FC}. Given that condition (7) failed to hold absent the limit, it follows expression (13) binds absent a limit:

$$g\widetilde{p} - \big(c(\widetilde{p}) + (1-\gamma)R(b^e)\big) = (1-\delta)(g - b^e)\widetilde{p} + \delta\pi^*_{\text{FC}}$$

(it remains optimal for the firm to set $w = 0$). Hence, with the limit:

$$g\widetilde{p} - \big(c(\widetilde{p}) + (1-\gamma)R(b^e)\big) > (1-\delta)(g - b^e)\widetilde{p} + \delta\pi_{\text{FC}}\,.$$

Because the first best was not attained: $\widetilde{p} < p^*(g)$, $b^e > 0$, or both. If $b^e > 0$, then the board can lower the bonus, maintaining $\widetilde{p}$ as the targeted action, without violating the credibility condition. This would raise expected profit. If $b^e = 0$, then the board could raise $\widetilde{p}$ by some amount, which would raise expected profit, without violating either the credibility condition or the realized compensation limit. ■

Whether shareholders would truly benefit from an *overall* cap on compensation, as in the example and proposition, depends on whether, in real life, $b_{\mathrm{FC}} > b^e + c(\widetilde{p})$. Because one side of that inequality is necessarily a counterfactual, a definitive answer would seem elusive; nonetheless, evidence suggests b_{FC} is large relative to other components of pay,[25] consistent with $b_{\mathrm{FC}} > b^e + c(\widetilde{p})$.

5. Who Ties the Knots?

A frequently asked question about the analysis to this point is whether the state need be the entity to lash the board to the mast? Couldn't the board lash itself to the mast via, for instance, the firm's corporate charter? We briefly address that concern here.

One might imagine that by including restrictions on bonuses in the corporate charter, the firm could accomplish what a state-imposed restriction would accomplish. But a corporate charter is, as a matter of law, just a contract (see, *e.g.,* Hansmann, 2006);[26] moreover, typically relatively easy to amend: a vote of the shareholders and, in some jurisdictions, filing the amended charter at a nominal fee, are all that is necessary.[27]

If the board reneges on the informal component, then the shareholders are left either having their CEO compensated under a restricted formal contract or voting to repeal the restriction and

[25] For large US companies, compensation corresponding to what we are calling b here appears to be in the neighborhood of 28 to 36% of total compensation (the lower estimate is from Core, Holthausen, and Larcker, 1999; the larger from Goergen and Renneboog, 2011).

[26] The law severely limits the ability of entities to bind their future selves contractually. For instance, it is not legally possible for parties to commit never to renegotiate or change the terms of their contract: if the parties wish to change the contract, the courts will let them do that regardless of whatever attempts they may have previously made to make the contract ironclad (see, *e.g.,* Hermalin, Katz, and Craswell, 2007, especially §§1.1.4, 2.5.2, 4.3.2, & 5.4.3).

[27] For more on amending corporate charters, see Hansmann (2006). *Inter alia*, Hansmann also discusses why corporations have typically been hesitant to adopt charters that differ from the default charter of their state of incorporation—yet another factor to consider with respect to the question of whether private action can substitute for state action.

utilizing an optimal formal contract. By definition, they do better under the latter; hence, we would expect rational shareholders to approve repeal.

On the other hand, in real life, there are transaction costs. In particular, there are various costs associated with the proxy process. There may also be costs associated with educating and convincing shareholders as to the rationale behind repeal. In short, it is reasonable to assume there is some cost, $C > 0$, to be incurred if repeal is to occur.

If C were large enough, the firm would not attempt repeal: there is *no* repeal if the expected present discounted value of repeal is less than the expected present discounted value of no repeal. That can be stated as

$$\frac{\pi_{\mathrm{FC}}^*}{1-\delta} - C \leq \frac{\pi_{\mathrm{FC}}}{1-\delta}\,, \tag{16}$$

where π_{FC}^* is, again, per-period expected profit under the optimal formal contract and π_{FC} per-period expected profit utilizing a restricted formal contract.

If, under the *optimal* restriction on bonuses as derived in Section 3, condition (16) holds, then there could be no need for the state to impose restrictions on bonuses: provided the charter is designed to maximize shareholder payoffs, private action will be sufficient. If, however, condition (16) fails, then the shareholders would strictly benefit if optimal restrictions were legally mandated (imposed by the state).

How much they would benefit in this latter case depends on how close they could come to the optimal restriction. Specifically, they can commit to any restriction such that (16) holds. Because we are considering the case in which the optimal restriction fails to satisfy (16), (16) must bind. Hence, the analysis of the preceding sections applies with $\pi_{\mathrm{FC}} = \pi_{\mathrm{FC}}^* - (1-\delta)C$. The greater is C, the better the firm can do with privately imposed restrictions.

The question of whether and by how much shareholders would benefit from a state mandate therefore boils down to how big is C? Evidence suggests the answer is "not very." Firstly, because firms make annual proxy solicitations anyway, much of the associated expenditure is sunk from the perspective of a charter amendment. Secondly, even those expenditures appear modest.[28] Hence, it is difficult to see that C is large enough to have a significant commitment effect.[29]

As a last point on this subject, were the model enriched to encompass variation in managerial talent, a firm that unilaterally restricted bonuses would be at a competitive disadvantage with regard to getting the best talent, as managers prefer firms without restrictions *ceteris paribus*.[30] In essence, when CEOs possess bargaining power, then they will block restrictions and state intervention will be necessary if the shareholders are to realize the benefits of limits on contingent pay (see, too, the discussion in Section 7 *infra*, especially Proposition 8).[31]

6. Board Quality

So far, we have assumed the board is a perfect monitor. But the quality of its monitoring could be endogenous; an issue we now explore.[32]

As an initial model, suppose, at the beginning of time, the board (or the shareholders) can decide whether the board will be able to see the CEO's action, p, in every future period (as heretofore assumed) or it won't be able to see it. If the latter choice is made, the firm is necessarily limited to formal contracting only; moreover, the efficiency-wage effects considered previously do not pertain. Assume the firm bears some cost, I, if it makes the former choice. This cost, which

[28] According to the Seward & Kissell LLP website, in a discussion of proxy *fights*: "Solicitation, printing and mailing fees and costs are dependent on the company's shareholder base. It is not unusual for aggregate costs to exceed \$1 million" (accessed April 24, 2014). The web article, "Proxy Fight Fees and Costs now Collected by SharkRepellent: Mackenzie Partners and Carl Icahn Involved in Largest Fights" by Adam Kommel, SharkRepellent.net, February 20, 2013 (accessed April 24, 2014), reports the average total cost of a proxy *fight* for a large corporation to be around \$1.3 million.

[29] Additionally, evidence suggests that management has considerable control over the proxy process (see, *e.g.,* Pound, 1988). As we've noted elsewhere, management would prefer there be no restrictions on pay and, thus, would presumably be biased towards repeal even if doing so did not have positive net present value (*i.e.,* even if (16) held).

[30] We thank the Editor, Itay Goldstein, for this observation.

[31] In this regard, also recall footnote 29 *supra*.

[32] An earlier version of this paper explored this issue utilizing a different approach than the one pursued here. We thank an anonymous referee for encouraging us to rethink the approach in order to have a model that is both more tractable and more general.

we don't model, could reflect expenditures to put in place the appropriate monitoring and auditing procedures, giving directors appropriate incentives, or the additional compensation necessary to attract knowledgeable directors.

If the firm elects to have a board that is a perfect monitor, then the analysis is as before. If it elects to have a board that cannot observe the CEO's action, then—because Lemmas 3 and 4 still pertain—it will set $w = 0$ and the bonus to solve either

$$\max_b (g - b)p^*(b) \text{ or } \max_{b \in [0,\bar{b}]} (g - b)p^*(b)\,,$$

which, respectively, are the programs for profit maximization with respect to b when there is no limit on bonuses and when there is a limit or cap of $\bar{b}$. Let the corresponding expected profits be denoted by $\widehat{\pi}^*_{\text{FC}}$ and $\widehat{\pi}_{\text{FC}}$. Obviously, $\widehat{\pi}_{\text{FC}} \leq \widehat{\pi}^*_{\text{FC}}$ and strictly so if the cap is binding. Because of the efficiency-wage effect that exists when the board *can* observe the CEO's action, $\pi^*_{\text{FC}} \geq \widehat{\pi}^*_{\text{FC}}$ and $\pi_{\text{FC}} \geq \widehat{\pi}_{\text{FC}}$, with equality holding only if the CEO is wholly myopic or, equivalently, a short-term player (*i.e.,* only if $\gamma = 0$).

Should the board be able to observe the CEO's action, let π_e be equilibrium expected profit when there is no limit on bonuses and π^*_e equilibrium expected profit when the optimal limit is imposed (for instance, .1033 in the example following Proposition 5). Necessarily, $\pi^* \geq \pi^*_e \geq \pi_e$. Equality among the three holds only if credibility condition (7) holds absent any limit on bonuses. If the second term strictly exceeds the third, then equality between the first and second holds only if condition (8) holds. Otherwise, all inequalities are strict.

If

$$\frac{\pi_e}{1-\delta} - I \geq \frac{\widehat{\pi}^*_{\text{FC}}}{1-\delta} \Longleftrightarrow \pi_e - \widehat{\pi}^*_{\text{FC}} \geq (1-\delta)I\,,$$

then the firm will elect to invest in a board that can observe the CEO's action and, if $\pi_e < \pi^*$, a limit on bonuses is beneficial. In contrast, if

$$\pi_e - \widehat{\pi}^*_{\text{FC}} < (1-\delta)I\,,$$

then the firm will prefer not to invest in a board capable of observing the CEO's action. In this case, because $\widehat{\pi}_{\text{FC}} \leq \widehat{\pi}^*_{\text{FC}}$, no benefit can accrue from a restriction on bonuses.

A case of some interest is

$$\pi_e - \widehat{\pi}^*_{\text{FC}} < (1-\delta)I < \pi^*_e - \widehat{\pi}_{\text{FC}}\,. \tag{17}$$

If (17) holds, then a consequence of imposing the optimal limit on bonuses is that it will induce the firm to invest in the board (*i.e.,* make it capable of observing the CEO's action); it will also raise firm value.

This analysis implies that, in addition to affecting managerial pay, a limit on bonuses can also affect other aspects of governance, such as decisions concerning the capabilities of the board of directors (*e.g.,* its composition). In particular, because $\pi^*_e > \pi_e$, this analysis implies that the incentives to improve the board's capabilities (*i.e.,* ability to observe the CEO's action) are greater when a cap on bonuses exists than when one doesn't.

An alternative to assuming the board's capabilities are set at the beginning of time is that the firm must continually invest in them: if it wishes the board capable of observing the CEO's action in a given period, it must expend $i > 0$ that period. As before, if the board were to renege on its promise to pay the informal component, then all subsequent play would be governed by a formal contract only. In this variant of the model, though, a question is whether the benefits of the efficiency-wage effect exceed the cost of being able to see the CEO's action. In other words, if limited to formal contracts, is the consequent per-period payoff $\pi_{\text{FC}} - i$ or $\widehat{\pi}_{\text{FC}}$? Define

$$\Delta^* = \max\left\{\pi^*_{\text{FC}}, \widehat{\pi}^*_{\text{FC}} + i\right\}, \Delta^0 = \max\left\{\pi^0_{\text{FC}}, i\right\}, \text{ and } \Delta = \max\left\{\pi_{\text{FC}}, \widehat{\pi}_{\text{FC}} + i\right\},$$

where, in the last, the values are optimal subject to whatever constraint on bonuses may apply (the $+i$ reflects that, relative to a regime in which the firm invests, *not* investing can be seen to yield a benefit of i). Utilizing the relevant "Δ" term in place of the relevant "π_{FC}" term, the analysis of the previous sections carries over. In particular, if credibility condition (7) holds with π_{FC} replaced by Δ^*, then, in equilibrium, the firm will expend i each period and utilize the optimal informal contract only; the first best attains, so no benefit would arise from limits on bonuses. If (7) fails, but (8) holds (with Δ^0 in place of π^0_{FC}), then there exist restrictions on bonuses that would benefit the firm even accounting for the cost of having a capable board. Of course, if i is too great, the firm does better not to invest. In that case, a binding restriction on bonuses harms the firm.

The costs and benefits of having a capable board likely vary across firms and industries. For some, assessment is straightforward and cost, thus, low (*e.g.,* an industry with well understood procedures); for others, it is more difficult (*e.g.,* a firm that operates in many idiosyncratic markets). For some firms and industries, the benefits will be low (*e.g.,* an industry in which there is little change) while for others, the benefits will be high (*e.g.,* an industry that is changing rapidly). For firms or industries with low costs and high benefits (*e.g.,* electric utilities at the dawn of the solar age), we should thus expect (i) a greater reliance on informal components in their executives' compensation *ceteris paribus*; and (ii) for them to benefit from restrictions on the formal components of executive compensation. Conversely, for firms or industries with high costs and low benefits (*e.g.,* a multi-national consumer-products company), we should expect (i) little to no reliance on informal components; and (ii) for them to benefit little (possibly even suffer) from restrictions on formal contracting.

7. The CEO has Bargaining Power

We have, to this point, assumed the board has all the bargaining power. In this section, we briefly consider the opposite: the CEO is the one to make take-it-or-leave-it offers. Largely for the sake of brevity, we assume, once more, that the board is a perfect monitor (equivalently, set $i = I = 0$).

If the CEO is very patient and possesses the bargaining power, then restrictions on bonuses are irrelevant in the sense that efficiency is achieved and surplus cannot be shifted to the shareholders:

Proposition 7. Assume that the CEO possesses all the bargaining power. Provided he is sufficiently patient—specifically, that $\gamma \geq c\big(p^*(g)\big)/\big(gp^*(g)\big)$—then full efficiency will be achieved in equilibrium even if there are restrictions on the use of bonuses. The CEO, however, will capture all surplus.

Proof: If the result holds given a complete prohibition on bonuses, then it will hold given less stringent restrictions. Hence, for convenience, assume $\bar{b} = 0$. Consider a formal contract $\langle gp^*(g), 0\rangle$ (*i.e.,* the wage is $gp^*(g)$). It is credible that the CEO chooses action $p^*(g)$ if

$$\sum_{t=0}^{\infty} \gamma^t \Big(gp^*(g) - c\big(p^*(g)\big)\Big) = \frac{gp^*(g) - c\left(p^*(g)\right)}{1-\gamma} \geq gp^*(g)\,. \tag{18}$$

Algebra reveals that (18) holds provided

$$\gamma \geq \frac{c\big(p^*(g)\big)}{gp^*(g)}\,.$$

The board is just willing to accept the contract given the firm's expected payoff will be zero under it. Given that full efficiency is achieved and the CEO captures all surplus, he can do no better than to offer $\langle gp^*(g), 0\rangle$. ■

On the other hand, if the CEO is sufficiently impatient and there is a sufficiently tight restriction on bonuses, then full efficiency is unachievable. Yet, in such circumstances, given the CEO has the bargaining power, a cap on bonuses can make the firm (the board) better off than it would otherwise be. To demonstrate this, consider the limiting case of a wholly myopic CEO (equivalently, the case in which the CEO is a short-run player) and allow for a complete prohibition on bonuses (*i.e.,*

$\bar{b} = 0$).[33]

Proposition 8. Assume that the CEO possesses all the bargaining power. Assume that $\gamma = 0$; that is, the CEO is either wholly myopic or a short-run player. Consider two regimes: (i) no restrictions on bonuses or (ii) bonuses are prohibited (*i.e.,* $\bar{b} = 0$). Full efficiency is achieved in the first regime, but shareholders realize a *zero* return. Full efficiency does not attain in the second regime, but shareholder will earn a *positive* expected return.

Proof: In regime (i), the formal contract $\langle 0, g \rangle$ maximizes surplus (the CEO is induced to choose action $p^*(g)$). Shareholders are held to their reservation payoff, 0, which means both that they will accept this contract and that the CEO must capture all surplus in expectation; as he cannot do better than that, he will indeed offer that contract.

Consider regime (ii). Given the assumptions, a formal contract cannot induce any action from the CEO other than $p = 0$. It follows that $\pi_{\text{FC}} = 0$. Using by now familiar reasoning, the board will honor the informal contract $\langle w, \tau(\cdot) \rangle$ with

$$\tau(p) = \begin{cases} \widehat{\tau}\,, \text{ if } p \geq \widetilde{p} \\ 0\,, \text{ if } p < \widetilde{p} \end{cases} \tag{19}$$

only if

$$-\widehat{\tau} + \frac{\delta}{1-\delta}(g\widetilde{p} - w - \widehat{\tau}) \geq \frac{\delta}{1-\delta}\pi_{\text{FC}} = 0\,;$$

equivalently, only if

$$\widehat{\tau} \leq \delta g\widetilde{p} - \delta w\,. \tag{20}$$

[33]The following proposition can be extended to allow for an impatient, but long-lived CEO; that is, $\gamma > 0$ but not too large. It can also be extended to permit a less severe cap on bonuses. Doing so would not change the basic insights of the proposition. So, for the sake of brevity, we restrict attention to this simplest case.

The CEO will choose $\widetilde{p}$ rather than the null action (his best alternative) if and only if

$$\widehat{\tau} - c(\widetilde{p}) \geq 0\,. \tag{21}$$

In equilibrium, the CEO chooses $\langle w, \tau(\cdot)\rangle$ and action $\widetilde{p}$ to maximize

$$w + \widehat{\tau} - c(\widetilde{p})$$

subject to (20) and (21). Holding w and $\widetilde{p}$ fixed, the objective function increases in $\widehat{\tau}$; hence, (20) must bind. Substituting that constraint, the CEO's seeks to choose $\widehat{\tau}$ and $\widetilde{p}$ to maximize

$$g\widetilde{p} - \frac{1-\delta}{\delta}\widehat{\tau} - c(\widetilde{p})$$

subject to (21). Because this objective function is decreasing in $\widehat{\tau}$, it follows that (21) binds. Substituting that constraint yields the unconstrained program

$$\max_{\widetilde{p}} g\widetilde{p} - \frac{1}{\delta}c(\widetilde{p})\,. \tag{22}$$

The solution to (22) is unaffected if that expression is multiplied by δ; hence, it follows the solution is $\widetilde{p} = p^*(\delta g)$. Substituting back into the binding constraints yields the contract:[34]

$$w = gp^*(\delta g) - \frac{1}{\delta}c\big(p^*(\delta g)\big) \text{ and } \tau(p) = \begin{cases} c\left(p^*(\delta g)\right), \text{ if } p \geq p^*(\delta g) \\ 0, \text{ if } p < p^*(\delta g) \end{cases} \tag{23}$$

[34]Because $p^*(\delta g)$ uniquely maximizes $gp - c(p)/\delta$, it follows that

$$gp^*(\delta g) - \frac{1}{\delta}c\big(p^*(\delta g)\big) > g \times 0 - \frac{1}{\delta}c(0) = 0\,;$$

hence, the contract must satisfy the no-negative-payment constraint.

Observe that, under the contract (23) and given $\widetilde{p} = p^*(\delta g)$, per-period profit is

$$gp^*(\delta g) - w - \widehat{\tau} = \frac{1-\delta}{\delta} c\bigl(p^*(\delta g)\bigr) > 0\,. \tag{24}$$

So the board will accept the CEO's offer; that is, it is an equilibrium for the CEO to offer contract (23), for the board to accept, and for the CEO to choose action $p^*(\delta g)$. Because $p^*(\delta g) < p^*(g)$, full efficiency is not achieved. Given (24), the firm earns a positive expected profit each period, as was to be shown. ■

We based our analysis of the previous sections on the assumption that the board is a perfect agent for shareholders. As discussed in the Introduction, the principal purpose of that assumption was to show that shareholders could benefit from limitations on contingent compensation even if there were no agency problems between them and their boards. If there is an agency problem, then the analysis could be more similar to the analysis just considered—think of the board as "captured" by the CEO and the CEO, thus, having the bargaining power. Limitations on contingent compensation would, then, raise shareholder profits; that is, as suggested by Bebchuk (2007) and others, restrictions on pay could help redress the shareholder-board agency problem.

8. Implications

An implication of the analysis, as noted in the Introduction, concerns the politics of executive pay. Shareholders (boards), because of the benefit they derive from being "lashed to the mast," can desire legislation or regulation that restricts executive compensation. Executives, in contrast, do better under formal contracts (*i.e.,* with bonuses) than under purely informal contracts. Hence, executives don't want to see boards lashed to the mast. The political battle lines with regard to executive compensation, such as "say on pay," have indeed had that flavor. For example, major business groups campaigned hard against the Swiss "say-on-pay" referendum of 2013.[35] Similarly, in the US, CEOs tended to oppose the say-on-pay provisions of the Dodd-Frank bill.[36] As remarked on earlier, such explicit conflict is a novel feature of our analysis: in previous work, if one side wishes to see informal contracting facilitated, the other side either does too or is, at worst, indifferent.

That much of this battle has taken place in the political arena and not in shareholder meetings is also consistent with the model: because state action is likely necessary to bind the board to the mast, there is little point to attempting to limit pay on a firm-by-firm basis.

Even absent state action, the model predicts that some firms could utilize contracts with informal components and, correspondingly, little to no compensation contractually tied to performance. All else equal, those firms will tend to be those with (i) capable boards (*i.e.,* able to monitor the CEO's actions); which are (ii) patient (*i.e.,* have relatively high δs); and which face (iii) short-lived or impatient CEOs (*i.e.,* who have relatively low γs).[37] Firms without those attributes will rely more on compensation contractually tied to performance.

These implications suggest a number of empirical tests. Board capability (as defined here) should be positively correlated with director longevity and industry experience. It should also be, *ceteris paribus*, positively correlated with stable environments (such as those with minimal innovation), situations in which directors will tend to understand the firm and its industry (*e.g.,* traditional businesses), and situations in which the actions of the CEO are more transparent to directors (*e.g.,* where there are clear internal metrics). All of those attributes should, thus, correlate negatively with the use and magnitude of performance-contingent compensation, such as stock options or bonuses contractually tied to verifiable targets. Although there are other

[35] See, *e.g.,* "Minders Kampf" by Peter Teuwsen, *Die Zeit*, January 24, 2013. Retrieved from *Zeit Online* May 28, 2013.

[36] See, *e.g.,* "CEOs Openly Oppose Push for Say-on-pay by Shareholders" by Del Jones, *USA Today*, July 17, 2009. Retrieved from *USA Today* website on May 28, 2013.

[37] We hasten to note, however, that, while an increase in $\delta - \gamma$ facilitates the use of informal contracts *ceteris paribus*, it is not *necessary* that $\delta - \gamma$ be large for the firm to wish to utilize an informal component and to benefit from restrictions on bonuses—see, in particular, Corollary 3 and Proposition 4.

models that relate board attributes to compensation (see, *e.g.,* Hermalin, 2005, and Kumar and Sivaramakrishnan, 2008), these particular predictions are, to the best of our knowledge, unique.

The parameter δ captures the extent to which the board (shareholders or principal, more generally) has a long-term perspective. Hence, we would predict that more use of informal contracting and less use of formal contracting is made in industries in which investments take a long time to come to fruition (*e.g.,* mining) *ceteris paribus*. Conversely, in situations in which the principals are short-run players, for instance hedge funds, we would expect them to rely more on performance-contingent compensation. Extending that point, commentators have, in recent decades, expressed concerns about both rapid increases in CEO compensation, especially in the US (see, *e.g.,* Bebchuk and Fried, 2003, 2004, 2005),[38] and increasing short-termism by institutional investors (see, *e.g.,* Bushee, 2001). Our analysis predicts that these two trends are linked: short-termism and lack of engagement correspond to a lower discount factor (smaller δ), which makes it harder to sustain informal contracts, and, thus, lead to increases in executive compensation due to a greater reliance on formal contracts. Conversely, if social and political pressures previously acted as a brake on executive compensation (as suggested by Jensen and Murphy, 1990), then the erosion of such pressures enhances the potential for formal contracting (increase π_{FC}). To the extent institutional investors are like the board in Section 6, their return to engagement (*i.e.,* spending i each period) falls, which rationally leads to less engagement and more short-termism.

The parameter γ reflects not only the CEO's patience, but also how likely he is to "survive" to the next period. When, *ceteris paribus*, the CEO's survival probability is low, then the value of formal contracting is low (Proposition 1), which facilitates the use of informal contracts. This insight suggests some empirical tests: for example, CEO dismissal rates are greater during recessions

[38]Hall and Liebman (1998) document the rapid increase of the 1990s. Kaplan (2012) suggests that this increase in executive pay—at least relative to other high-income groups—"leveled off" after the 1990s. We do not wish to enter into that debate *per se*: but Kaplan's data do indicate that top executives continue to be compensated at real levels well above their long-run average. A recent *New York Times* article, "That Unstoppable Climb in C.E.O. Pay" by Gretchen Morgenson (page 1 of the Business Section, June 29, 2013) suggests that CEO compensation could again be on the rise.

and early in a CEO's tenure.[39] Our model predicts less use of formal contracts (or at least lower performance-contingent pay components) in those situations. Consistent with the latter, Gibbons and Murphy (1992) find evidence that the incentive-pay components of CEO compensation are greater later in their tenure than early in it. To be sure, there are other explanations for this pattern, including the one put forth by Gibbons and Murphy. But these explanations appear distinguishable: in Gibbons and Murphy's model, incentive pay increases to replace the loss of career concerns as the CEO approaches retirement age; in contrast, our model suggests that once the CEO is reasonably well entrenched, his incentive (performance-contingent) pay should increase. It follows that if chronological age or years to normal retirement age is a better predictor of the amount of incentive pay than years since appointment, then Gibbons and Murphy's model has more explanatory power; but if years since appointment is the better predictor, then that would favor our model.

A related phenomenon is that there are reasons to expect a surviving CEO to gain bargaining power *vis-à-vis* his board (see, *e.g.,* Hermalin and Weisbach, 1998). In such models, the level of the CEO's compensation goes up as a consequence, but, as far as we know, those models are silent about the composition of his compensation. Our model indicates how the composition should change: as Section 7 showed, going from a regime in which the board has most of the bargaining power (*e.g.,* early in the CEO's tenure) to one in which the CEO does (*e.g.,* later in his career) will lead to greater use of performance-contingent pay.

Yet another related phenomenon is the growth of CEO bargaining power over time (see, *e.g.,* Frydman and Jenter, 2010, for evidence). An increase in CEO bargaining power necessarily increases the level of their compensation, but need not say anything directly about the composition of their pay. Indeed, within a standard agency framework,[40] it is straightforward to construct models in which a shift in bargaining power to the agent yields contracts with less incentive and more base

[39] See Walker and Wang (2010) for evidence on the relation between dismissal and recessions and Allgood and Farrell (2003) for evidence on the relation between dismissal and tenure.

[40] For instance, Grossman and Hart (1983), Holmstrom (1979), or Shavell (1979).

pay.[41] In contrast, our model predicts such a shift would lead to greater use of incentive pay (*i.e.,* an increase in b) as formal contracting would replace informal contracting. This is consistent with the evidence in Frydman and Jenter, which finds that executive bargaining power and the use of performance-contingent compensation have co-varied positively over time.

The last implication we consider has to do with corporate strategies.[42] Some strategies, especially those with long-term objectives or in which CEOs don't typically "live" to see the fruits of their efforts, could be supportable with informal contracts only (*i.e.,* the board can judge whether the CEO's actions are consistent with the long-term objectives, but, by the time profits reflect this, the CEO is "dead"). Other, more short-term strategies, are implementable via formal contracts. If secular trends undermine informal contracting (*e.g.,* investors or boards become less patient; political and social pressures limiting pay relax; etc.), then firms will find it harder to pursue long-term strategies. Shareholders would, then, lose in two ways: first, because of the regime shift to formal contracting; and, second, because of the shift from long-term strategies to less profitable short-term strategies.

This last implication, as well as some points that preceded it, suggest yet another empirical strategy for testing our model: look for performance differentials when companies' corporate governance systems are at odds with their strategy. For instance, if companies that, by necessity, pursue long-term strategies (*e.g.,* mining firms) make extensive use of formal contracts (perhaps due to an entrenched CEO) we would expect to see worse relative performance *vis-à-vis* companies in the same industry that rely on informal contracts.

[41] See, *e.g.,* Hermalin (1992, Proposition 4) for a model with that property.

[42] An earlier working paper, available from the corresponding author upon request, considered this implication in greater detail.

9. Conclusions

Our main finding is that circumstances exist such that shareholders do better—even when they possess all the bargaining power—if there is an externally imposed cap on contingent CEO pay than if there is not. The basic driver of this result is that an incentive (formal) contract based on outcomes necessarily entails the CEO capturing a rent (in expectation), which lessens the efficiency and profitability of such contracting. Yet, the ability to write formal contracts in the future can undermine the writing of more efficient informal contracts today. If performance (outcome)-based payments are capped, however, formal contracts become an even worse substitute for informal contracts, so the board is less tempted to renege on an informal contract, which facilitates the use of such contracts. Consequently, conditions exist such that limits or caps on performance-based payments increase surplus and company profits (see, in particular, Corollary 3 and Propositions 4 & 5).

This finding is not universal: the benefits of capping performance pay depend on a number of factors, as set forth in Propositions 5–8. Moreover, caps reduce total welfare when the CEO possesses the bargaining power, although shareholders can still benefit from them (see Proposition 8). It is also important to recognize that the optimal policy prescription could be *limits*, not bans, on performance-based compensation (see, *e.g.,* the example following Proposition 5).

As discussed in Section 6, the benefits of restricting performance-based pay also rely on the ability of the board to assess what is going on in the firm. If the board is incapable of observing (understanding) the CEO's actions, then restrictions on performance-based pay will be harmful, not beneficial. That point also runs in reverse: the value of improving board quality is greater when a cap is in place.

Appendix A: Proofs and Additional Material

Some of our analysis relies on the following well-known revealed-preference result, which is worth stating once, at a general level. Note our use of subscripts to denote partial derivatives.

Lemma A.1. Let $f(\cdot,\cdot) : \mathbb{R}^2 \to \mathbb{R}$ be continuously differentiable in each argument. Let $\hat{x}$ maximize $f(x,z)$ and let $\hat{x}'$ maximize $f(x,z')$, where $z > z'$. Suppose that $f_{12}(\cdot,\cdot)$ exists. Assume that cross-partial derivative has a constant sign (not zero) on $[\hat{x}' \wedge \hat{x}, \hat{x}' \vee \hat{x}] \times [z', z]$.[43] Then $\hat{x} \geq \hat{x}'$ if $f_{12}(\cdot,\cdot) > 0$ and $\hat{x} \leq \hat{x}'$ if $f_{12}(\cdot,\cdot) < 0$. The inequalities are strict if either $\hat{x}$ or $\hat{x}'$ (or both) are interior maxima.

Proof: By the definition of an optimum (revealed preference):

$$f(\hat{x}, z) \geq f(\hat{x}', z) \text{ and } f(\hat{x}', z') \geq f(\hat{x}, z')\,. \tag{25}$$

Expression (25) implies, via the fundamental theorem of calculus, that

$$\begin{aligned} 0 \leq \big(f(\hat{x}, z) - f(\hat{x}', z)\big) - \big(f(\hat{x}, z') - f(\hat{x}', z')\big) &= \int_{\hat{x}'}^{\hat{x}} \big(f_1(x, z) - f_1(x, z')\big)dx \\ &= \int_{\hat{x}'}^{\hat{x}} \left(\int_{z'}^{z} f_{12}(x, y)dy\right) dx\,. \end{aligned}$$

Consider the last term: given that $z > z'$, the inner integral is positive if $f_{12}(\cdot,\cdot) > 0$ and negative if $f_{12}(\cdot,\cdot) < 0$. The direction of integration in the outer integral must be weakly left to right (*i.e.,* $\hat{x}' \leq \hat{x}$) if the inner integral is positive and weakly right to left (*i.e.,* $\hat{x}' \geq \hat{x}$) if the inner integral is negative. This establishes the first part of the lemma.

To establish the second part, because $f(\cdot, \zeta)$ is differentiable for all ζ, if $\tilde{x}$ is an interior maximum, then it must satisfy the first-order condition $0 = f_1(\tilde{x}, \zeta)$. Because $f_1(\hat{x}, \cdot)$ is strictly monotone, $f_1(\hat{x}, z) \neq f_1(\hat{x}, z')$, $z \neq z'$. Hence, $\hat{x}$ does not satisfy the necessary first-order condition to maximize $f(\cdot, z')$. Therefore, $\hat{x}' \neq \hat{x}$; that is, the inequalities are strict. ■

Proof of Lemma 1: Surplus is $pg - c(p)$, a continuous function of p. By a well-known theorem

[43] The operator $\wedge$ (the *meet*) denotes the pairwise minimum and the operator $\vee$ (the *join*) denotes the pairwise maximum.

of Weierstrass's (see, *e.g.,* Sundaram, 1996, p. 90), a $p \in [0,1]$ that maximizes that function must then exist. Because $pg - c(p)$ is strictly concave in p, the maximizer of $pg - c(p)$ is unique. That $0 < p^*(g) < 1$ was shown in the discussion preceding the lemma. ■

Proof of Lemma 2: Because $b < g$ and $p^*(g) < 1$, a corner solution in which $p^*(b) = 1$ is impossible.

Consider program (1). If $b = 0$, the solution is $p = 0$. If $b > 0$, then $b - c'(0) = b > 0$, so the solution to (1), $p^*(b)$, must be positive because the program is strictly concave. Strict concavity also means it uniquely solves the first-order condition, $b - c'(p) = 0$; hence,

$$b = c'\big(p^*(b)\big)\,. \tag{26}$$

The function $c(\cdot)$ is strictly convex (recall $c''(\cdot) > 0$) and a convex function lies above its first-order Taylor series approximation; hence, for $b > 0$ and, thus, $p^*(b) > 0$, it must be that

$$c\big(p^*(b)\big) - c'\big(p^*(b)\big)p^*(b) < c(0) = 0\,.$$

Multiplying through by -1 and using (26) yields

$$bp^*(b) - c\big(p^*(b)\big) > 0\,. \tag{27}$$

Because $w \geq 0$ by assumption (the CEO can never be made to pay the firm), expression (27) entails the CEO must earn a rent. ■

Proof of Lemma 3: Were the profit-maximizing $\widetilde{p} = 0$, the firm would lose money unless it offered the formal contract $\langle 0, 0\rangle$. In that case, (2) is trivially an equality.

Suppose, henceforth, that the profit-maximizing $\widetilde{p} > 0$. Suppose that $w > 0$ and (2) is a strict inequality; hence,

$$\gamma w > c(\widetilde{p}) - b\widetilde{p} + (1-\gamma)R(b)\,,$$

which means the firm could profitably reduce w while continuing to satisfy the incentive-compatibility constraint. It cannot, therefore, be that $w > 0$ and (2) is a strict inequality.

Suppose $w = 0$. Because $\widetilde{p} > 0$, $c(\widetilde{p}) > 0$ and, thus, $b > 0$ if (2) is to hold (by Lemma 2 the righthand side of (2) is non-negative). It must be that $\widetilde{p} > p^*(b)$: expression (2) holds as a strict inequality if $\widetilde{p} = p^*(b)$, so the board can raise $\widetilde{p}$, holding w and b fixed, without violating (2). Doing so increases per-period profit by $g - b > 0$ per unit increase in $\widetilde{p}$. Suppose (2) were a strict inequality; that is,

$$b\widetilde{p} - c(\widetilde{p}) - (1-\gamma)R(b) > 0\,.$$

The derivative of the lefthand side with respect to b, holding $\widetilde{p}$ fixed, is $\widetilde{p} - (1-\gamma)p^*(b) > 0$; hence, the board could lower b, thereby increasing expected profit, without violating (2). ■

Proof of Lemma 4: If $\widetilde{p} = 0$, then the firm must set $w = 0$ to avoid a loss. Assume, therefore, that $\widetilde{p} > 0$. Suppose, counter to the lemma's claim, that the firm offers $\langle w_0, b_0\rangle$ in equilibrium, $w_0 > 0$. By Lemma 3, expression (2) holds as an equality. Define

$$y_0 = w_0 + b_0\widetilde{p} \text{ and } \omega(b) = y_0 - b\widetilde{p}\,;$$

that is, y_0 is the CEO's expected compensation—so the firm's cost—under $\langle w_0, b_0\rangle$. The expected cost of any contract $\langle \omega(b), b\rangle$ is y_0. Observe raising b above b_0 while setting $w = \omega(b)$ leaves the lefthand side of (2) unchanged, but *decreases* the righthand side.[44] By continuity, then, there must

[44]The derivative of

$$(1-\gamma)\big(\omega(b) + R(b)\big)$$

with respect to b is, using the envelope theorem,

$$(1-\gamma)\big(p^*(b) - \widetilde{p}\big)\,.$$

exist a $b_1 > b_0$ such that $\omega(b_1) > 0$ and

$$\omega(b_1) + b_1\widetilde{p} - c(\widetilde{p}) > (1-\gamma)\big(\omega(b_1) + R(b_1)\big)\,.$$

But then there exists an $\varepsilon \in \big(0, \omega(b_1)\big)$ such that

$$\omega(b_1) - \varepsilon + b_1\widetilde{p} - c(\widetilde{p}) \geq (1-\gamma)\Big(\omega(b_1) - \varepsilon + R(b_1)\big)\,,$$

which means the firm could have implemented $\widetilde{p}$ using the contract $\langle \omega(b_1) - \varepsilon, b_1 \rangle$, which costs less than y_0: the contract $\langle \omega(b_1) - \varepsilon, b_1 \rangle$ is a profitable deviation, contradicting the supposition that $\langle w_0, b_0 \rangle$ would be offered in equilibrium. The result follows *reductio ad absurdum*. ■

Proof of Lemma 5: Suppose that $\langle w, b \rangle$ is a contract offered in equilibrium. Suppose, contrary to the first claim of the lemma, that there exist $\widetilde{p}'$ and $\widetilde{p}''$, $\widetilde{p}'' > \widetilde{p}' \geq p^*(b)$, such that (2) is an equality both when $\widetilde{p} = \widetilde{p}'$ and when $\widetilde{p} = \widetilde{p}''$. Because $bp - c(p)$ is a strictly concave function of p with a unique maximizer, $p^*(b)$, it must be that

$$b\widetilde{p}'' - c(\widetilde{p}'') < b\widetilde{p}' - c(\widetilde{p}')\,.$$

That insight leads to the contradictory chain:

$$(1-\gamma)\big(w + R(b)\big) = w + b\widetilde{p}'' - c(\widetilde{p}'') < w + b\widetilde{p}' - c(\widetilde{p}') = (1-\gamma)\big(w + R(b)\big)\,.$$

The implicit function theorem entails $\widehat{p}(\cdot,\cdot)$ is differentiable in each argument.

At $b = b_0$, the sign of the derivative is negative because $\widetilde{p} > p^*(b_0)$ in equilibrium.

Differentiating (2) with respect to w yields

$$1 + \Big(b - c'\big(\widehat{p}(w,b)\big)\Big)\frac{\partial \widehat{p}(w,b)}{\partial w} = 1 - \gamma\,.$$

Because $\widehat{p}(w,b) > p^*(b)$, the expression in the largest parentheses is negative, from which it follows that $\partial\widehat{p}(w,b)/\partial w > 0$.

Differentiating (2) with respect to b yields

$$\widehat{p}(w,b) + \Big(b - c'\big(\widehat{p}(w,b)\big)\Big)\frac{\partial \widehat{p}(w,b)}{\partial b} = (1-\gamma)p^*(b)$$

(utilizing the envelope theorem on the righthand side). It follows, given $\widehat{p}(w,b) > p^*(b) \geq (1-\gamma)p^*(b)$, that $\partial\widehat{p}(w,b)/\partial b > 0$. ■

Proof of Proposition 1: Let $y(w,b)$ denote the firm's expected cost (the CEO's expected compensation) in equilibrium given contract $\langle w,b\rangle$. From Lemmas 3 and 5:

$$y(w,b) = c\big(\widehat{p}(w,b)\big) + (1-\gamma)\big(w + R(b)\big)\,. \tag{28}$$

The firm (board) seeks to maximize

$$\widehat{p}(w,b)g - y(w,b)\,. \tag{29}$$

The firm either faces a binding constraint (limit or cap) on bonuses, in which case its only degree of freedom is to adjust w, or it faces no such constraint, in which case, given Lemma 4, $w = 0$ and it adjusts b only. Using (28), the relevant derivative of (29) is

$$\Big(g - c'\big(\widehat{p}(w,\bar{b})\big)\Big)\frac{\partial \widehat{p}(w,\bar{b})}{\partial w} - (1-\gamma) \tag{30}$$

in the first case and

$$\Big(g - c'\big(\widehat{p}(b)\big)\Big)\frac{d\widehat{p}(b)}{db} - (1-\gamma)p^*(b) \tag{31}$$

in the second. Given Lemma 5 and the fact that $g - c'(p) \leq 0$ for all $p \geq p^*(g)$, it follows from (30) or (31), as appropriate, that the firm can never find it profit-maximizing to choose a contract such that $\widehat{p}(w,b) \geq p^*(g)$.[45] It follows that, in equilibrium, $\widehat{p}(w,b) < p^*(g)$, which establishes the first claim.

Fix a γ and let $\langle w, b\rangle$ be the contract the board offers in equilibrium. In equilibrium, the firm earns a positive expected profit; hence, it must be that w or b or both are positive. Suppose γ increases to γ'. Observe, fixing $\widetilde{p} = \widehat{p}(w,b)$, that the lefthand side of (2) is unchanged, while the righthand side falls. It follows that the firm can reduce b or w slightly so that (2) continues to hold at the previously fixed target $\widetilde{p}$. Hence, the firm's expected equilibrium profit must be greater when the CEO's discount factor is γ' than when it is γ. ■

Proof of Lemma 6: Because $\tau(p)$, $p \neq \widetilde{p}$, is relevant only off the equilibrium path, it matters only for the CEO's incentive constraint, expression (9). If (9) holds for an arbitrary $\tau(p)$, it holds if $\tau(p) = 0$. Moreover, relaxing that constraint permits the board to reduce $\tau(\widetilde{p})$, which is both directly beneficial and relaxes the credibility condition; hence, the board is weakly better off setting $\tau(p) = 0$ for $p \neq \widetilde{p}$ than setting any other value for $\tau(p)$. ■

[45] When $w = 0$, it must be that $p^*(b) > 0$ if $\widehat{p}(b) > 0$. To see this, suppose not: the righthand side of (2) is then zero; hence, from Lemma 3, $b\widehat{p}(b) - c\big(\widehat{p}(b)\big) = 0$. Because $\widehat{p}(b) > 0$ and $bp - c(p)$ is strictly concave in p, it follows that $bp - c(p) > 0$ for any $p \in \big(0, \widehat{p}(b)\big)$, which contradicts the claim that $p^*(b) = 0$.

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