Journal of Accounting and Economics 69 (2020) 101300

Contents lists available at ScienceDirect

Journal of Accounting and Economics

journal homepage: www.journals.elsevier.com/journal-of-accounting-and-economics

On the relation between managerial power and CEO pay[☆]

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ARTICLE INFO

Article history:
Received 21 February 2019
Received in revised form 20 January 2020
Accepted 27 January 2020
Available online 5 February 2020

JEL classification:
J33
M40

Keywords:
Executive compensation
Optimal contracting
Managerial power theory
Corporate governance

ABSTRACT

We study how friendly boards design the structure of optimal compensation contracts in favor of powerful CEOs. Our study yields unexpected results. First, powerful managers receive higher pay and a contract with a higher pay-performance sensitivity (PPS) if firm performance is low and vice versa. Moreover, we identify conditions where expected pay and expected PPS are both increasing in the friendliness of the board. Second, we show that friendly boards provide managers with higher salaries, more shares, but less options. Third, friendly boards offering contracts with a higher PPS also make more intensive use of relative performance evaluation (RPE). Overall, our results suggest that frequently used indicators of poor (or sound) compensation practices should be interpreted with care. Extending the scope of our model beyond executive pay, we show that powerful managers underinvest in capital but have less incentives to manage earnings.

1. Introduction

Whether or not the executive compensation practice in public firms reflects arm's length bargaining or rent seeking is one of the most fundamental and controversial issues in empirical compensation research (Core and Guay, 2010). The "arms length bargaining perspective" suggests that executive compensation contracts are designed by boards acting in the best interest of shareholders in order to mitigate the agency problem caused by the separation of ownership and control. In contrast, the "managerial power perspective" argues that weak governance structures allow CEOs to exercise power over the board of directors and to control the level and structure of their own pay.

According to Bebchuk and Fried (2004), CEO-friendly boards[1] inflate pay levels at the expense of shareholders by proposing inefficient compensation contracts featuring an insufficient link between pay and firm performance and/or a lack of control for common risk factors in measuring firm performance. Thus, ceteris paribus, compensation arrangements implemented by friendly boards favoring powerful CEOs should exhibit one ore more of the following characteristics: the

☆ The authors acknowledge helpful comments and suggestions from Michelle Hanlon (the editor), Jeremy Bertomeu (the referee), Davide Cianciaruso, Andrew Clausen, George Drymiotes (discussant), Christian Laux, Thomas Pfeiffer (discussant), Ulrich Schäfer, Stefan Wielenberg (discussant), and seminar participants at the 2017 meeting of the VFSP accounting committee, the 2018 MAS midyear meeting, EAA 2018, 2018 EIASM Workshop on Accounting and Economics, HEC Paris, and UCLA.

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[1] In the following we simply refer to a board that favors the CEO in its compensation decisions as a friendly board (Adams and Ferreira, 2007).

https://doi.org/10.1016/j.jacceco.2020.101300
0165-4101/

compensation is generally *too high*, the pay-performance sensitivity is *too low*, the contract exhibits *reward for luck*, or, equivalently, lacks *relative performance evaluation* (RPE).[2]

Despite the intensity of the debate and the large body of empirical research on the topic,[3] there is surprisingly little theoretical research that addresses the question of whether and how optimal compensation contracts designed by friendly boards differ from those designed in the best interest of shareholders. In this paper, we aim to close this gap by providing a framework for the analysis of the contracting problem faced by friendly boards. To that end, we modify the standard agency model proposed by Mirrlees (1974, 1999) and Holmström (1979). Instead of having the residual claimant(s) (the "principal") design the contract with the CEO (or "agent") this task in our model is delegated to a board of directors. The rationale for this is that the principal here is taken to be an ever-changing group of anonymous and unrelated shareholders lacking the means to coordinate directly on the optimal CEO compensation.

Depending on the board structure and the individuals serving on the board, the board can exhibit varying degrees of preference alignment with shareholders and the CEO. We capture this in our model by assuming that the board maximizes a weighted average of the principal's and the agent's utility, where a higher weight on the agent's utility represents a more friendly board. The specific analysis of our thus augmented principal-agent model suggests that while more friendly boards affect both the pay level and the structure of the optimal compensation contract, the implications of having a friendly board are much more subtle than what is generally suggested by the managerial power perspective.

We first determine the conditions for which the structure of the optimal compensation contract varies in a non-trivial way with the friendliness of the board. We then show that the board uses such a contract to allocate a part of the net surplus to the CEO. While the CEO benefits from such a contract because it promises an expected gain relative to his reservation utility, the resulting allocation is socially wasteful because the contract induces a lower equilibrium effort than a standard Pareto optimal contract designed in the best interest of shareholders.[4]

The optimal compensation contract in our model is convex and has several other interesting properties. First, the realized compensation level conditional on firm performance is not simply an increasing function of the board's friendliness. While friendly boards always provide the agent with higher pay for low performance, there exists a critical performance level above which a friendly board offers a lower compensation than a board acting in the interest of shareholders. Second, while there is always a range of performance levels for which the contract provided by a friendly board exhibits a lower pay-performance-sensitivity (PPS), we identify conditions where the contract offered by a friendly board exhibits a higher PPS than a contract designed in the best interest of shareholders. The reason for these results is that a more friendly board offers a flatter compensation contract that provides higher rewards for low performance but lower rewards for high performance. Whenever the optimal contract is strictly convex, its slope is increasing in firm performance and it can be higher than the slope of the second-best contract that maximizes the firm's expected profit.[5]

To gain further insights into the influence of the board's preference on the optimal structure of the compensation contract, we analyze an optimal quadratic compensation contract in the spirit of Hemmer et al. (1999). For this contract, we determine the impact of a more friendly board on the expected levels of pay and the PPS. Perhaps most surprisingly, we find that not only expected pay but also the expected PPS are increasing as the board becomes more friendly. Moreover, if we consider expected compensation outcomes conditional on firm performance, optimal contracts written by friendly boards exhibit an inverse relation between firm performance, expected pay levels and expected PPS. Specifically, in expectation, firms with below average performance pay more and propose contracts with a higher PPS than the average firm in the population. The opposite is true for firms with friendly boards and superior performance.

As an added advantage, the optimal quadratic contract also closely resembles the compensation mix commonly found in many public firms. Specifically, it can be reasonably approximated by a mix of cash and equity-based compensation that can readily be interpreted as a salary, shares, and at the money options. Using this approximation we find that a more friendly board pays a higher salary, grants more shares, and uses a lower number of options to incentivize the agent.

We study two extension of our baseline model. First, we examine how a friendly board affects the optimal use of RPE and the sensitivity of pay to peer performance. We find that the friendliness of the board neither affects the firm's decision on the performance measures used in the compensation contract nor the rules for aggregating multiple performance measures into a single performance index. Intuitively, even a friendly board optimally insures the CEO against exogenous compensation shocks to improve risk sharing.

[2] The managerial power perspective was put forward by Bebchuk and Fried (2004). Bertrand and Mullainathan (2001) provide theoretical arguments and empirical evidence of reward for luck in executive pay. Core et al. (2005) and Weisbach (2007) provide critical discussion of the managerial power perspective and its key hypotheses.

[3] In the second part of this introduction we summarize the most important empirical findings on the subject. For comprehensive surveys of the empirical literature see Frydman and Jenter (2010) or Murphy (2013).

[4] If the board assigns a relatively low value to the CEO's utility, it implements the second-best contract of the standard agency model. The reason is that the board's most preferred contract is not feasible because it would allocate a negative rent to the CEO. As an extension, we also study a model version where the board must assure that shareholders break even. Not surprisingly, such a constraint essentially limits the extent to which the board can allocate rents to the CEO.

[5] As a limiting case, the optimal contract in our model can also be an affine function of firm performance. In this case, a friendly board offers a contract with a higher constant and a lower slope. Such a contract still provides the agent with higher pay for low performance but the PPS of such a contract is constant and strictly lower than the PPS of a contract designed in the best interest of shareholders.

We also, however, identify conditions where a friendly board provides the agent with a contract that exhibits a higher sensitivity of pay to peer performance than a contract designed in the best interest of shareholders. Particularly, whenever the optimal contract exhibits a higher PPS, it also puts a more negative weight on available measures of peer performance and thus evaluates the CEO's performance more intensively against the performance of his peers. The reason for this result is that the friendliness of the board affects the optimal weight on the aggregate performance index but not the relative weights of single performance measures within the index. Because the optimal peer index puts a positive weight on firm performance and a negative weight on peer performance, the sensitivity of peer performance is proportional to the PPS but has the opposite sign. Overall, these observations suggest that poor governance quality from the perspective of shareholders need not go hand in hand with inflated pay levels, a low PPS, reward for luck, or a lack of RPE.

Finally, we briefly extend the focus of our analysis beyond the structure of executive pay. Specifically, using a multi-task version of the quadratic model in Section 4, we study how the friendliness of the board affects the CEO's investment decisions as well as his earnings management incentives. We find that a contract proposed by a more friendly board induces not only underinvestment but also a lower level of performance manipulation because both decisions are positively related to the agent's equilibrium effort.

Our paper contributes to the literature on the interplay among corporate governance structure, firm performance, and CEO compensation. A large number of empirical studies have examined the relation between various measures of governance quality and the structure and level of executive pay and found mixed results. Core et al. (1999) find a positive association between the level of CEO pay and the number of outside directors on the board that is more pronounced if these directors are appointed by the CEO. Hartzell and Starks (2003) find that firms with a high concentration of institutional ownership exhibit lower levels of executive pay but a higher PPS. On the other hand, Fahlenbrach (2009) studies the association between various proxies of governance quality and executive pay and finds little evidence consistent with the idea that managers of large U.S. corporations design their own compensation contracts.

Chhaochharia and Grinstein (2009) find that the independence requirements for board and committee members introduced by NYSE and Nasdaq after the Sarbanes-Oxley Act of 2002 are associated with a decline of CEO pay in firms that did not comply with these requirements before the regulation became effective. In contrast, Anderson and Bizjak (2003) find little evidence that the level and structure of executive pay varies with the composition of the compensation committee. Likewise, Hwang and Kim (2009) find no significant difference in pay levels among firms with different degrees of formally independent board members. However, using an augmented measure of director independence that considers the social ties between the board and the CEO, they find that (conventionally and socially) independent boards are associated with lower levels of executive pay and a higher PPS. Guthrie et al. (2012) find that key results in Chhaochharia and Grinstein (2009) are driven by outliers and present additional evidence, suggesting that firms with more independent compensation committees exhibit even higher levels of CEO pay.

On the theoretical side, Drymiotes (2007) studies a double moral hazard problem in which the board can improve the information content of the performance signal used for compensating the agent by unobservable monitoring effort. He shows that a commitment to a more friendly board can improve the effectiveness of monitoring process if a commitment to a specific monitoring level is impossible. Kumar and Sivaramakrishnan (2008) study a related problem and find that a more friendly board sometimes improves monitoring efficiency but always proposes an inefficient compensation contract that reduces shareholder value. Moreover, a friendly board always proposes a contract with higher equity-based incentives than a board acting in the best interest of shareholders.[6]

Laux and Mittendorf (2011) consider a setting where a manager must be motivated to search and implement investment projects. They find that a more friendly board improves the CEO's investment incentives by providing the manager with a higher bonus payment in case of project success. While this policy destroys shareholder value if the set of investment opportunities is exogenous, shareholders can actually benefit from a friendly board if the CEO must be motivated to search for investment projects before signing the compensation contract. Ferri and Göx (2018) study the optimal compensation policy of a friendly board in the context of a binary moral hazard model with limited liability. As in Laux and Mittendorf (2011), a more friendly board proposes a contract with a constant salary and a higher bonus for good performance. Ferri and Göx (2018) also show that the limited liability assumption is critical for this result. If wealth transfers between shareholders and the CEO are not restricted, a friendly board always sets second-best effort incentives and adjusts the fixed contractual payment to allocate a part of the total surplus to the agent.

Different from extant literature, our study employs the optimal contracting framework proposed by Holmström (1979) to derive predictions about the consequences of managerial power for the board's compensation decisions. This model, and its quadratic version studied by Hemmer et al. (1999), are particularly convenient for analyzing the underlying research question for at least two reasons. First, the model imposes no explicit restrictions on the structure of the optimal compensation contract. Second, the optimal contract structure in our model varies in a non-trivial ways with the CEO's power over the board and allows us to derive some novel predictions regarding the consequences of managerial power for the structure of the

[6] Other models, such as Hermalin and Weisbach (1998), Hermalin (2005), and Laux (2008) study the relation between the structure of the board and CEO turnover. In these models the board typically acts as a monitor where a friendly board in the sense of Adams and Ferreira (2007) has less incentives to monitor the agent.

optimal contract, the pay level, the PPS, and the optimal use of RPE. Our findings not only facilitate a more nuanced assessment of the managerial power problem but also help interpreting the mixed empirical evidence on the subject.

Our model and findings are also related to recent literature on the role of wealth effects for the contractual solution of the standard agency model. Bertomeu (2015) addresses this question in the context of a capital market model, where each firm exhibits a production technology as in Holmström (1979) and cash flows are an increasing function of a controllable performance measure and an independent but undiversifiable market shock.[7] In this setting, the compensation level is increasing in the market shock and the PPS varies in the same direction as the agent's risk tolerance. That is, the PPS is increasing in the market shock if the agent has DARA (decreasing absolute risk aversion) preferences and constant with CARA (decreasing absolute risk aversion) preferences. These results are consistent with the structure of the optimal compensation in our model where the pay level and the PPS are generally increasing functions of realized firm performance if the contract is strictly convex.

Our analysis of the role of managerial power for the use of RPE adds to an existing literature explaining the lack of RPE in the context of optimal contracting models. Other arguments for the lack of RPE are the softening of product market competition (Aggarwal and Samwick, 1999), the presence of costly hedging opportunities for the agent and the presence of relative wealth concerns (Fischer, 1999; Fershtman et al., 2003; Garvey and Milbourn, 2003; Bertomeu, 2015), discriminatory taxes on non-performance-based compensation components (Göx, 2008), or the CEO's ability to choose the firm's common risk exposure (Gopalan et al., 2010). In all these cases, even a board acting in the best interest of shareholders optimally designs a contract that partly rewards the CEO for peer performance. On the other hand, and consistent with our findings, there is little theoretical support for the lack of RPE as a consequence of governance failures as suggested by the empirical results of Bertrand and Mullainathan (2001).[8]

The rest of this paper is organized as follows. In Section 2, we lay out the model assumptions. In Section 3, we derive the structure of the optimal compensation contract and discuss its properties. In Section 4, we provide further insights into the structure of the optimal compensation contract and discuss empirical implications of our results. The section uses a quadratic contract structure as in Hemmer et al. (1999). In Section 5, we study two extensions. First, we ask how the presence of a friendly board affects the optimal use of RPE. Second, we study how managerial power affects investment decisions and performance manipulation. In Section 6 we end this paper with a summary and some suggestions for empirical research. All proofs not shown in the main part of the papers are in the Appendix.

2. Model

We consider an agency problem as in Holmström (1979). A risk and effort-averse CEO (the agent) exerts unobservable effort $a \in [0, \overline{a}]$ on behalf of a group of risk neutral shareholders (the principal). The agent has additively separable utility $U(s) - C(a)$, where $U(s)$ is the utility derived from monetary compensation s and $C(a)$ is the agent's personal cost of effort. We assume that $U_s > 0$, $U_{ss} < 0$, $C_a > 0$, and $C_{aa} > 0$, where subscripts denote (partial) derivatives. The agent's effort stochastically affects the firm's output $x \in [0, \overline{x}]$ via the distribution $F(x,a)$ with twice continuously differentiable density function $f(x,a)$. We limit our attention to the class of exponential density functions

$$f(x,a) = \kappa(x) \cdot G_0(a) \cdot \exp(G_1(a) \cdot x). \tag{1}$$

This class of probability distributions has been widely used in the agency literature (e.g. Holmström, 1979; Amershi and Hughes, 1989; Banker and Datar, 1989), it contains well-known distributions such as the Exponential, the Gamma, or the Poisson distribution. A convenient feature of this distribution class is the fact that the likelihood ratio,

$$h(x,a) = \frac{f_a(x,a)}{f(x,a)} = g_1(a) \cdot (x - E[x]), \tag{2}$$

is an affine function of firm performance x, where $g_1(a) = G_1'(a)$.[9] To facilitate the analysis, we assume that the agent's utility function belongs to the HARA (hyperbolic absolute risk aversion) class

$$U(s) = \frac{(1-q)}{q} \cdot \left(\frac{c_1 s}{1-q} + c_2\right)^q, \tag{3}$$

[7] Bertomeu et al. (2018) employ a calibrated version of the model in Bertomeu (2015) to examine empirically the relation between factor returns and performance pay.

[8] An exception is Dikolli et al. (2018) who examine a linear agency model in which the CEO can decide how much peer performance is weighted in his compensation contract but shareholders can set all other contract parameters. With these assumptions, the best linear compensation contract removes less common risk from the agent's compensation than a contract where all parameters are designed by the firm's shareholders.

[9] It is straightforward to show that $E[x] = -G_0'(a)/[G_1'(a) \bullet G_0(a)]$. For example, if $\tilde{x} \sim \Gamma(k, a)$, where k is the shape parameter and a is the scale parameter, it holds that $\kappa(x) = x^{k-1}$, $G_0(a) = 1/(\Gamma(k) \cdot a^k)$, $G_1(a) = -1/a$, and $E[x] = ak$.

with parameter q in the range $[0, 1/2]$ and positive constants c_1 and c_2. With these assumptions, our model satisfies Jewitt's conditions for the validity of the first-order approach (Jewitt, 1988).[10] Considering the range of q, our model encompasses a wide range of utility functions such as power utility or logarithmic utility. For this class of utility functions, the reciprocal of the agent's marginal utility $1/U_s(s)$ is concave in s which implies that the compensation function in our model belongs to the empirical relevant class of convex compensation contracts.[11] Further, because $q < 1$, the agent's utility function exhibits decreasing absolute risk aversion (DARA) as in Bertomeu (2015).

To compensate the agent for his effort, the firm offers him a performance-based compensation contract $s(x)$, where the structure of the likelihood ratio in (2) implies that s is increasing in x. With these assumptions, the expected utilities of the principal (4) and the agent (5) are:

$$V(s,a) = \int (x - s(x))f(x,a)dx, \tag{4}$$

$$H(s,a) = \int U(s(x))f(x,a)dx - C(a). \tag{5}$$

Different from Holmström (1979), we assume that the decision on the agent's compensation contract is not taken by the firm's shareholders but by a board of directors that maximizes a weighted average of the agent's and the principal's utilities[12] in (4) and (5).

$$B(s,a) = (1-\gamma) \cdot V(s,a) + \gamma \cdot H(s,a). \tag{6}$$

The weighting factor $\gamma \in [0,1]$ captures the CEO's power over the board (Drymiotes, 2007; Kumar and Sivaramakrishnan, 2008). Equivalently, γ could represent the board's friendliness, or its affinity with the CEO.[13] The higher γ, the more weight the board puts on the CEO's utility in deciding on $s(x)$. At the extremes, if $\gamma = 1$, the board's objectives are perfectly aligned with those of the CEO, whereas for $\gamma = 0$, the board sets the CEO's compensation as to maximize shareholder value. The board's problem consists of maximizing (6) subject to the following two constraints

$$H_a(s,a) = \int U(s(x)) \cdot f_a(x,a)dx - C_a(a) = 0 \tag{7}$$

$$H(s,a) \geq \underline{H} \tag{8}$$

Condition (7) is the agent's incentive constraint. It requires that the equilibrium effort maximizes the agent's expected utility. Condition (8) is the agent's participation constraint. It assures that the agent accepts the contract and works for the firm, where $\underline{H}$ is the utility derived from alternative employment opportunities in the managerial labor market.

3. Optimal contract with a friendly board

In this section, we study how a friendly board affects the CEO's compensation. Lemma 1 characterizes the structure of the optimal contract found after maximizing the board's objective function in (6) subject to the agent's incentive constraint in (7) and the participation constraint in (8).

Lemma 1. *For a given friendliness of the board $\gamma \in [0,1)$ the optimal compensation contract takes the form*

$$\frac{1}{U_s(s(x))} = \alpha + \beta \cdot h(x,a), \tag{9}$$

[10] The class of density functions in (1) in conjunction with the concavity of the agent's utility derived from the optimal compensation contract assures the validity of the first-order approach (Jewitt, 1988, Theorem 1 and Corollary 1). For the HARA utility in (3), the agent's utility derived from the optimal contract is concave if $q \in [0, 1/2]$. Therefore, we limit q to this range.

[11] The central components of CEO pay are salary, bonus, restricted shares, stock options, and pension benefits (e.g. Larcker and Tayan, 2011). Combining these components into a compensation contract yields a convex function of the firm's stock price (Core et al., 2003).

[12] In principle, the board's objective function could also be modeled as a weighted average of the players' certainty equivalents. Unfortunately, this alternative is not tractable in the context of Holmström (1979) because it does not allow us to characterize the agent's incentive constraint in closed form.

[13] More generally, if we rescale the objective function in (6) and rewrite it as $V(s,a) + \frac{\gamma}{1-\gamma} \cdot H(s,a)$, the board's objective can be interpreted as a welfare function with $\gamma/(1-\gamma)$ being the Pareto weight that determines how the expected surplus of the agency is allocated between the principal and the agent. The weight $\gamma/(1-\gamma)$ can best be interpreted as the relative bargaining power of the agent vis-a-vis the principal (Bolton and Dewatripont, 2005). We elaborate on this point in more detail in section 3.

$$\text{where} \quad \alpha = \frac{\gamma + \lambda}{1-\gamma}, \quad \beta = \frac{\mu}{1-\gamma}, \tag{10}$$

and λ *and* μ *are the Lagrangian multipliers associated with the agent's incentive and participation constraints in* (7) and (8), *respectively. The optimal weight on the likelihood ratio,* β, *is increasing in the agent's effort* a.

The expression in (9) implicitly determines the structure of the optimal compensation contract. As in Holmström (1979), the optimal contract is found where the reciprocal of the agent's marginal utility equals an affine function of the likelihood ratio. The parameters α and β determine to what extent the agent's compensation depends on the magnitude of the likelihood ratio $h(x,a)$. Quite intuitively, a higher weight on the likelihood ratio aligns the agent's pay more closely to firm performance and induces a higher equilibrium effort such that a is increasing in β and vice versa. Since the likelihood ratio in our model is linear, we can rewrite the argument of the agent's compensation function on the right hand side of (9),

$$z(x) = \alpha + \beta \cdot h(x,a) = z_0 + z_x \cdot x, \tag{11}$$

as an affine function of firm performance with constant z_0 and slope z_x, where

$$z_x = \beta \cdot g_1(a) \quad \text{and} \quad z_0 = \alpha - z_x \cdot E[x]. \tag{12}$$

The relative magnitude of these parameters determines the shape of the agent's compensation function. Their values depend on the optimal solution of the agency problem in Lemma 1 and the extent to which this solution is affected by the friendliness of the board.

Proposition 1. *There is a critical level of friendliness* $\underline{\gamma} \in (0,1)$ *such that*

i) *If* $\gamma \in (\underline{\gamma}, 1)$, *only the agent's incentive constraint is binding* $(\mu > 0, \lambda = 0)$. *In this case,* $\alpha = \gamma/(1-\gamma)$ *is increasing in* γ *and* β *is decreasing in* γ. *The optimal contract implements the effort* $a = a^*$. *The optimal effort level* a^* *is decreasing in* γ.
ii) *If* $\gamma \le \underline{\gamma}$, *the agent's incentive and participation constraints are binding* $(\mu > 0, \lambda > 0)$ *and the contract parameters* α *and* β *in* (10) *are constants. The optimal contract implements a constant effort level* $a = \underline{a}$ *for all* $\gamma \in [0, \underline{\gamma}]$.

There are two solutions to the board's contracting problem. First, if the board's objectives are closely aligned with the interests of shareholders ($\gamma \le \underline{\gamma}$), the optimal contract in (9) replicates the solution of the standard agency model in Holmström (1979). In fact, for $\gamma = 0$ it holds that $\lambda = \underline{\alpha}$ and $\mu = \underline{\beta}$, so that the contract takes the well-known form.

$$\frac{1}{U_s(s(x))} = \lambda + \mu \cdot h(x,a). \tag{13}$$

Interestingly, the contract in (13) is not only optimal for a board acting in the best interest of shareholders but also for boards considering the CEO's utility in their compensation decision. In fact, we find that all boards with types $\gamma \le \underline{\gamma}$ offer the same contract to the CEO and implement a constant equilibrium $a = \underline{a}$. The reason for this result is that boards with a degree of friendliness below $\underline{\gamma}$ actually prefer a contract that violates the agent's participation constraint. Because the agent does not accept such a contract, all boards with a degree of friendliness $\gamma \le \underline{\gamma}$ choose the same contract as a board acting in the best interest of shareholders.

Second, if $\gamma \in (\underline{\gamma}, 1)$, the board optimally implements a contract that provides the agent with an expected utility above his reservation utility $\underline{H}$.[14] As a consequence, the optimal contract splits the surplus of the agency between the CEO and the firm's shareholders. To implement such an allocation, the board chooses the contract parameters in (10) so that the constant α is higher and the weight β on the likelihood ratio is lower than for the standard contract with a binding participation constraint. Taken together, these changes imply that a more friendly board induces a lower equilibrium effort on the part of the agent. These effects are summarized in Fig. 1.

To explain why a more friendly board implements a lower equilibrium effort, we note that a higher value of α increases the agent's compensation independent of realized firm performance. This change in the contract structure is economically equivalent to an exogenous increase of the agent's wealth. However, since the agent's utility function exhibits DARA, a higher level of wealth reduces the agent's marginal utility of performance-based pay.[15] It follows that

[14] In the absence of a participation constraint for shareholders, the unconstrained solution only yields meaningful results if $\gamma \in (\underline{\gamma}, 1)$. The reason is that $\alpha = \gamma/(1-\gamma)$ becomes infinitely large as γ goes to 1. We formally derive the solution for this case as an extension in Corollary 2.

[15] In fact, let $\pi = \beta h(x,a)$ denote the performance-based component in the argument of the agent's reduced-form utility function. It holds that $w_{\pi\alpha} = w''(\alpha + \pi) \le 0$ because $w(\cdot)$ is concave in its argument.

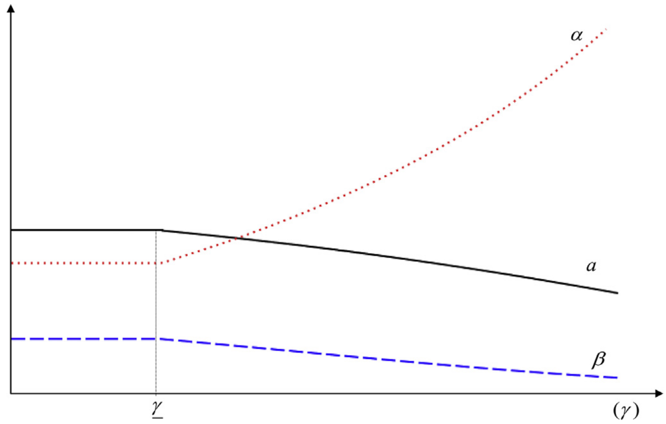

Fig. 1. Optimal contract parameters and equilibrium effort.
The figure shows how the contract parameters and the agent's effort vary with the friendliness of the board. The solid curve shows the agent's equilibrium effort, the dotted curve shows the parameter α and the dashed curve shows β, the weight on the likelihood ratio. The figure is drawn for $H(a,s) = 2\sqrt{s} - a^2$ and $\tilde{x}\sim\Gamma(2, a)$.

the principal faces a higher marginal cost for inducing a given effort level as α is increasing. As a consequence, a more friendly board cuts back the incentive component β of the agent's compensation contract and rationally implements a lower equilibrium effort. This outcome also explains why β is decreasing in γ. The more friendly the board, the more pronounced are the changes to the structure of the compensation contract and the lower the agent's equilibrium effort.

Corollary 1. *Consider the unconstrained contract in Proposition 1. For a given degree of friendliness $\gamma \in (\underline{\gamma}, 1)$, there is an equivalent constrained contract where the agent's reservation utility equals $\underline{H} + \Delta_H$, the agent's participation constraint is binding, and the optimal contract implements the effort level $a = a^*$.*

If we interpret the agent's reservation utility $\underline{H}$ as the value of the agent's outside opportunity in a competitive managerial labor market, the CEO's power over the board represents a deviation from arm's length contracting in the sense that a sufficiently friendly board pays the agent more than the equilibrium wage in a competitive labor market. Moreover, holding the market determinants of the agent's reservation utility fixed, an increase of γ in the relevant range $\gamma \in (\underline{\gamma}, 1)$ is equivalent to an increase in the agent's reservation utility unsupported by market factors. Therefore, any unconstrained contract for $\gamma \in (\underline{\gamma}, 1)$ in Proposition 1 can be replaced by an equivalent constrained contract with a binding participation constraint and a reservation utility $\underline{H} + \Delta_H$ so that both contracts are identical and implement the same equilibrium effort. Because a more friendly board allocates a higher rent to the CEO, a higher value of γ is equivalent to an increase of the agent's reservation utility as measured by a higher value of Δ_H.

We study next how the friendliness of the board affects the agent's compensation and the pay-performance sensitivity (PPS). To this end, we first derive the closed form of the optimal contract for the HARA utility function in (3).

Lemma 2. *Let $P(x) = s_x(x)$ denote the PPS of the optimal compensation contract. In equilibrium, the agent's compensation and the PPS equal*

$$s(x) = (1-q)\cdot\left(c_1^{\frac{q}{1-q}}\cdot z(x)^{\frac{1}{1-q}} - \frac{c_2}{c_1}\right), \tag{14}$$

$$P(x) = z_x\cdot(c_1\cdot z(x))^{\frac{q}{1-q}}. \tag{15}$$

where $z(x) = z_0 + z_x \cdot x$ as defined in (11). If $q \in (0, 0.5]$, $s(x)$ is strictly convex and $P(x)$ is increasing in x. If q approaches zero, $s(x)$ becomes an affine function of x and $P(x)$ is a constant.

First, for an arbitrary nonnegative parameter $q \le 0.5$ the agent's compensation is monotonically increasing in $z(x)$. Because $z(x)$ is an affine function of x by the monotonicity of the likelihood ratio, the agent's compensation is increasing in the firm performance x. Second, for HARA utility with parameter $q \in (0, 1/2]$ the compensation function is strictly convex. This structure implies that PPS is not a constant but an increasing function and the realized performance level

x.[16] Third, if q goes to zero, the optimal compensation function becomes an affine function of firm performance and the PPS is independent of x.

Proposition 2. *Let $s_i(x)$ and $P_i(x)$ denote the optimal contract and the PPS proposed by two arbitrary boards ($i = A, B$) with friendliness $\gamma_i \in (\underline{\gamma}, 1)$ and suppose that $\gamma_B > \gamma_A$.*

i) *There exists a critical performance level $x_0 > 0$ such that $s_B(x) > s_A(x)$ if $x < x_0$ and $s_B(x) \leq s_A(x)$ if $x \geq x_0$.*
ii) *There is always a range of performance levels for which $P_B(x) < P_A(x)$.*
- *If $s(x)$ is linear $P_B(x) < P_A(x)$ for all x.*
- *If $s(x)$ is strictly convex and $P_B(0) > P_A(0)$, there exists a critical performance level $x_1 > 0$ so that $P_B(x) > P_A(x)$ if $x < x_1$ and $P_B(x) \leq P_A(x)$ if $x \geq x_1$.*

Perhaps surprisingly, a friendly board does not necessarily pay a higher compensation to the CEO. In fact, we identify conditions under which a friendly board finds it optimal to raise the CEO's compensation for low levels of firm performance but to cut the CEO's compensation for high levels of firm performance. As we show in the Proof of Proposition 2, there is always a strictly positive cut-off level x_0 beyond which a friendly board lowers the CEO's compensation relative to a board acting in the interest of shareholders. Thus, according to our analysis, high pay-levels in the presence of a high firm performance are an indicator of a compensation policy in the best interest of shareholders, whereas high pay levels in the presence of low firm performance indicate a compensation policy that favors the CEO.

Furthermore, a friendly board does not necessarily provide the CEO with a contract that exhibits a lower PPS. Interestingly, we find that the PPS is only generally decreasing in γ if the optimal compensation contract is linear in x. More generally, we find that for the class of strictly convex optimal compensation contracts, the PPS can in fact be decreasing or increasing in γ. To be precise, we identify conditions for the existence of a cut-off level x_1 below which the optimal contract provided by a friendly board exhibits a higher PPS than the contract proposed by a board acting in the best interest of shareholders.

These results can be intuitively understood if we study how a friendly board affects the argument $z(x)$ of the agent's compensation function (14). As illustrated in Fig. 2, a more friendly board raises the constant component z_0 and lowers the slope parameter z_x. Put differently, a more friendly board uses a flatter function $z(x)$ as the argument of the agent's compensation function. Because the agent's compensation is monotonically increasing in $z(x)$, a more friendly board must offer a higher compensation for low performance levels and a lower compensation for high performance levels. Because the same observation holds for the argument of the PPS, a more friendly board always offers a lower PPS for high performance levels. However, a closer inspection of the expression in (15) shows that the PPS is scaled by z_x. Because z_x is decreasing in γ, and $z(0) = z_0$ is increasing in γ, there is a range of low performance levels for which a friendly board proposes optimal contract with a higher PPS whenever $P(0) = z_x \cdot (c_1 \cdot z_0)^{\frac{q}{1-q}}$ is increasing in γ. Otherwise, the PPS is lower for all performance levels as for a linear contract.

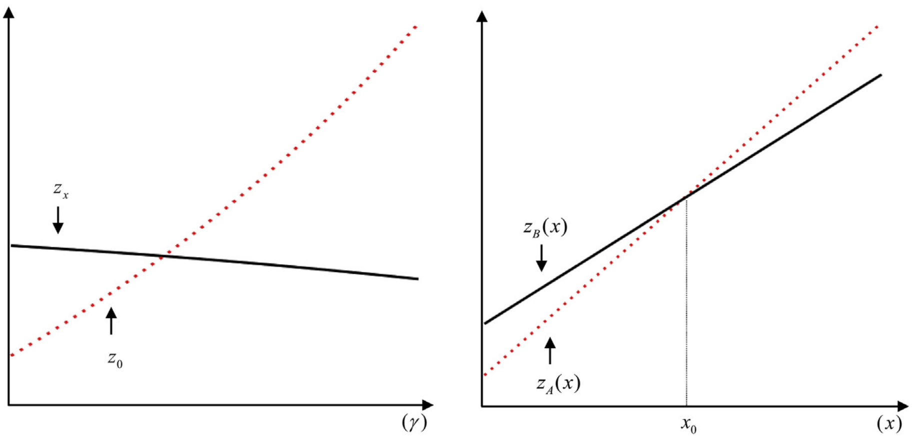

Fig. 2. Optimal elements of the compensation function.
The figure shows how the argument $z(x)$ of the agent's compensation function varies with the friendliness of the board. The left panel shows how the constant z_0 and the slope z_x vary with γ. The right panel shows $z(x)$ for the values $\gamma_A = 0.4$ and $\gamma_B = 0.6$. The figures are drawn for $H(a, s) = 2\sqrt{s} - a^2$ and $\tilde{x} \sim \Gamma(2, a)$.

[16] This result is consistent with the findings of Bertomeu (2015). He studies a closely related agency model with a different focus and without considering governance issues. In his model the agent's pay and the firm's output are functions of a controllable performance measure y and a state variable s. He shows that the sensitivity of pay with respect to y is increasing in s if the agent has DARA preferences and constant if he has CARA preferences.

One limitation of our model is the fact the optimal contract imposes no upper limit on the agent's expected compensation. As a consequence, the board's compensation policy might fail to receive shareholder support. In fact, it can been seen from the expression for the optimal value of α in Proposition 1 that the lump sum component of the agent's pay can become very large as γ goes to one. To account for the fact that such a contract must be acceptable by shareholders, we can always add a participation constraint for shareholders to our model without changing its key insights. The solution of this model extension is summarized in Corollary 2. Essentially a participation constraint for shareholders is economically equivalent to an upper limit $\overline{\gamma} < 1$ for the board's friendliness so that all boards with friendliness $\gamma > \overline{\gamma}$ optimally implement the same contract as the board with $\overline{\gamma}$.

Corollary 2. *Suppose that shareholders must break even such that $V(s,a) \geq 0$. There exists a degree of friendliness $\overline{\gamma} < 1$ such that the shareholders' participation constraint is binding and the board implements a constant effort level $a = \overline{a}$ for all $\gamma \in [\overline{\gamma}, 1]$.*

Taken together, these results clearly contradict the predictions of the managerial power perspective that poor governance quality goes hand in hand with inflated pay levels and a weaker link between pay and firm performance. According to our analysis, the impact of friendly boards on CEO pay levels and the PPS cannot be determined independent of the firm's performance level due to the convexity of the optimal compensation contract. For the same reason, the magnitude of the PPS cannot be taken as an indicator of the severeness of the underlying agency problem without reference to the realized performance level. In Section 4, we explore these issues in greater detail in the context of a quadratic setting that allows us to derive the optimal compensation contract in closed form.

4. An optimal quadratic compensation contract

In this section, we study the properties of an optimal convex compensation contract that exhibits the main features of equity-based incentive schemes used by most public firms. Suppose that the agent has utility $U(s) = 2\sqrt{s}$ and the effort cost function is $C(a) = a^2$. The utility function is a special case of the HARA utility function in (3) considering that $q = c_1 = 1/2$ and $c_2 = 3s$. As in Hemmer et al. (1999) we let $\tilde{x} \sim \Gamma(k,a)$, where $k > 0$ is the shape parameter and a is scale parameter. The agent's effort and the parameter k affect the moments of the distribution and the shape of the density function. The expectation $E[x] = ka$ and variance $Var(x) = ka^2$ of firm performance x are both increasing in a and k. For low values of k, the density

$$f(x,a) = \frac{x^{k-1} \cdot \exp\left(-\frac{x}{a}\right)}{\Gamma(k) \cdot a^k}, \tag{16}$$

is skewed to the left, whereas for higher values of k, the density tends to become more centered around the mean. The likelihood ratio of the Gamma distribution is a special case of (2) and takes the form

$$h(x,a) = \frac{x - E[x]}{a^2}.$$

Using these assumptions and the definition of $z(x)$ in equation (11), the agent's compensation contract takes the quadratic form

$$s(x) = (z_0 + z_x \cdot x)^2, \quad \text{where} \quad z_0 = \alpha - a^2, \quad z_x = \frac{a}{k}. \tag{17}$$

Because α is increasing in γ and a is decreasing in γ, z_0 is increasing and z_x is decreasing if the board becomes more friendly. The PPS,

$$P(x) = 2z_0 z_x + 2z_x^2 \cdot x, \tag{18}$$

of the optimal contract $s(x)$ is an affine increasing function of the firm's stock price.

Fig. 3 compares the optimal compensation functions and the PPS for the standard contract proposed by a board that maximizes shareholder value ($\gamma = 0$) with two contracts proposed by friendly boards ($\gamma = \gamma_i$, $i = A, B$) such that $\gamma_B > \gamma_A > \underline{\gamma}$ and only the agent's IC constraint is binding. The solid curves show the standard contract $s(x,0)$ and its PPS $P(x, 0)$. The dashed curves show the contract $s(x, \gamma_A)$ and its PPS $P(x, \gamma_A)$. The dotted curves show the contract $s(x, \gamma_B)$ and its PPS $P(x, \gamma_B)$.

The dashed (dotted) curve in the left panel lies above the solid curve for performance levels below x_{0A} (x_{0B}) and above it for performance levels beyond these critical values. In line with Proposition 2, a friendly board provides the CEO with higher pay for low performance levels and with lower pay for high performance levels relative to a board acting in the best interest of shareholders. The right panel provides a comparison of the PPS for the three compensation types. As for the left panel, the dashed (dotted) line lies above the solid line for performance levels below x_{1A} (x_{1B}) and above it for performance levels above

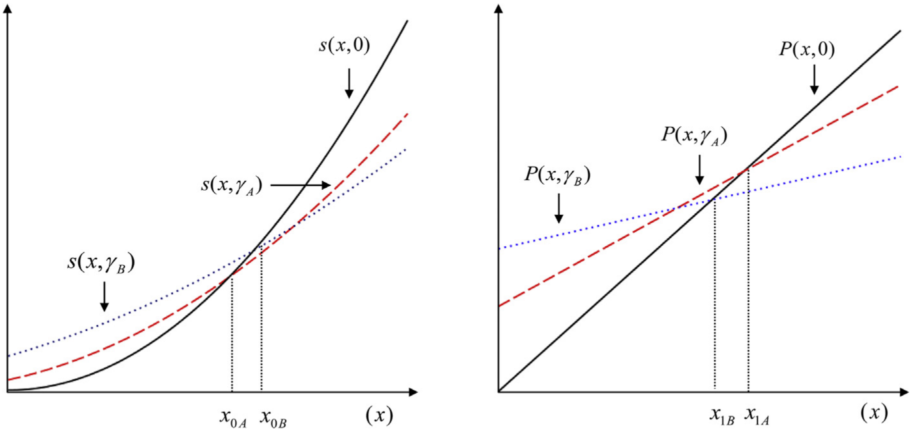

Fig. 3. Total compensation and PPS for optimal quadratic contract.
The left panel shows the compensation and the right panel the PPS for the optimal contract in (17), $k = 2$, and different γ. The solid curves represent the standard contract $s(x,0)$ and its PPS $P(x,0)$ for $\gamma = 0$ and $\underline{H} = C(a)$. The dashed (dotted) curves show contracts for friendly boards with $\gamma_A = 0.55$ ($\gamma_B = 0.70$). The intersection points at x_{0i} (x_{1i}), $i = A, B$ denote performance levels above which friendly boards offer higher pay (a higher PPS) than shareholders.

these values. Moreover, since $x_{0B} > x_{0A}$ but $x_{1A} > x_{1B}$, the range of performance levels for which the board provides the agent with higher pay (a higher PPS) is increasing (shrinking) as γ gets larger. The reason is that a more friendly board not only pays more for low performance but also implements a flatter contract.

These observations are relevant for proxy advisors and activist investors who seek to evaluate the efficiency of compensation contracts at the firm level. In contrast, empirical studies typically capture the aggregate relation between governance variables and compensation measures in a sample of firms. Our next result shows how a more friendly board affects expected compensation.

Proposition 3. *Consider the optimal quadratic contract $s(x)$ with the parameters in* (17). *In expectation, the pay level and the PPS are increasing in γ for all $\gamma \in (\underline{\gamma}, 1)$.*

As illustrated in Fig. 4, a more friendly board is associated with an increase of expected pay levels and an increase of the expected PPS. While the first part of Proposition 3 is consistent with the predictions of the managerial power perspective, the second is clearly not. Particularly, our findings suggest that, on average, high pay levels and a high PPS are suitable indicators of a compensation policy in the interest of the CEO rather than in the interest of shareholders. Put differently, a high PPS cannot be taken as evidence of sound compensation practice without carefully considering the realized performance level and the shape of the optimal compensation contract.

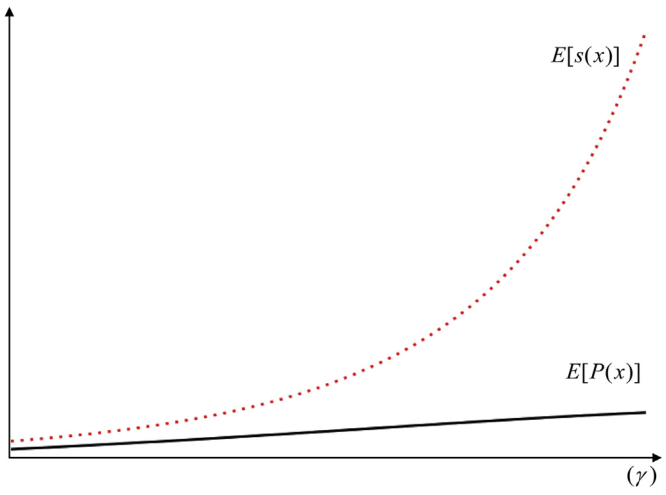

Fig. 4. Expected pay and expected PPS for optimal quadratic contract.
The dotted curve shows expected pay $E[s(x)]$ and the solid curve the expected PPS $E[P(x)]$ as a function of friendliness γ for the optimal contract in (17) and $k = 2$.

Table 1
Expected pay and PPS conditional on performance.
The table shows expected pay levels and the expected PPS conditional on firm performance x being above ($E_+[\cdot] = E[\cdot|x > E[x]]$) or below ($E_-[\cdot] = E[\cdot|x \le E[x]]$) expected performance $E[x]$. All values shown in the table are calculated for the optimal contract in (17) and $k = 2$.

γ	$E_-[s(x)]$	$E[s(x)]$	$E_+[s(x)]$	$E_-[P(x)]$	$E[P(x)]$	$E_+[P(x)]$
0.00	0.21	0.60	0.86	0.40	0.50	0.57
0.45	0.51	0.82	1.03	0.62	0.60	0.59
0.50	0.93	1.11	1.23	0.79	0.68	0.61
0.55	1.62	1.57	1.54	0.95	0.76	0.63
0.60	2.72	2.30	2.01	1.10	0.83	0.64

Table 1 shows expected pay levels and expected PPS conditional on firm performance for the optimal contract in (17), and different levels of board friendliness. Specifically, the table compares the population means to the conditional means of firms with performance above and below the population mean holding γ constant for all firms. If all boards act in the best interest of shareholders ($\gamma = 0$), the average low performance firm pays less ($E_-[s(x)] = 0.21$) and exhibits a lower PPS ($E_-[P(x)] = 0.40$) than the average firm in the population ($E[s(x)] = 0.60, E[P(x)] = 0.50$). In contrast, the average high performance firm pays more ($E_+[s(x)] = 0.86$) and exhibits a higher PPS ($E_+[P(x)] = 0.57$) than the average firm in the population. Put differently, if boards write contracts in the best interest of shareholders, there is a monotonic relation between firm performance, expected pay levels and the expected PPS in the sense that firms with a superior performance should be expected to pay more and to exhibit a higher PPS. The opposite is true for firms with below-average performance.

However, if all boards become more friendly, this relation can be reversed. For example, if $\gamma = 0.55$, the average low performance firm pays more (1.62) and the average high performing firm pays less (1.54) than the average firm in the population (1.57). The same relation holds for the PPS, with values of 0.95 for the average low performing firm, 0.76 for the average firm in the population, and 0.63 for the average high performing firm. Thus, if boards write contracts in the interest of the CEO rather than in the interest of shareholders, firms with a superior performance should be expected to pay less and to exhibit a lower PPS than the average firm in the population. In contrast, firms with below-average performance should be expected to pay more and to have a higher PPS than the average firm in the population. These results suggest, that a test for the monotonicity of sample means conditional on realized firm performance could provide a more nuanced view on the empirical relation between measures of governance quality and firms' compensation structure.

The structure of the optimal contract $s(x)$ closely resembles the payoff profile of a typical CEO compensation package. Suppose that x represents the firm's stock price, then the shape of $s(x)$ can be reasonably approximated by a piecewise linear compensation function[17]

$$\sigma(x) = \begin{cases} w + nx & \text{if} \quad 0 \le x < E[x] \\ w + nx + m(x - E[x]) & \text{if} \quad E[x] \le x. \end{cases} \tag{19}$$

The function $\sigma(x)$ allows us to interpret the structure of the optimal compensation contract $s(x)$ as a combination of frequently used compensation components. It combines a salary of w with a portfolio of n shares and m at the money options with a strike price reflecting the firm's expected stock price at the grant date. The left panel of Fig. 5 depicts the optimal contract and its approximation where the solid curve represents $s(x)$ and the dashed function represents $\sigma(x)$.

In the example, the upper bound of the relevant stock prices range is chosen so that $F(\hat{x}, a) = 0.99$. This choice implies that the difference between $\sigma(x)$ and $s(x)$ is small but positive except for the unlikely event of an extraordinary high stock performance for which $s(x)$ can become considerably larger than $\sigma(x)$. The pay components of the piecewise linear approximation $\sigma(x)$ can be expressed as functions of the contract parameters z_0 and z_x, where

$$w = z_0^2, \quad n = 2 \cdot z_0 \cdot z_x + z_x^2 \cdot E[x], \quad m = z_x^2 \cdot \hat{x}. \tag{20}$$

Considering the definitions of z_0 and z_x in (17), all three pay components in (20) are functions of the agent's equilibrium effort and the contract parameters α measuring the friendliness of the board. Evaluating the resulting expressions allows us to determine how the contract components vary with the magnitude of the CEO's power over the board.

Proposition 4. *Suppose that the firm implements the optimal contract $s(x)$ and consider the piecewise approximation $\sigma(x)$ in (19). Then, for all $\gamma \in (\underline{\gamma}, 1)$ the salary is increasing in γ, the number of shares is increasing in γ, and the number of options is decreasing in γ.*

The friendliness of the board affects the components of the agent's pay package $\sigma(x)$ as well as the strike price in different ways. As illustrated in the right panel of Fig. 5, the salary and the number of shares are increasing as the board becomes more friendly, whereas the number of options goes down as the board's preferences become sufficiently aligned with the

[17] A reasonable approximation of $s(x)$ in the relevant interval $[0, \hat{x}]$ of stock prices defined by the board at the contracting stage can be constructed if the parameters of $\sigma(x)$ are set so that $s(x) = \sigma(x)$ for $x \in \{0, E[x], \hat{x}\}$.

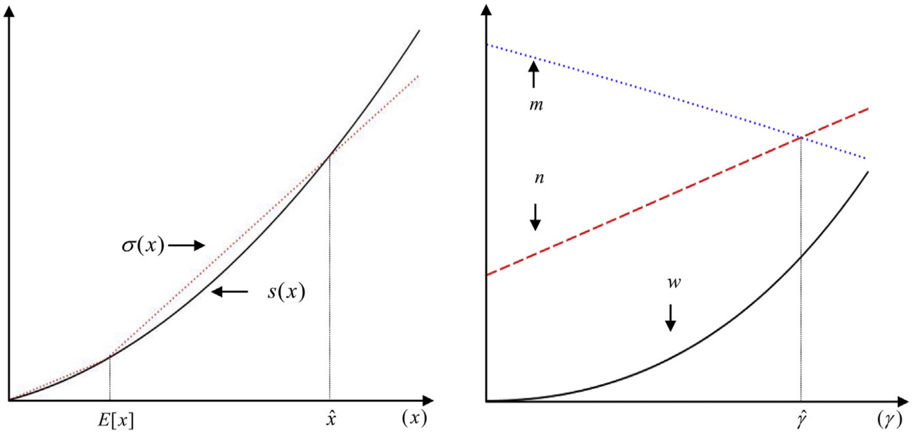

Fig. 5. Piecewise linear approximation of optimal quadratic contract.
The left panel shows the optimal contract $s(x)$ in (17) and its approximation $\sigma(x)$ in (19). The latter combines a salary w and an equity portfolio with n stocks and m at the money options. It is calibrated so that $s(x) = \sigma(x)$ at $x \in \{0, E[x], \hat{x}\}$, where $E[x]$ is the strike price and $\hat{x}$ is chosen so that $F(\hat{x}, a) = 0.99$. The right panel shows how the components of $\sigma(x)$ vary with γ. The solid curve represents the salary, the dashed line the number of stocks, and the dotted line the number of options.

preferences of the CEO. In the figure, the solid upward sloping curve labeled w represents the salary, the dashed increasing line labeled n represents the number of shares, and the dotted downward sloping line labeled m represents the number of options. The intuition behind these effects is straightforward. Because the salary is increasing in z_0 and the number of options is increasing in z_x, it must be that a more friendly board prefers a contract with a higher salary and less options. The implication of a more friendly board for the number of shares is less obvious because n is increasing in z_0, z_x, and E[x] but z_0 is increasing and z_x and E[x] are decreasing in γ. By Proposition 4, the former effect always dominates the latter so that a more friendly board always grants more shares to the CEO.

To summarize, the above observations underscore the fact that poor governance need not go hand in hand with inflated pay levels and a low pay-performance sensitivity. In line with the results of the general model, the properties of the optimal quadratic contract suggest that pay levels and the PPS should be considered relative to the firm's realized performance when evaluating the board's compensation policy. If high pay levels and a high PPS are associated with high performance, both measures are more likely indicators of sound compensation practices. In contrast, a high pay level and a high PPS in the presence of low performance should be taken as indicators for a compensation policy that primarily serves the interest of the CEO rather than the interest of shareholders.

5. Extensions

5.1. Friendly boards and the lack of RPE

In this section, we study how a friendly board affects the use and aggregation of additional performance measures in addition to firm performance x for the purpose of compensating the CEO. This aspect of the problem is of particular interest because proponents of the managerial power perspective appear to view weak governance structures as the main reason for suboptimal compensation practices such as reward for luck or the lack of RPE in executive compensation (Bertrand and Mullainathan, 2001; Bebchuk and Fried, 2004).

To examine whether or not these observations can be rationalized as optimal choices of friendly boards, we extend the base model in Section 3 by introducing a second performance signal y. The joint distribution of x and y is $F(x, y, a)$ with twice continuously differentiable density function $f(x, y, a)$. Let

$$h(x, y, a) = \frac{f_a(x, y, a)}{f(x, y, a)}, \tag{21}$$

denote the associated likelihood ratio. It follows directly from Lemma 1, that the optimal contract then takes the form

$$\frac{1}{U_s(s(x, y))} = \alpha + \beta \cdot h(x, y, a), \tag{22}$$

where α and β are defined in (10). The structure of the expression in (22) implies the following observation:

Proposition 5. *An optimal contract $s(x, y)$ improves the solution of the agency problem achieved by the contract $s(x)$ if it is false that*

$$f(x,y,a) = g(x,y) \cdot z(x,a). \tag{23}$$

The board's friendliness does not affect the firms' decision on the use of y. Proof: the first part is shown in Holmström (1979), the second part follows from the fact that the informativeness criterion in (23) does not dependent on γ.

The informativeness criterion in (23) states that any performance measure that is informative about the agent's action in the presence of x improves the risk sharing between the principal and the agent. Put differently, it should not be possible to decompose the joint density $f(x,y,a)$ into a factor $z(x,a)$, that only depends on a and x, and a factor $g(x,y)$ that depends on x and y but not on a. If such decomposition was possible, the additional performance measure would make the agent's compensation more risky without providing additional effort incentives. Because the informativeness criterion only depends on the properties of $f(x,y,a)$ but not on γ, the optimal decision on the use of additional performance measures in compensation contracts is not affected by the CEO's power over the board. Thus, regardless of its degree of friendliness, a rational board always finds it optimal to insure the agent against exogenous performance shocks and to evaluate his performance relative to the performance of his peers.

We next examine whether and how a friendly board affects the optimal rules for aggregating performance measures in RPE contracts. These contracts focus on the case where the additional performance measure y is informative about the agent's action in the sense of Holmström (1979) but not controllable by the agent, where non-controllability means that the distribution of y is independent of a. These properties are typically satisfied by standard measures of peer performance such as a stock market index, customized peer groups from the same industry, or other measures of common risk factors affecting firm performance such as commodity or currency prices. As shown by Banker and Datar (1989), the optimal aggregation rule is linear in the two performance measures if the joint density function belongs to the class

$$f(x,y,a) = \exp\ [R_0(a) \cdot x + R_1(a) \cdot y - R_2(a) + R_3(y) + R_4(x - \rho \cdot y)], \tag{24}$$

where $R_i(\cdot)$ are arbitrary functions of a, x and y.

Proposition 6. *Consider a performance measure y which joint density function belongs to the class in (24) and is not controllable by the CEO. The optimal compensation contract $s(x,y)$ can be decomposed into a compensation function $s(z(\cdot))$, and an aggregate performance measure $z(x,y)$ with relative weight $r_{yx} = cov(x,y)/Var(y)$on y. The relative weight r_{yx} is independent of γ but the intensity of RPE is proportional to the PPS and varies with γ.*

By Proposition 6, the relative weight of the peer performance measure y in the optimal compensation contract is determined by its information content relative to the information content of x and independent of the firm's governance structure. In fact, drawing on Banker and Datar (1989) the argument of the optimal compensation function is an affine function of the aggregate performance measure $x - r_{yx} \cdot y$ where the relative weight of y takes the form of a regression slope, $r_{xy} = cov(x,y)/Var(y)$. Accordingly, the aggregate performance measure can be interpreted as a net measure of firm performance after eliminating the impact of y measured in a linear regression of firm performance x on peer performance y. Because r_{xy} does not depend on γ, the optimal structure of the aggregate performance measure does not depend on the friendliness of the board.

Of course, because y enters the optimal aggregation rule with a negative sign, the agent's compensation is decreasing in the performance of his peers. This structure not only avoids that the agent is rewarded for windfall profits such as general market trends that positively affect x and y but it also prevents an asymmetric use of RPE in the sense of Garvey and Milbourn (2006) because the relative impact of peer performance on the aggregate performance measure is the same for high and low levels of peer performance within the relevant range of performance measure realizations for which $z(x,y)$ is positive.

However, as demonstrated for the PPS of the optimal compensation contract $s(x)$ in Proposition 2, the sensitivity of the agent's compensation to peer performance y varies with the friendliness of the board whenever $\gamma > \underline{\gamma}$. The sensitivity to peer performance is proportional to the PPS and equals $s_y(x,y) = -r_{xy} \cdot s_x(x,y)$. Because the pay-to-peer-performance is a linear function of the firm's own PPS with the opposite sign, a higher PPS implies a lower pay-to-peer-performance sensitivity. Thus, for the performance regions where the firm's own PPS is increasing in γ, the pay-to-peer-performance sensitivity is decreasing in γ and vice versa.

Because a lower (i.e. more negative) weight on y is equivalent to a more intensive use of RPE, this observation implies that a more friendly board can either evaluate the CEO more or less intensively relative to the performance of peer firms. Accordingly, whenever a more friendly board proposes a contract with a higher PPS, it also makes more intensive use of RPE. Considering that Proposition 3 predicts an increase of the expected PPS, the results of Proposition 6 also imply that weak governance structures are on average more likely to be associated with a more intensive rather than a less intensive use of RPE.

5.2. Earnings management and investment incentives

In this section, we consider two different multi-task versions of our quadratic model in Section 4 to study how the friendliness of the board affects decisions beyond the design of optimal compensation contracts. In both extensions the agent derives utility $U(s) = 2\sqrt{s}$ from compensation and the effort cost function is $C(a) = a^2$. We first explain the structure of the two extensions and then show how the additional decisions are affected by the friendliness of the board.

The first of our extensions here considers a setting where firm performance not only depends on the agent's effort but also on the amount of capital invested in the firm. Firm performance x follows a Gamma distribution with shape parameter k and scale parameter $\theta(a,I) = aI^n - I$, where I is the investment level and $n < 0.5$ to assure the existence of an interior solution. The expected firm performance $E[x] = k \cdot \theta(a,I)$ is jointly determined by the agent's productive effort a and the amount of investment I so that the marginal productivity of effort is increasing in the amount of investment and vice versa. Since the investment cost is borne by the firm, it diminishes the expected firm performance but not the agent's utility.[18] To make the problem interesting, assume that the CEO makes the investment decision but the precise amount of money spent to increase expected firm performance is not verifiable.[19] Accordingly, the board must consider the additional incentive constraint

$$H_I(s,a,I) = \int U(s) \cdot f_I(x,a,I)dx = 0, \tag{25}$$

where $f(x,\theta(a,I)) := f(x,a,I)$ denotes the density function of firm performance x.

Our second extension considers a setting where the agent can manipulate the performance measure used in his compensation contract by window dressing activities as in Dutta and Gigler (2002) or Beyer et al. (2014). To this end, we let firm performance take the same distribution as in Section 4 with the density function in (16) but assume that x is not verifiable or realized too late in order to use it for compensating the agent. Because x is not available for contracting, the board must rely on a performance measure y for compensating the agent. This performance measure not only depends on the agent's productive effort a but also on his manipulation effort e, where the unobservable manipulation effort is personally costly for the agent with $C(e) = e^2$. Particularly, we let y follow a Gamma distribution with shape parameter k and scale parameter $\theta(a,e) = a + te$ which implies that the expected performance $E[y] = k \cdot \theta(a,e)$ is increasing in a and e. The parameter t measures the sensitivity of expected performance to the agent's window dressing effort.

To find the optimal contract, the board must not only anticipate the agent's productive effort choice but also his manipulation incentives. Considering these choices and the performance measure used for compensating the agent, the incentive constraints of the board's multi-task problem take the form

$$H_i(s,a,e) = \int U(s) \cdot f_i(y,a,e)dy - 2i = 0, \quad i \in \{a,e\}. \tag{26}$$

To solve the agency problem, the board maximizes its objective function subject to the agent's participation and incentive constraints. As in the baseline model, the agent's investment and performance manipulation incentives can only vary with the friendliness of the board if the agent's participation constraint is not binding.

Proposition 7. *Suppose that $\gamma \in (\underline{\gamma}, 1)$ such that the agent's productive effort a^* varies with the friendliness of the board. The optimal amount of investment I^* and the equilibrium level of performance manipulation e^* are decreasing in γ.*

The results of our two model extensions indicate that a more friendly board can have positive or negative consequences for shareholders if the agent is responsible for more than a single decision. On the one hand, a more friendly board not only implements a lower productive effort but also provides lower investment incentives to the agent. On the other hand, the optimal compensation contract proposed by a more friendly board provides less manipulation incentives. Intuitively, these effects stem from the fact that the agent's additional actions are positively related to his productive effort choice for a given compensation contract. The reason for this is that in both extensions productive effort a and the second task positively affect the expected value of the performance measure in the agent's compensation contract. This explains why a contract that induces less productive effort also induces less investment incentives and less performance manipulation. Put differently, a more friendly board not only provides less incentives for desirable actions, it also provides less incentives for undesirable actions. While the former effect is harmful for shareholders, the latter effect partly benefits them.

6. Summary and conclusions

The managerial power perspective is frequently advanced to explain the use of seemingly inefficient compensation practices such as inflated pay levels, a weak relation between pay and performance, or the lack of RPE. In this paper, we provide a rigorous theoretical analysis of these arguments and other potential consequences of the CEO's power over the board of directors. We find that the typical measures of seemingly flawed compensation practices proposed by the proponents of the managerial power perspective are at best imperfect because they can equally indicate arm's length contracting.

[18] The fact that the investment choice requires resources at the firm level but causes no personal cost on the part of the agent is the key difference between a *regular* effort choice and an investment decision.

[19] The assumption that capital investments cannot be perfectly observed or measured is common in accounting models considering investment problems, e.g. Kanodia and Sapra (2016). It is the main reason for delegating investment decisions and typically justified by the fact that firms can only measure the aggregate cash outflow for investments but not trace back this cash flow to individual projects.

The optimal compensation contract in our model has several properties that can hardly be reconciled with the simple hypotheses put forward by the managerial power perspective. First, the compensation level generally only increases in the CEO's power over the board if the firm performance falls below a critical threshold. For performance levels beyond this threshold, a more friendly board provides the CEO with lower pay. Second, the PPS in our model is an increasing function of firm performance. We identify conditions where the contract offered by a friendly board exhibits a higher PPS than the standard contract written in the best interest of shareholders. We also study the properties of an optimal quadratic contract that can be approximated by a typical CEO compensation package composed of a salary and an equity portfolio with a given number of shares and at the money options. For this approximation, we find that a more friendly board pays a higher salary, grants more shares, and offers a lower number of options to incentivize the CEO.

We study two extension of the baseline model. First, we show that a friendly board optimally uses RPE. However, we find that a more friendly board evaluates the CEO's performance even more intensively against the performance of its peers whenever it optimally proposes a contract with a higher PPS than a board acting in the best interest of shareholders. Second, we find that a contract proposed by a more friendly board not only induces underinvestment but also a lower level of performance manipulation. The reason for this result is that both decisions are positively related to the agent's equilibrium effort and this effort is decreasing with a more friendly board.

Our results are not only relevant for evaluating the efficiency of compensation practices at the firm level but also for empirical research. Particularly, the quadratic contract version of our model allows us to predict how friendly boards affect expected compensation outcomes. We find that a more friendly board is associated with a higher level of expected pay and a higher expected PPS. We also compare expected pay levels and PPS conditional on realized firm performance and find that firms with friendly boards and superior performance are associated with lower levels of expected pay and a lower expected PPS and vice versa for poorly governed firms with below average performance. In contrast, there is a positive relation between performance and the expected levels of pay and PPS in firms with boards acting in the best interest of shareholders.

Taken together, these observations suggest that pay levels and the PPS should be considered relative to the firm's realized performance when evaluating the board's compensation policy. If high pay levels and a high PPS are associated with high performance, both measures are more likely indicators of sound compensation practices. In contrast, a high pay level and a high PPS in the presence of low performance should be taken as indicators for a compensation policy that primarily serves the interest of the CEO rather than the interest of shareholders. Using these insights could provide a more nuanced view on the empirical relation between measures of governance quality and firm's compensation structure.

Appendix

Proof of Lemma 1. The board maximizes the objective function in (6) subject to the constraints in (7) and (8). This optimization problem can be expressed by the Lagrangian

$$L=(1-\gamma)\cdot V(s,a)+\gamma\cdot H(s,a)+\mu\cdot H_a(s,a)+\lambda\cdot(H(s,a)-\underline{H}). \tag{27}$$

Pointwise differentiation of (27) with respect to s yields the first-order condition

$$L_s=(1-\gamma)\cdot V_s+(\gamma+\lambda)\cdot H_s+\mu\cdot H_{as}=0, \tag{28}$$

where $V_s=-f(x,a), H_s=U_s(s(x))\cdot f(x,a)$ and $H_{as}=U_s(s(x))\cdot f_a(x,a)$. Using these expressions and rearranging terms yields the optimal contract structure in (9) and the optimal parameters in (10). The parameter β determines the optimal weight on the likelihood ratio. Its optimal value is found by differentiating (27) with respect to a. Solving the condition

$$L_a=(1-\gamma)\cdot V_a+\mu\cdot H_{aa}=0 \tag{29}$$

yields $\beta=\mu/(1-\gamma)=-V_a/H_{aa}$. Because the agent's incentive constraint is binding by the validity of the first-order approach, it holds that $\mu>0$ so that β is positive for $\gamma\in[0,1)$.

To prove that β is increasing in a, we consider how a change of β affects the agent's equilibrium effort. We first solve equation (9) for $s(z(x))$, where $z(x)=\alpha+\beta\cdot h(x,a)$ is the argument of the agent's compensation function as defined in (11). Second, we substitute the result back into $U(s)$ which allows us to write the agent's utility as

$$u(z(x))=\left(\frac{1-q}{q}\right)\cdot(c_1\cdot z(x))^{\frac{q}{1-q}}. \tag{30}$$

Third, we totally differentiate the agent's incentive constraint $H_a=0$ and find that in equilibrium $d\beta/da=-H_{aa}/H_{a\beta}$. Because, by the definition of the likelihood ratio,

$$H_{a\beta} = \int u'(z(x)) \cdot h(x,a) \cdot f_a(x,a)dx = E\left[u'(z(x)) \cdot h(x,a)^2\right] > 0 \tag{31}$$

and $H_{aa} < 0$ by the validity of the first-order approach, it holds that $d\beta/da > 0$.

Proof of Proposition 1. The board's problem has two solutions:

i) If the agent's participation constraint is not binding ($\lambda = 0$), it holds that

$$\alpha^* = \frac{\gamma}{1-\gamma} \tag{32}$$

which is increasing in γ. To establish that the agent's equilibrium effort a^* is decreasing in γ in this case, we totally differentiate the agent's incentive constraint and find that $da/d\alpha = -H_{a\alpha}/H_{aa}$. Because $H_{aa} < 0$ by the validity of the first-order approach, $da/d\alpha$ has the same sign as

$$H_{a\alpha} = \int u'(z(x)) \cdot f_a(x,a)dx = \int u'(z(x)) \cdot h(x,a) \cdot f(x,a)dx.$$

Further, because

$$\omega(x) = u'(z(x)) \cdot h(x,a) = \frac{c_1^{\frac{q}{1-q}}}{z(x)^{\frac{1-2q}{1-q}}} \cdot h(x,a)$$

is increasing concave in x and $E[h(E[x],a)] = h(E[x],a) = 0$ by the linearity of the likelihood ratio, Jensen's inequality implies that

$$0 = \omega(E[x]) \geq E(\omega(x)).$$

It follows that $H_{a\alpha} \leq 0$, where the inequality is strict for $q \in [0, 0.5)$. Thus, because α^* is increasing in γ, we can readily conclude that a is decreasing in γ. Finally, because β is increasing in a by Lemma 1 and a is decreasing in γ, it follows that β is decreasing in γ. In the Proof of Proposition 3 we show that the same results hold for $q = 0.5$ where $H_{a\alpha} = 0$.

ii) If the agent's participation constraint is binding, it holds that $\lambda > 0$ and $\alpha = \underline{\alpha} > 0$, where $\underline{\alpha}$ is the lowest value of α that satisfies the agent's participation constraint for the second-best effort level $\underline{a}$ implemented by a board acting in the best interest of shareholders ($\gamma = 0$). In this case $\lambda = \underline{\alpha}$. Comparing the second-best solution with the unconstrained solution in (32) shows that the latter violates the agent's participation constraint whenever

$$\frac{\gamma}{1-\gamma} < \underline{\alpha}.$$

It follows that all boards with $\gamma \leq \underline{\gamma} = \underline{\alpha}/(1+\underline{\alpha})$ implement a contract that meets the agent's participation constraint with equality. This contract is the same as the second-best contract offered by a board acting in the best interest of shareholders. For $\gamma \in (0, \underline{\gamma})$, the Lagrangian multiplier solves the expression in (10) for λ considering that $\alpha = \underline{\alpha}$. The solution $\lambda = (1-\gamma)\underline{\alpha} - \gamma$is decreasing in γ and positive for all $\gamma \in (0, \underline{\gamma})$.

Proof of Corollary 1. As shown in the Proof of Proposition 1, for $\gamma \in (\underline{\gamma}, 1)$ and a given reservation utility $\underline{H}$ the optimal contract implements the effort level a^*so that, in equilibrium, the agent's expected utility exceeds $\underline{H}$. For a given value of $\gamma \in (\underline{\gamma}, 1)$ it holds that

$$\int u(z(x)) \cdot f(x,a^*) = \left(\frac{1-q}{q}\right) \cdot c_1^{\frac{q}{1-q}} \cdot E\left[\left(\alpha^* + \beta^* \cdot h(x,a^*)\right)^{\frac{q}{1-q}}\right] > \underline{H} + C(a^*), \tag{33}$$

where α^* is the optimal contract parameter in (10) and β^* is the optimal weight on the likelihood ratio that solves (29) given α^* and a^*. Consider now an exogenous increase of the agent's reservation utility by Δ_H so that

$$\left(\frac{1-q}{q}\right) \cdot c_1^{\frac{q}{1-q}} \cdot E\left[\left(\alpha^* + \beta^* \cdot h(x,a^*)\right)^{\frac{q}{1-q}}\right] = \underline{H} + \Delta_H + C(a^*) \tag{34}$$

holding the contract parameters and effort level in (33) constant. Thus, for any unconstrained contract with given values of γ and $\underline{H}$ there is always an equivalent constrained contract with reservation utility $\underline{H}+\Delta_H$ that implements the same effort level.

Because the right hand side of (34) is increasing in Δ_H, the left hand side of (34) is increasing in α, and α^* is increasing in γ, a higher value of γ in the unconstrained problem is equivalent to a higher value of Δ_H in the corresponding constrained problem.

Proof of Lemma 2. Solving the optimal contract equation $1/U_s(s(x)) = z(x)$ in (9) for $s(x)$ and differentiating the resulting expression with respect to x yields

$$s(x) = (1-q)\cdot\left(c_1^{\frac{q}{1-q}}\cdot z(x)^{\frac{1}{1-q}} - \frac{c_2}{c_1}\right), \tag{35}$$

$$P(x) = s_x(x) = z_x\cdot(c_1\cdot z(x))^{\frac{q}{1-q}}, \tag{36}$$

where $z(x) = z_0 + z_x\cdot x$ as defined in (11). Because

$$P_x(x) = s_{xx}(x) = \frac{q}{1-q}\cdot\frac{z_x^2\cdot c_1^{\frac{q}{1-q}}}{z(x)^{\frac{1-2q}{1-q}}} > 0$$

for $q\in(0,0.5]$, $s(x)$ is strictly convex and $P(x)$ is increasing in x. However, because

$$\lim_{q\to 0} s(x) = z(x) - \frac{c_2}{c_1},$$

which is an affine function of x, the PPS is constant as q approaches zero.

Proof of Proposition 2. i) Considering the compensation function in (14) and the results of Lemma 2, it can readily be seen that $s_B(x) > s_A(x)$ whenever it holds that $z_B(x) > z_A(x)$ where

$$z_i(x) = z_{0i} + z_{xi}\cdot x \tag{37}$$

$$z_{xi} = \beta_i\cdot g_1\left(a_i^*\right) \quad \text{and} \quad z_{0i} = \alpha_i - z_{xi}\cdot E\left[x|a_i^*\right] \tag{38}$$

as defined in (11) and (12), and a_i^* is the equilibrium effort induced by board $i\in\{A,B\}$. To compare $z_A(x)$ and $z_B(x)$, we note that, in equilibrium, z_{0i} and z_{xi} are constant parameters of the agent's compensation contract and derive the solution in two steps. We first determine how z_{xi} varies with the agent's equilibrium effort a_i. We totally differentiate the agent's incentive constraint and find that $dz_{xi}/da_i = -H_{aa}/H_{az_{xi}}$. Using the expression for the agent's equilibrium utility in (30), the definition of $z_i(x)$ in (37), and $h(x,a)$ in (2), we find that

$$H_{az_{xi}} = \int u'(z_i(x))\cdot(x - E[x|a_i])\cdot f_a(x,a_i)dx = E\left[u'(z(x))\cdot\frac{h(x,a_i)^2}{g_1(a_i)}\right] > 0. \tag{39}$$

Because $H_{aa} < 0$ by the validity of the first-order approach, it holds that $dz_{xi}/da_i > 0$.

Second, using these results we rank the components of $z_A(x)$ and $z_B(x)$. Because $dz_{xi}/da_i > 0$ and $a_B < a_A$ if $\gamma_B > \gamma_A$ by Proposition 1, we conclude that $z_{xB} < z_{xA}$. Moreover, because expected performance is increasing in a, it also holds that $E[x|a_B] < E[x|a_A]$. Thus, because $\alpha_B > \alpha_A$ if $\gamma_B > \gamma_A$ by Proposition 1, we conclude that $z_{0B} > z_{0A}$. It follows that there exists a unique intersection point

$$x_0 = \frac{z_{0B} - z_{0A}}{z_{xA} - z_{xB}}$$

such that $z_B(x) > z_A(x)$ if $x < x_0$ and $z_B(x) < z_A(x)$ if $x > x_0$.

ii) Using the expression for the PPS in (15), the definition of $z_i(x)$ and its components in (37) and (38) allows to rewrite the PPS for γ_i as

$$P_i(x) = c_1^{\frac{q}{1-q}} \cdot z_{xi} \cdot (z_{0i} + z_{xi} \cdot x)^{\frac{q}{1-q}}. \tag{40}$$

Because it holds that

$$\lim_{q \to 0} P_i(x) = z_{xi}$$

and $z_{xB} < z_{xA}$, it can readily be seen that $P_B(x) < P_A(x)$ for all performance levels if the contract is linear in x which implies that the slope of $z_i(x)$ equals the slope of $s_i(x)$. If $q \in (0, 0.5]$, the contract is strictly convex. In this case a more friendly board implements a compensation contract with a higher PPS if it holds that

$$\frac{P_B(x)}{P_A(x)} = \frac{z_{xB}}{z_{xA}} \left(\frac{z_{0B} + z_{xB} \cdot x}{z_{0A} + z_{xA} \cdot x} \right)^{\frac{q}{1-q}} > 1 \tag{41}$$

for some x. Since $z_{xB} < z_{xA}$ and $z_{0B} > z_{0A}$, the expression in (41) is monotonically decreasing in x and takes its maximum value

$$\frac{P_B(0)}{P_A(0)} = \frac{z_{xB}}{z_{xA}} \left(\frac{z_{0B}}{z_{0A}} \right)^{\frac{q}{1-q}}$$

for $x = 0$. Suppose that $P_B(0) > P_A(0)$. It follows that there exists a unique performance level $x = x_1$ such that $P_B(x) > P_A(x)$ if $x < x_1$ and $P_B(x) < P_A(x)$ if $x > x_1$. In contrast, if $P_B(0) < P_A(0)$ it holds that $P_B(x) < P_A(x)$ for all x as for the case of a linear contract.

Proof of Corollary 2. Suppose that shareholders must break even. In addition to the agent's participation and incentive constraints in (8) and (7), the board must assure that $V(a,s) \geq 0$. Following the Proof of Lemma 1 the contract parameters take the form

$$\alpha = \frac{\gamma + \lambda}{1 - \gamma + \nu}, \quad \beta = \frac{\mu}{1 - \gamma + \nu}, \tag{42}$$

where ν is the Lagrangian multiplier of the shareholders' participation constraint, and λ and μ are the Lagrangian multipliers associated with the agent's participation and incentive constraints, respectively. To rule out trivial solutions, suppose that shareholders break even under the second best contract so that $V(\underline{a}, s) > 0$. It follows that only one of the two participation constraints can be binding. Thus, in addition to the two solutions in Proposition 1, there is a third solution where $\lambda = 0, \mu > 0$, and $\nu > 0$.

Let $\overline{\alpha}$ denote the highest value of α that satisfies the shareholder's participation constraint for the optimal effort level $\overline{a}$ implemented by a board acting purely in the interest of the CEO ($\gamma = 1$). In this case it holds that $\nu = 1/\overline{\alpha} > 0$. Comparing this solution with the unconstrained solution in (32) shows that the unconstrained solution violates the shareholders' participation constraint whenever.

$$\frac{\gamma}{1 - \gamma} > \overline{\alpha}.$$

It follows that all boards with $\gamma \geq \overline{\gamma} = \overline{\alpha}/(1 + \overline{\alpha})$ implement a contract that meets the shareholders' participation constraint with equality. This contract is the same as the optimal contract offered by a board acting in the best interest of the CEO. For $\gamma \in (\overline{\gamma}, 1)$, the Lagrangian multiplier solves the expression in (10) for ν considering that $\alpha = \overline{\alpha}$. The solution $\nu = \gamma(1 + 1/\underline{\alpha}) - 1$ is increasing in γ and positive for all $\gamma \in (\overline{\gamma}, 1]$.

Proof of Proposition 3. Because the contract parameters in (17) can only vary with γ if the participation constraint is slack, we can ignore it here and focus on the unconstrained solution where $\lambda = 0$. For this solution we know from Proposition 1 that $\alpha^* = \gamma/(1 - \gamma)$ is increasing in γ. To study how γ affects the expected pay level and the expected PPS, we first derive the optimal contract and the agent's equilibrium effort. To determine the optimal values of a and β, the board maximizes the objective function

$$B = (1 - \gamma) \cdot \left(k \cdot a - \alpha^2 - k \cdot \frac{\beta^2}{a^2} \right) + \gamma \cdot \left(2 \cdot \alpha - a^2 \right) \tag{43}$$

subject to the agent's incentive constraint

$$2 \cdot k \cdot \frac{\beta}{a^2} - 2a = 0. \tag{44}$$

We complete next the Proof of Proposition 1 for $q = 0.5$ and show that a is decreasing in γ even though the incentive constraint does not directly depend on α in this case, i.e. $H_{a\alpha} = 0$. Solving the incentive constraint for β, substituting the result into (43), and differentiating with respect to a yields the board's first-order condition for the optimal effort level

$$B_a = k - \frac{4a^3}{k} - 2\alpha \cdot a = 0.$$

Totally differentiating this condition and rearranging terms yields

$$\frac{da}{d\alpha} = -\frac{ka}{6a^2 + k\alpha} < 0. \tag{45}$$

Because a is decreasing in α and α^* is increasing in γ, it follows that a is decreasing in γ.

Using the solution for β and the fact that $g_1(a) = 1/a^2$ and $E[x] = ka$ yields the optimal contract parameters $z_x = \beta \cdot g_1(a) = a/k$ and $z_0 = \alpha - a^2$ in (17). Substituting these expressions into the compensation function $s(x) = (z_0 + z_x x)^2$ and the PPS and integrating using the Gamma density in (42) yields expected pay and the expected PPS

$$E[s(x)] = \int_0^\infty \left(\alpha - a^2 + \frac{a}{k} \cdot x\right)^2 \times f(x, a)dx = \alpha^2 + \frac{a^4}{k}, \tag{46}$$

$$E[P(x)] = \int_0^\infty \left(\frac{2a \cdot (\alpha - a^2)}{k} + \frac{2a^2}{k^2} \cdot x\right) \times f(x, a)dx = \frac{2a \cdot \alpha}{k}. \tag{47}$$

Using (45) allows us to determine the net effect of a change in α on the agent's expected pay and the expected PPS

$$\frac{dE[s(x)]}{d\alpha} = 2\alpha + \frac{4a^3}{k} \cdot \frac{da}{d\alpha} = 2\left(\frac{k\alpha^2 + 6\alpha a^2 - 2a^4}{6a^2 + k\alpha}\right) > 0, \tag{48}$$

$$\frac{dE[P(x)]}{d\alpha} = \frac{2}{k}\left(a + \alpha \cdot \frac{da}{d\alpha}\right) = \frac{2a}{k}\left(1 - \frac{k\alpha}{6a^2 + k\alpha}\right) > 0. \tag{49}$$

Because $z(x)$ must be positive for all realizations of x to satisfy the optimality condition for the contract in (9), we can use the fact that $z(0) = z_0 = \alpha - a^2$ which is positive if $\alpha > a^2$. Using this condition, it is straightforward to see that (48) and (49) are both positive. Thus, because α^* is increasing in γ, the expected pay and the expected PPS are increasing in γ.

Proof of Proposition 4. To determine how the components of the approximation $\sigma(x)$ vary with γ, we assume that the board still implements the optimal contract and decompose $s(x)$ into three components s_w, $s_n \cdot x$, and $s_m \cdot x^2$ with parameters

$$s_w = z_0^2, \quad s_n = 2z_0 \cdot z_x, \quad \text{and} \quad s_m = z_x^2. \tag{50}$$

Because s_w is a constant and the second component is linear in x, we can interpret s_w as the agent's salary and s_n as the number of shares. Finally, the third component is convex in the stock price and mimics the payoff profile of a stock option. To determine how the components of the optimal contract vary with the friendliness of the board, we recall from Proposition 2 that z_0 is increasing in $\gamma$and z_x is decreasing in γ and conclude that

$$\frac{ds_w}{d\gamma} > 0 \quad \text{and} \quad \frac{ds_m}{d\gamma} < 0. \tag{51}$$

Using the same procedure as in Proposition 3, we next determine how s_n varies with γ and find that

$$\frac{ds_n}{d\alpha} = \frac{2}{k}\left(a + \left(\alpha - 3a^2\right) \cdot \frac{da}{d\alpha}\right) = \frac{k+2}{k} \cdot \frac{6a^3}{6a^2 + k\alpha} > 0.$$

Thus, using the interpretation above, a more friendly board provides the agent with a higher salary, more shares, and a smaller option component. If we compare the components of $s(x)$ with the components of the piecewise linear approximation $\sigma(x)$ we can see that

$$w = s_w, \quad n = s_n + z_x^2 \cdot E[x], \quad m = z_x^2 \cdot \widehat{x}.$$

Considering (51) and the fact that

$$\frac{dn}{d\alpha} = \frac{2}{k}\left(a + \left(\alpha - \frac{3}{2}a^2\right) \cdot \frac{da}{d\alpha}\right) = \frac{k+4}{k} \cdot \frac{3a^3}{6a^2 + k\alpha} > 0,$$

we conclude that the components of the linear approximation $\sigma(x)$ vary in the same way with the friendliness of the board as the corresponding components of $s(x)$.

Proof of Proposition 6. The likelihood ratio of the density function in (24) is an affine function of x and y

$$h(x,y,a) = r_0(a) \cdot x + r_1(a) \cdot y - r_2(a),$$

where $r_i(a) = R_i'(a)$, so that the argument of the compensation function can be expressed as

$$z(x,y) = \alpha + \beta \cdot \left[r_0(a) \cdot (x - r_{xy} \cdot y) - r_2(a)\right],$$

where r_{xy} the relative weight on peer performance y in $z(x,y)$. As shown in Banker and Datar (1989, Proposition 4), the relative weight on y for the exponential class of density functions in (24) can be expressed in terms of the moments of the two performance measures

$$r_{xy} = \frac{r_1(a)}{r_0(a)} = \frac{Var(x)\left(\frac{\partial E[y]}{\partial a} - \frac{cov(x,y)}{Var(x)}\frac{\partial E[x]}{\partial a}\right)}{Var(y)\left(\frac{\partial E[x]}{\partial a} - \frac{cov(x,y)}{Var(y)}\frac{\partial E[y]}{\partial a}\right)}. \tag{52}$$

Because y is not controllable, the moments of y do not depend on a and $\partial E[y]/\partial a = 0$. Therefore, the expression in (52) simplifies to the coefficient of a linear regression of x on y

$$r_{xy} = \frac{cov(x,y)}{Var(y)}$$

which is independent of a and does not vary with the friendliness of the board. However, if we evaluate the slope of the optimal compensation contract

$$s(x,y) = (1-q) \cdot \left(c_1^{\frac{q}{1-q}} \cdot z(x,y)^{\frac{1}{1-q}} - \frac{c_2}{c_1}\right),$$

with respect to peer performance, we find that

$$s_y(x,y) = -r_{xy} \cdot \beta \cdot r_0(a) \cdot (c_1 \cdot z(x,y))^{\frac{q}{1-q}} = -r_{xy} \cdot s_x(x,y),$$

where $s_x(x,y) = \beta \cdot r_0(a) \cdot (c_1 \cdot z(x,y))^{\frac{q}{1-q}}$ is the PPS. Thus, the firm's sensitivity to peer performance is proportional to the PPS with the opposite sign. Because a more negative weight on peer performance is equivalent to a higher intensity of RPE, the firm makes more intensive use of RPE if the PPS is increasing in γ and vice versa.

Proof of Proposition 7. Let $p \in \{x,y\}$ denote the performance measure in the agent's compensation contract and let $\theta(a, b)$denote the scale parameter of the Gamma distribution as a function of the agent's productive effort a and the second activity $b \in \{I,e\}$. Solving the board's optimization problem in Proposition 1 considering the additional incentive constraints in (25) and (26) yields the optimal contract structure

$$\frac{1}{U_s} = \alpha + \mu \cdot \frac{f_a(p,a,b)}{f(p,a,b)} + \eta \cdot \frac{f_b(p,a,b)}{f(p,a,b)},$$

where η is the Lagrangian multiplier for the additional incentive constraint and the likelihood ratios for the Gamma distribution take the form

$$\frac{f_i(p,a,b)}{f(p,a,b)} = \frac{\theta_i(a,b)}{\theta(a,b)^2} \cdot (p - E[p]), \quad i \in \{a,b\}.$$

Thus, if we define $\beta = \mu \cdot \theta_a(a,b) + \eta \cdot \theta_b(a,b)$ and consider that $1/U_s = \sqrt{s}$, the optimal contract takes the familiar quadratic form

$$s = \left(\alpha + \frac{\beta}{\theta(a,b)^2} \cdot (p - E[p])\right)^2.$$

Using this expression to evaluate the principal's and the agent's expected utilities allows us to represent the board's optimization problem for the investment model, where $p = x$ and $b = I$, in the relevant range $\gamma \in (\underline{\gamma}, 1)$ as of maximizing

$$B(a,I) = (1-\gamma)\left[k \cdot (aI^n - I) - \alpha^2 - k \cdot \frac{\beta^2}{(aI^n - I)^2}\right] + \gamma \cdot \left(2\alpha - a^2\right) \tag{53}$$

subject to the incentive constraints

$$2k\frac{\beta}{(aI^n - I)^2} \cdot I^n - 2a = 0, \tag{54}$$

$$2k\frac{\beta}{(aI^n - I)^2} \cdot \left(na \cdot I^{n-1} - 1\right) = 0. \tag{55}$$

Since the last equation implies that $I = (na)^{\frac{1}{1-n}}$, a higher equilibrium effort implies a higher investment. Likewise, in the performance manipulation model, where $p = y$ and $b = e$, the board maximizes its objective function

$$B(a,e) = (1-\gamma)\left[k \cdot a - \alpha^2 - k \cdot \frac{\beta^2}{(a+et)^2}\right] + \gamma \cdot \left(2\alpha - a^2 - e^2\right) \tag{56}$$

subject to

$$2k\frac{\beta}{(a+et)^2} = 2a \tag{57}$$

$$2k\frac{\beta \cdot t}{(a+et)^2} = 2e \tag{58}$$

in the relevant range. Solving the incentive constraint for the manipulation effort yields $e = t \cdot a$ which is a linear function of productive effort a. Because the predictions of the general model continue to hold for both extension, a is decreasing in γ. Therefore, it must be that the optimal investment level I and the manipulation effort e are decreasing in γ.

To demonstrate that the conditions of the general model are still valid for the multi-task extension, consider the earnings manipulation model. Solving the incentive constraints in (57) and (58) for β and e, substituting the resulting expressions back into the board's objective function (56) and differentiating this function with respect to a yields the board's first-order condition for the optimal effort level

$$B_a = k - \frac{a^3}{k} \cdot 4\left(1+t^2\right)^2 - \alpha \cdot a \cdot 2\left(1+t^2\right) = 0.$$

Totally differentiating the resulting expression and rearranging terms yields

$$\frac{da}{d\alpha} = -\frac{ka}{6a^2(1+t^2) + k\alpha} < 0.$$

It follows that a is decreasing in α. Because α is increasing in γ, a is decreasing in γ. The Proof for the investment model is similar and left to the reader.

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