Boards and Executive Compensation: Another Look*

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Abstract: We analyze the optimal contracts offered to an empire-building CEO and a reputation-concerned board when the CEO persuades the board to approve an investment project. We show that lack of flexibility about the fixed part of the board's or the executive compensation generates shareholders' tradeoff between size and share of profits. The shareholders choose between contracts for which profits are large but also CEO's and board's compensations are large and contracts for which profits and compensations are low. Tolerance to excessive investments with low profits is optimal if the ex ante expected value of the project is large, the CEO's outside option on the labor market is not very attractive, the CEO's empire-building benefit is large, and the board's reputational concerns are moderate. We show that the optimal contracts involve stocks but not options and the variable parts of the CEO's and the board's compensations are substitutes. Boards' reputational concerns affect information quality and company profits in a non-monotonic manner.

Keywords: board monitoring, director compensation, executive compensation, Bayesian persuasion

1 Introduction

How to motivate corporate boards if their primary task is to approve risky projects that the CEO is interested in pursuing? A large body of literature documents that certain individual directors' characteristics, such as accounting and finance expertise, legal, consulting and industry experience, management experience, prior board experience and independence, enhance the boards' monitoring capacity and corporate outcomes (Field and Mkrtchyan 2017; Adams, Akyol and Verwijmeren 2018; Erel, Stern, Tan and Weisbach 2021). Little is known, however, about the effects of compensation structure (cash, stocks, and options), the interplay between directors' non-financial characteristics and financial compensation, and the optimal mix of CEO's and board's variable compensations.

This paper examines the optimal contracts offered to CEOs and boards in a classic economic setting where a centralized (outsider-controlled) board approves or rejects an investment opportunity presented by an empire-building CEO (Adams and Ferreira 2007; Harris and Raviv 2008; Baldenius, Melumad and Meng 2014; Baldenius, Meng and Qiu 2019; Gregor and Michaeli 2022). The CEO has a tendency to overinvest due to private perks and delivers an optimally constructed but credible report about the investment project to the board (e.g., estimate of the project success based on an efficiency test or safety experiment—Bayesian persuasion). The board has non-financial—career or reputation related—biases such that the board incurs a private cost when the approved project destroys the company value and earns a private benefit when it enhances the value.[1] Our main research question is what motivates shareholders to construct contracts that tolerate imprecise project information and excessive investments when achieving profit-maximizing investments is contractually feasible. In addition, we study whether the CEO and the board receive variable compensation or not, whether these incentive payments

[1] In extensions we illustrate the robustness of our results in settings where (i) the rationally inattentive board can learn additional information and (ii) the board is tasked with writing the contract offered to the CEO.

are through stocks or options, and whether incentive payments to the CEO and the board substitute or complement each other. When addressing each of these questions, we exploit the role of the project's, the CEO's and the board's characteristics.

We provide two sets of results: positive and normative. Our positive results are about the effect of variable financial compensation on the incentives of the players, i.e., on the CEO's willingness to prepare a precise report and the board's willingness to approve the project. We show that overinvestments (due to low precision of the CEO's reports and the board's willingness to approve projects with imprecise information) can be addressed either directly or indirectly. The direct way is to motivate the CEO to prepare precise reports, and the indirect way is to motivate the board to reject projects submitted with imprecise information, which indirectly motivates the CEO to increase the precision of her reports.

By offering a sufficiently large variable financial compensation to the CEO, the direct way aligns the CEO's preferences over project adoption with the profitability criterion. We show that achieving this through stocks is always preferred to achieving it through (call or put) options. The indirect way requires provision of variable financial compensation to the board. Again, like in the case of the CEO, we show that motivating the directors with stocks is always preferred to granting options. However, shares have a dual effect on information. On the one hand, shares increase the board's stakes involved in the approval decision which, all else equal, motivate the CEO to send a more precise report. On the other hand, providing shares to directors crowds out their non-financial (e.g., career-related) concerns and this may be detrimental to information quality.

Our normative results are about the optimal contracts when the contracting space is defined by piecewise linear instruments (non-negative amounts of base salary, stocks, and put and call options). A player compensated with these instruments may earn rents. This implies that the shareholders avoid using variable compensation unless it is necessary to

generate desirable incentives. We show that, as a consequence, the direct and indirect ways to reduce overinvestments are not used jointly: equity compensations to management and corporate boards are substitutes.

The shareholders' core contracting decision can be presented as a decision on which player deserves equity payments. When making this choice, the shareholders compare project profits and rents earned by the players. Typically, a tradeoff exists. The shareholders choose between high company profits and high rents (this outcome is associated with stocks provided only to the CEO) versus low company profits and low rents (this outcome is associated with stocks provided only to the board). We focus on conditions under which the shareholders sacrifice profits for rents. This occurs when the ex ante expected project value is high, the CEO's private (empire-building) benefit from approval is high, and the CEO's outside option (labor market value) is low. In other words, large overinvestments are associated with a favorable economic environment and a low CEO's quality. In these situations, providing sufficiently large variable executive compensation that eliminates the CEO's bias to undertake unprofitable projects and build an empire is relatively costly to the shareholders, and the shareholders are willing to tolerate excessive investments instead. We also explain how board's non-financial interests affect the shareholders' tradeoff.

Our paper contributes to several strands of literature. We show that provision of a high number of shares to directors might be optimal. This is consistent with findings in the literature on financial incentives of (independent) directors who are tasked with monitoring firm management. For example, several studies empirically document the recent trends for high total compensation (Linck, Netter and Yang 2009) and providing more equity but less cash compensation to directors (Yermack 2004).

In our model, directors are motivated not only by financial incentives, but also exhibit career concerns. Prior literature has documented that such concerns exist when directors'

reputation for high-quality monitoring is rewarded in the labor market, mainly in the form of outside directorships (which bring additional compensation, prestige, and experience) but also in lower regulatory sanctions imposed in case of company frauds (Jiang, Wan and Zhao 2016). Career concerns are found to be high for young directors, directors with large numbers of independent directorships, directors with high media exposure and in companies with high market capitalization (Masulis and Mobbs 2014). Prior literature finds that career-concerned directors do not receive performance-sensitive compensation (Fama and Jensen 1983). Such substitution effect arises also in our model. We find that variable financial compensation negatively affects the willingness of boards with high career concerns to approve projects, which decreases the shareholders' willingness to financially compensate directors by stocks. This implies that, for directors, financial and non-financial incentives are substitutes. At the same time, as the shareholders jointly choose both the CEO's and the board's contracts, we identify a cross-effect of the boards' career concerns on executive compensation due to substitution of financial incentives of the CEOs and the boards. This cross effect may eventually increase the shareholders' willingness to financially compensate directors by stocks.

Our model introduces two dimensions of non-financial (career) concerns, namely reputation cost of project failures and reputation benefit of project successes. When non-financial concerns reflect directors' reputation for general firm performance (Yermack 2004), the structure of non-financial incentives is very similar to the structure of financial incentives. In a knife-edge case when the reputation benefits are linear in the company value, more intensive career concerns are equivalent to receiving higher variable compensation in stocks. Typically, however, intense career concerns have a different structure than financial incentives: Reputation benefits are non-linear in company value because directors' reputation is affected only in specific reputation-relevant events (e.g., lawsuits, proxy contest nominations, or successful rescissions of takeover defenses). On the side

of firm management, we suppose non-financial benefits of the management are mostly dominated by their interest in carrying out pet projects or similar empire-building benefits (Décaire and Sosyura 2021). In addition, existing CEOs' reputation considerations seem to be directly related to the financial side of incentives: Edmans, Gosling and Jenter (2021) report that the executive compensation is constructed with the idea that it is the pay that serves as recognition and a signal for the market.

Regarding executive compensation, our paper focuses exclusively on the shareholders' optimal way to treat managerial overinvestment that follows from limited liability. In particular, there is no role for risk-sharing, incentivizing costly implementation effort, or for limited liability as protection of the players. Our perspective is thus orthogonal to classic executive contracting issues, especially in a multi-tasking context (Göx and Hemmer 2021). Given an exogenous project type, we don't address the role of CEO's equity incentives at the project selection stage, and focus exclusively on the role at the reporting stage. The differential effects of executive compensation on the different board roles are analyzed, among others, in Chen, Guay and Lambert (2021). Our results on the structure of the CEO's variable compensation schemes are close to Laux (2014), where the options increase the CEO's incentives to manipulate information. Our analysis thus adds to the recently observed adverse role of options provided to the management (Shue and Townsend 2017; Liu, Masulis and Steinfeld 2021).

Our paper also speaks to the CEO-director compensation nexus: Empirically, the CEO's and the board's compensation levels are positively related, and this association is stronger with greater CEO's control and power, manifested either in co-optation of the directors by the CEO (Coles, Daniel and Naveen 2014), the CEO-chairman duality (Fedaseyeu, Linck and Wagner 2018), the low extent of monitoring by institutional investors (Chen, Goergen, Leung and Song 2019), or the excessive use or related-player transactions (Hope, Lu and Saiy 2019). However, the association may also reflect other

unobserved time-varying firm effects such as nature of projects (most studies account for firm fixed effects). Kim, Kwak, Lee and Suk (2019) find that CEO and director equity compensation are substitutes when the outcome variable are financial disclosure policies.

Finally, we provide a novel perspective on the CEO-board interactions that combines persuasion and optimal contracting. Persuasion perspective on CEO-board interactions is built on the idea that with proliferation of data analytic techniques and rich underlying data (both internal and external), the management is better off with selecting a (credible) reporting technology instead of leaving information transmission to soft communication (Gregor and Michaeli 2021). Therefore, with the explosion of analytical technologies, the board's advisory role is less important and the board's monitoring problem becomes of central importance. In the extreme, the advisory role is fully eliminated by the CEO's unrestricted and costless access to reporting structures.

2 Model setup

The model entails a CEO (referred to as "she" and labeled "C") and a corporate board of directors (labeled "B"). The CEO comes across an investment opportunity ("project") which is approved or rejected by the board. The project requires an upfront investment normalized to one. In case of success ($\theta = 1$), the project yields a return of $r > 0$. In case of failure ($\theta = 0$), the firm loses the investment.

Information structure. All players share a common prior belief $\mu \equiv \Pr(\theta = 1)$. We assume that $\mu \in \left(0, \frac{1}{1+r}\right)$, which implies that the expected value of the project (without further information) is negative. The CEO chooses the properties of a report about the project success (e.g., by conducting an efficiency test or safety experiment). The realizations of the public report cannot be biased or misreported. That is, the CEO commits to the properties of the information included in the report in advance. This commitment assumption, commonly involved in Bayesian persuasion models (Kamenica

and Gentzkow 2011), is relevant in our setting as the data collected and included in company reports is available within the company, can be verified and thus the CEO can not easily conceal or misrepresent it.

We denote p_ρ the probability that the CEO's report is ρ. A realization ρ induces a belief about the project success $\mu_\rho \equiv \Pr(\theta = 1 \mid \rho)$. Since the board's action is binary (approve or reject the project), it is sufficient to consider a binary report with a low and a high realization, $\rho \in \{l, h\}$. The report can be characterized either as a distribution over the report realizations, (p_l, p_h) or, equivalently, as a pair of the induced beliefs, (μ_l, μ_h), where $\mu_l \leq \mu \leq \mu_h$. The two characterizations are linked by the martingale (Bayes-plausibility) property, which—for a binary state space—is represented by a single constraint, $p_l\mu_l + p_h\mu_h = \mu$.[2] In the main analysis, we assume that the board does not gather information on its own. In Appendix A.2, we provide a brief analysis when this assumption is relaxed.

Payoffs and contracts. We use u and v to denote the payoffs of the CEO and the board, respectively. Both players receive fixed non-negative wages (u_w, v_w). In addition, the players receive continuation payoffs that equal (u_θ, v_θ) when the project is approved and $(\widehat{u}, \widehat{v})$ when the project is rejected. The continuation payoffs depend on the financial instruments—shares, call and put options—with which the players are compensated. For player $i \in \{B, C\}$, the number of shares is $\alpha_i \in [0, 1]$, the number of call options is $\beta_i^{call} \in [0, 1]$, and the number of put options is $\beta_i^{put} \in [0, \alpha_i]$. The restriction $\beta_i^{put} \leq \alpha_i$ implies that put options can be exercised only if the player holds shares of the corresponding amount. The amounts of shares and call options provided to the players cannot exceed the total amount of shares, $\sum_{i=B,C} \left(\alpha_i + \beta_i^{call}\right) \leq 1$. We assume that the strike prices of the options, K^{call} and K^{put}, are identical across players and restrict their levels to the

[2] Another way of describing the public report is by considering the probability of a report realization conditional on the state θ. This can easily be derived from the distribution (p_l, p_h) and the beliefs (μ_l, μ_h) using Bayes rule, $\Pr(\rho \mid \theta) = \frac{\Pr(\theta|\rho)\Pr(\rho)}{\Pr(\theta)}$ for $\theta \in \{0, 1\}$ and $\rho \in \{l, h\}$. For instance, $\Pr(\rho \mid \theta = 1) = \frac{\mu_\rho p_\rho}{\mu}$.

interval between a minimum and maximum project value, $[-1, r]$. The latter constraint implies that exercising the option pays off sometimes but not always.[3] Depending on whether the strike price is above or below zero, the options are exercised in one or two events.[4]

In addition to financial compensation, the continuation payoffs of the players depend on non-financial incentives. The CEO is motivated by a state-independent benefit $c \in (0, 1)$ from project approval—it reflects the CEO's empire-building tendency. The board has a state-dependent non-financial benefit b_θ that is positive in case of project success and negative in case of failure, $b_0 < 0 < b_1$. Put differently, b_1 is a reputation benefit from a project success and $-b_0$ is a reputation cost from a project failure.

In the main analysis, we assume that the shareholders offer contracts to the board and the CEO. In Appendix A.1, we briefly analyze a setting where the contract with the CEO is written by the board. Throughout the analysis, we present compensation contracts in two ways. Most commonly, we present the contracts directly by specifying the number of shares, options, and the base salary, e.g., the CEO's compensation is $(\alpha_C, \beta_C^{call}, \beta_C^{put}, u_w)$ where all variables are restricted to their domains. On occasion, we also present the contracts indirectly as a vector of the payoffs in the three possible outcomes (the project is rejected, the approved project fails, and the approved project succeeds). In particular, the CEO's outcome-specific payoffs are $(u_w + \widehat{u}, u_w + u_0, u_w + u_1)$ and those of the board are $(v_w + \widehat{v}, v_w + v_0, v_w + v_1)$. The indirect representation emphasizes the restrictions on the contract space that lead to contracting frictions: First, the board's liability is limited, $\widehat{v} - v_0 \leq -b_0 + 1$: this restricts the set of feasible incentives at the project approval stage. Second, the base salaries are non-negative: this constrains the shareholders' ability to

[3] An option that is never exercised is irrelevant. An option that is always exercised is equivalent to a fixed wage increase.

[4] A single-event call option is when the strike price is positive, $K^{call} > 0$, and a two-event call option is when the strike price is negative, $K^{call} < 0$. A single-event put option is when the strike price is negative, $K^{put} < 0$, and a two-event put option is when the strike price is positive, $K^{put} > 0$.

extract value from the agents when giving take-it-or-leave-it offers.[5] We assume that the reservation value of the CEO and the board are positive and sufficiently high, $\underline{u} > \mu c > 0$ and $\underline{v} > \mu b_1 \geq 0$. This assumption suggests that the outside options for executives are sufficiently attractive.[6]

Players' types and regimes. Based on her payoffs, the CEO is either "normal" or "empire-builder." We say that the CEO is normal if $u_1 > \widehat{u} > u_0$, i.e., if her payoff increases when an approved project succeeds and decreases when the project fails. We say that the CEO is empire-builder when $u_\theta > \widehat{u}$ for $\theta \in \{0, 1\}$, i.e., if her payoff increases when the project is approved, regardless of the success. The assumption $c > 0$ implies that, in the absence of financial compensations, the CEO is an empire-builder. The assumption $c < 1$ ensures that financial compensation can change the CEO's type to normal.[7] Board's type is defined by analogy. Because $b_0 < 0 < b_1$, the board is normal in the absence of financial compensations and also remains normal under any compensation contract feasible with our contracting instruments. Throughout the analysis, we differentiate between two regimes: under "A-form" both players are normal (aligned interests) and under "M-form" the CEO is an empire-builder and the board is normal (misaligned interests).

Timeline. At date 1, the shareholders offer contracts to the CEO and the board. If they accept, the company is established; otherwise, the game ends and all players receive their reservation payoffs. At date 2, the CEO finds a project with unobservable success probability θ and chooses the report properties. At date 3, the CEO's report is realized and observed by the board. At date 4, the board approves or rejects the project. At date

[5]For instance, the minimum board's outcome-specific payoffs are bounded from below due to the following lower bounds: $\widehat{v} \geq 0$, $v_0 \geq b_0 - 1$, $v_1 \geq 0$ and $v_w \geq 0$.

[6]In particular, we assume that non-financial benefits from working for a profit-maximizing company (a company that can reveal the project fundamental and approves project if successful) are not sufficient to motivate either the CEO or the directors; with zero monetary compensation, each agent leaves the profit-maximizing company.

[7]For example, a CEO compensated with a sufficiently large amount of shares, $\alpha_C \in (c, 1]$, is normal: then, $u_0 = -\alpha_C + c < 0 = \widehat{u}$.

5, all players receive their ex post payoffs. We solve the game with a subgame-perfect Nash equilibrium and restrict attention to weakly undominated strategies.[8]

3 Main analysis

3.1 Board's approval

At date 5, after observing the CEO's report, the board approves the project if and only if the post-report belief about project success is sufficiently high,

$$\mu_\rho \geq \tau \equiv \frac{\widehat{v} - v_0}{v_1 - v_0}.$$

The cutoff τ depends on the relative magnitude of the loss from approving a failing project, $\widehat{v} - v_0$, and the gain from approving a successful project, $v_1 - \widehat{v}$. Note that $\tau \in [0, 1]$ because the board is assumed to be normal for any contract. Because τ can be interpreted as the extent to which the board is prudent (or cautious) when approving the project, we often refer to it as the board's "prudence."

The effect of financial instruments on τ are graphically illustrated in Figure 1. The loss incurred by the board when it approves a failing project is on the horizontal axis and the gain from approving a successful project is on the vertical axis. We refer to these as the "board's stakes." Recalling that the board's prudence is the ratio of loss and gain, it is obvious that offering financial instruments that decrease the loss without changing the gain (shift to the right on the x-axis) increases the board's prudence and thereby requires a higher posterior belief about the project success for the board to approve the project. And vice versa, offering instruments that increase the gain without changing the loss (upward shift on the y-axis) makes it easier for the board to approve the project.

[8] With this restriction, we only avoid an inefficient weak equilibrium (miscoordination) which occurs when each agent expects that the other player rejects the contract, and therefore also rejects the contract.

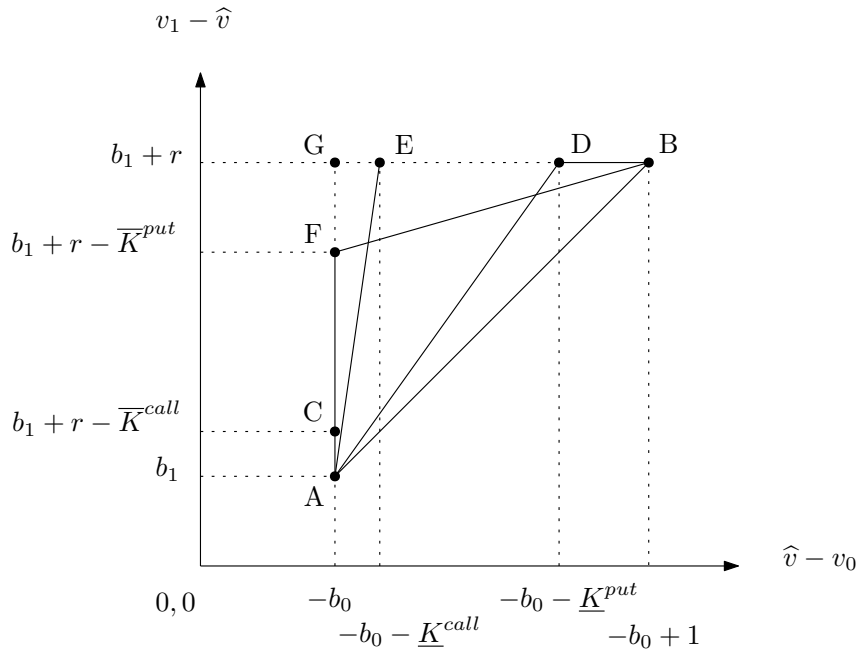

Figure 1: The effects of financial instruments on the board' stakes

In the absence of financial instruments (point A), the boards' stakes are positive (as the board is normal). Providing any instruments to the board (weakly) increases both the loss and the gain, and therefore doesn't change the fact that the board is normal. To visualize the effect of put options, we illustrate the case in which the board holds the maximum amount of shares (point B) and is subsequently offered put options to cover the shares (points D and F; depending on whether this is a single or two-event option). This contract is equivalent to a composite security that consists of maximum shares and maximum put options. We also illustrate provision of call options (points C and E; depending on whether this is a single or two-event option).[9]

Figure 1 highlights several stylized facts. First, by convexification, the shareholders can implement any pair of board's stakes in the triangle of ABG by offering an appropriate combination of securities with appropriately selected strike prices. Second, any pair of board's stakes (any point in the triangle ABG) can be implemented by multiple

[9]To illustrate the role of strike prices, we give an example with arbitrarily chosen positive and negative strike prices for each type of option. A negative price is $\underline{K} \in [-1, 0)$, and a positive price is $\overline{K} \in (0, r]$.

contracts. For example, the corner point G may represent a contract with call options, $(\alpha_B, \beta_B^{call}, \beta_B^{put}) = (0, 1, 0)$, where the strike price of the call options is zero, $K^{call} = 0$, but also a contract with shares and put options, $(\alpha_B, \beta_B^{call}, \beta_B^{put}) = (1, 0, 1)$, where the strike price of the put options is zero, $K^{put} = 0$. Third, stakes implemented by shares feature high levels of board prudence (as the loss $\widehat{v} - v_0$ is high relatively to the gain $v_1 - \widehat{v}$). Within the triangle ABG, the highest prudence arises on the line AB where only shares are provided. Furthermore, contracts on the AB-line have on average larger total stakes than other feasible contracts. In particular, the board's total stakes at point B exceed those of any other feasible contract in the triangle AGB.

3.2 CEO's report

We next consider the CEO's choice of report properties at date 3. Because the CEO's preferences over outcomes are regime-specific (i.e., depend on whether we are under the A-form or under the M-form), her choices are also regime-specific. Under the A-form, the CEO is normal—thus, she prefers that the board's project decisions maximize project profit. A sufficient condition for this is that the (normal) board knows whether the project is successful or not. Therefore, in a weakly undominated equilibrium, the CEO prepares a perfectly informative report, $(\mu_l, \mu_h) = (0, 1)$. From ex ante perspective, the board approves the project after a high report (with frequency μ) and rejects it after a low report (with frequency $1 - \mu$).

Under the M-form, the empire-building CEO seeks to maximize the probability that the project is approved. The solution to this classic CEO's persuasion problem is to send a binary report that is a (Bayes-plausible) lottery over posteriors $(\mu_l, \mu_h) = (0, \tau)$. Ex ante, the board now approves the projects after a high report (with frequency $\frac{\mu}{\tau}$) and rejects after a low report (with frequency $1 - \frac{\mu}{\tau}$). Notably, the report properties are such that the posterior belief after high signal is optimally adjusted to the board's prudence—just high

enough for the board to approve the project. The most precise report under the M-form is thus when τ achieves its highest value of one. As a result, the comparative statics of prudence with respect to financial instruments discussed in Section 3.1 applies also to the quality of information as long as the regime is M-form.

3.3 Optimal contracts

We are now ready to derive the optimal contracts offered to the CEO and the board. In the following, we first derive the *regime-specific* contracts and then consider the shareholders' preference over the regimes (i.e., preferences over the regime-specific contracts).

3.3.1 Regime-specific contracts

For each form $k \in \{A, M\}$, we are interested in finding the"cheapest profit-maximizing" pair of contracts. Out of all pairs of contracts that implement regime k and maximize the expected profit associated with the project, this pair minimizes the (total ex ante expected) monetary transfer from the shareholders to the agents.

A-form. Under the A-form, the reason for offering financial instruments to the CEO is for her to remain normal—this is achieved when the CEO's stakes do not fall below a certain threshold. As long as the CEO is normal, her report is perfectly informative. Thus, offering additional instruments no longer has effect on information. As a result, financial instruments are provided only up to the point that makes the CEO normal. Lemma 1 below evaluates the monetary transfer from the shareholders to the CEO that must be provided to the CEO to make her normal and shows that this transfer is lowest when the CEO is offered only shares.

Lemma 1 (A-form: offering shares to the CEO dominates offering options)**.** *The ex ante expected monetary transfer from the shareholders to the CEO that makes the CEO normal is minimized by a contract that offers only shares to the CEO.*

Our result implies that, under the A-form, the cheapest profit-maximizing contract offered to the CEO involves securities

$$(\alpha_C^A, \beta_C^{put,A}, \beta_C^{call,A}) = (c, 0, 0),$$

plus a fixed salary, u_w^A, is set to meet the CEO's participation and a non-negativity salary constraint. Here, offering the CEO a fraction of shares that equals just her private benefit, $\alpha_C^A = c$, is sufficient to ensure that she is normal.

Offering any financial instruments to the board under the A-form only increases the monetary transfer from shareholders to the board without any effect on information (it is already perfect). Thus the board's cheapest profit-maximizing contract under the A-form involves zero securities,

$$(\alpha_B^A, \beta_B^{put,A}, \beta_B^{call,A}) = (0, 0, 0),$$

and the fixed salary, v_w^A, is set to meet the participation and non-negativity salary constraint.

M-form. Under the M-form, as long as the CEO is an empire-builder, her contract has no effect on information quality and offering her any securities only increases the monetary transfer. Thus the CEO's cheapest profit-maximizing contract involves zero securities,

$$(\alpha_C^M, \beta_C^{put,M}, \beta_C^{call,M}) = (0, 0, 0),$$

and her salary u_w^M is set to meet her participation and non-negativity constraints. The instruments offered to the board, however, affect not only the monetary transfer but also the quality of information (via their effect on board's prudence). To make a comparison that preserves the quality of information, we proceed in two steps. First, we use that a pair of stakes (i.e., any point in Figure 1) may represent multiple contracts and show that two-event call options and two-event put options cannot minimize the ex ante monetary

transfers. Second, for a contract with single-event options, we find a purely share-based contract which preserves the quality of information, and show that the ex ante monetary transfer is lower for this contract.

Lemma 2 (M-form: offering shares to the board dominates offering options)**.** *It is always possible to (weakly) decrease the ex ante monetary transfer from the shareholders to the board and preserve the quality of information by eliminating all options and compensating the board only with shares.*

In light of the dominance of shares over options, a natural next step is to ask how do shares offered to the board affect the quality of information (determined by the board's prudence) under the M-form? Let us note that the prudence of a board incentivized solely with shares can be simplified to $\tau = \frac{\alpha_B - b_0}{\alpha_B(1+r) - b_0 + b_1}$ so that $\frac{\partial \tau}{\partial \alpha_B} \propto b_1 + b_0 r$. Because $b_0 < 0$, the effect of shares on prudence depends on the relative magnitude of b_1, b_0 and r.

Lemma 3 (M-form: Extreme board's incentives maximize prudence)**.** *Suppose that, under the M-form, the board is compensated solely with shares. If $b_1 > -rb_0$, the board's prudence is maximized when the project is sold to the board. Otherwise, it is maximized when the board is offered zero shares.*

Given that under the M-form the quality of the CEO's information is represented by the prudence, $(\mu_l, \mu_h) = (0, \tau)$, our result implies that shareholders aiming to maximize the quality of information about the project, should either offer minimum or maximum share-based compensation to the board. Therefore, the cheapest profit-maximizing contract to the board is

$$(\alpha_B^M, \beta_B^{put,M}, \beta_B^{call,M}) = (\overline{\alpha}_B^M, 0, 0),$$

where $\overline{\alpha}_B^M = \mathbb{1}_{b_1 > -rb_0}$ by Lemma 3. The contract also offers fixed salary v_w^M that meets the board's participation and non-negativity constraints.

Lemma 4 (Regime-specific optimal contracts)**.** *Under either regime, the cheapest profit-maximizing pair of contracts is also the regime-specific optimal pair.*

Our last result in this section establishes that the cheapest profit-maximizing contracts are the optimal ones for a specific regime. For future reference, we denote W^k the total value associated with the project at the regime-specific contracts.

3.3.2 Regime-specific rents and minimum continuation payoffs

Intuitively, the players earn rents if their outside options are sufficiently attractive and the player's surplus (minimum payoff minus the outside option) cannot be extracted by decreasing the fixed salary to negative values. To illustrate how a rent is created in a regime-specific contract, suppose that the shareholders decide to implement the A-form. To that end, the CEO receives $\alpha_C^A = c$ of shares. This contract gives the lowest variable compensation that is sufficient to make the CEO normal. That is, there is an (ex ante expected) monetary transfer to the CEO at the amount of $c\mu r$ (recall that under the A-form, information is perfect, $\mu_h = 1$, and the ex ante expected project value is μr), plus an ex ante expected private benefit to the CEO μc (recall that under the A-form, the approval rate is $p_h = \mu$). In total, this amounts to giving the CEO a "minimum continuation payoff" of

$$\underline{U}^A \equiv (1-\mu)\widehat{v}^A + \mu v_1^A = \mu v_1^A = \mu(r+1)c.$$

When the shareholders set the base salary, u_w, they extract total value W^A by minimizing the CEO's ex ante expected payoff, $U^A = u_w + \underline{U}^A$, subject to the CEO's participation constraint, $U^A \geq \underline{u}$, and a non-negativity constraint on the CEO's base salary, $u_w \geq 0$. The latter constraint can be restated as $U^A = u_w + \underline{U}^A \geq \underline{U}^A$. Meeting both constraints then is simply $U^A \geq \max\{\underline{U}^A, \underline{u}\}$. As a result, the minimized CEO's ex ante expected payoff is $U^A = \max\{\underline{U}^A, \underline{u}\}$, the minimized CEO's base salary is

$u_w = U^A - \underline{U}^A = \max\{0, \underline{u} - \underline{U}^A\}$, and the CEO's rent is

$$R_C^A = \max\{\underline{U}^A, \underline{u}\} - \underline{u} = \max\{\underline{U}^A - \underline{u}, 0\}.$$

By analogy, Lemma 5 derives minimum continuation payoffs and rents also for the M-form.

Lemma 5 (Rents)**.** *Under form $k \in \{A, M\}$, the CEO's rent is $R_C^k = \max\{\underline{U}^k - \underline{u}, 0\}$ and the board's rent is $R_B^k = \max\{\underline{V}^k - \underline{v}, 0\}$, where the CEO's and the board's minimum continuation payoffs are given by $\left(\underline{U}^A, \underline{V}^A\right) = (\mu(r+1)c, \mu \cdot b_1)$ and $\left(\underline{U}^M, \underline{V}^M\right) = \left(\mu \cdot \frac{c}{\tau}, 0\right)$.*

Notably, under the A-form the board does not earn rent, $R_B^A = 0$ as $\underline{V}^k < \underline{v}$. Under the M-form, the information quality of high report makes the board exactly indifferent, $\mu_h = \tau$, and therefore the board's minimum continuation payoff is zero, $\underline{V}^M = 0$. Because the board's outside option is positive, $\underline{v} > 0$, the board's rent under the M-form is zero, $R_B^M = \max\{-\underline{v}, 0\} = 0$. As we illustrate later, there exist admissible values of parameters under which the CEO earns rents (under either regime).

3.3.3 Optimal regime choice

Taking into account the rents of the players, the shareholders' payoff under regime k is

$$S^k = W^k - \max\{\underline{U}^k, \underline{u}\} - \max\{\underline{V}^k, \underline{v}\}. \tag{1}$$

Given that the board never earns rents ($R_B^M = R_B^A = 0$), the shareholders' payoff and the regime choice depend only on the total values, W^k, and the CEO's rents, $R_C^k = \max\{\underline{U}^k, \underline{u}\}$, for $k \in \{A, M\}$.

Proposition 1 (Optimal regime)**.** *The shareholders prefer the M-form if and only if*

$$W^M - \max\{\underline{u}, \underline{U}^M\} > W^A - \underline{U}^A, \tag{2}$$

or, equivalently, if $W^M - W^A - \underline{U}^M + \underline{U}^A > 0$ *(Condition 1) and* $\underline{u} < \widetilde{U} \equiv W^M - W^A + \underline{U}^A$ *(Condition 2).*

Our result illustrates that shareholders often face a dilemma between the size of profits (total value) and the share of profits (rents). In our setting, this dilemma arises when the shareholders have to choose between higher profits under the A-form ($W^A > W^M$) and lower CEO's rents under the M-form ($R_C^A > R_C^M$ or, equivalently, $\max\{\underline{U}^A, \underline{u}\} > \max\{\underline{U}^M, \underline{u}\}$).

Because the regime choice involves a number of parameters, there are several ways to visualize it. One way is through regime-specific feasibility sets. A feasibility set $\mathcal{P}^k$ in regime k is the set of pairs of the players' outside options, $(\underline{u}, \underline{v})$, such that the shareholders' payoff is non-negative, $S^k \geq 0$. To characterize $\mathcal{P}^k$, we recall that the shareholders' payoff in the feasibility set is $S^k = W^k - R_C^k - \underline{u} - \underline{v} = W^k - \max\{\underline{U}^k, \underline{u}\} - \underline{v} \geq 0$. The first subset of the feasibility set is characterized by $\underline{u} + \underline{v} \leq W^k$ and $\underline{u} > \underline{U}^k$. The second subset of the feasibility set is characterized by $\underline{v} \leq W^k - \underline{U}^k$ and $\underline{u} < \underline{U}^k$. Their union is when $\underline{u} + \underline{v} \leq W^k$ and $\underline{v} \leq W^k - \underline{U}^k$. Adding limits on the outsider options,

$$\mathcal{P}^k = \{\underline{u} \geq \mu c, \underline{v} \geq \mu b_1 : \underline{u} + \underline{v} \leq W^k, \underline{v} \leq W^k - \underline{U}^k\}.$$

Figures 2 and 3 show the feasibility set $\mathcal{P}^A$ (in red color) and the feasibility set $\mathcal{P}^M$ (in blue color) when $\underline{U}^A \geq \underline{U}^M$. (If not, then Condition 1 is clearly not satisfied for any $\underline{u}$ and the A-form is always preferred). It shows two different cases, depending on $W^M - \underline{U}^M \lesseqgtr W^A - \underline{U}^A$: (i) In Figure 2, $W^M - \underline{U}^M < W^A - \underline{U}^A$, and therefore it is impossible to satisfy inequality (2). Thus the A-form is always preferred. (ii) In Figure 3, $W^M - \underline{U}^M > W^A - \underline{U}^A$, and therefore the M-form is preferred when the CEO's outside option is sufficiently low. Figure 4 provides another way of visualizing the shareholders' regime choice. The figure plots the difference in shareholders' payoff, $S^M - S^A$, as a function of the CEO's outside option, $\underline{u}$. This allows to visually interpret

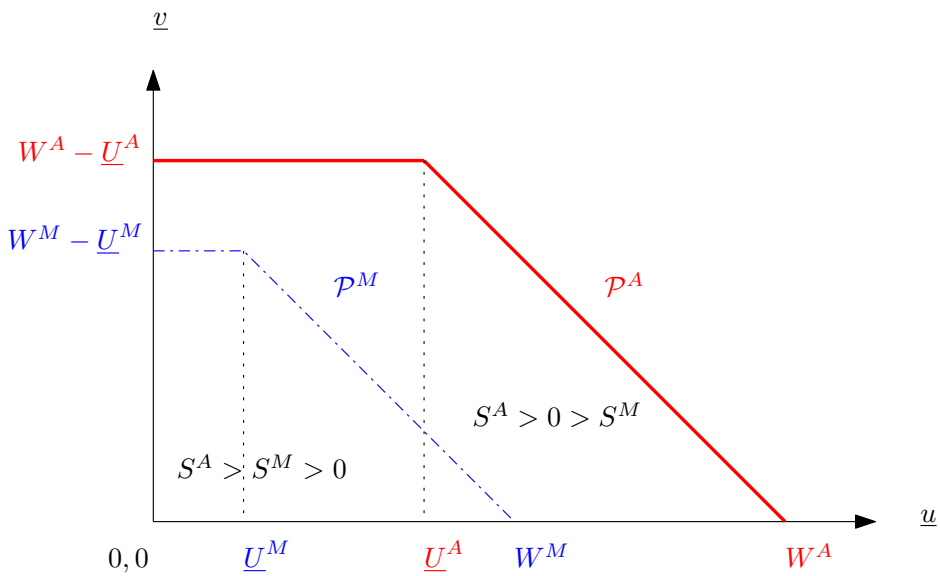

Figure 2: The shareholders' regime choice when $W^M - \underline{U}^M < W^A - \underline{U}^A$

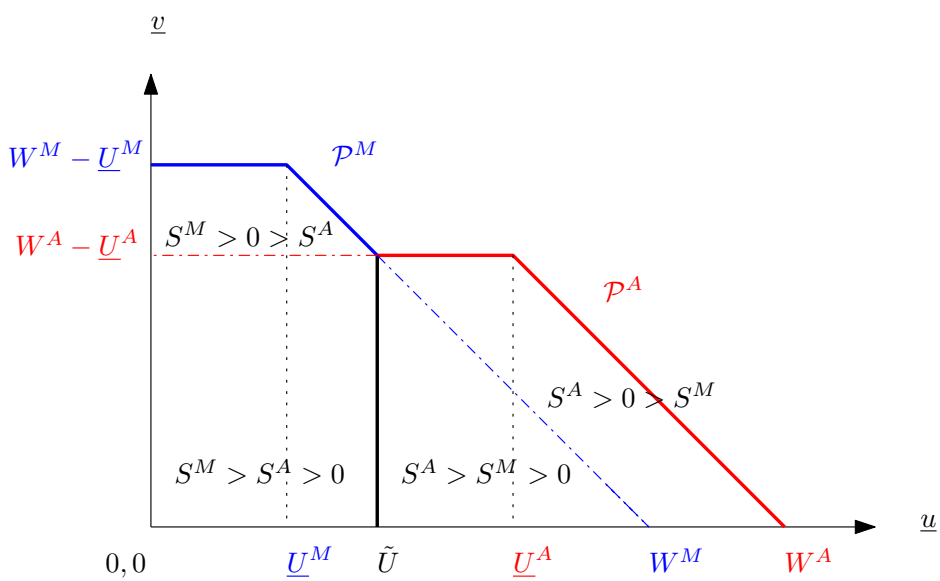

Figure 3: The shareholders' regime choice when $W^M - \underline{U}^M > W^A - \underline{U}^A$

both Condition 1 (the extra total value under the A-form doesn't cover the extra CEO's minimum continuation payoff) and Condition 2 (the CEO's outside option is sufficiently small).

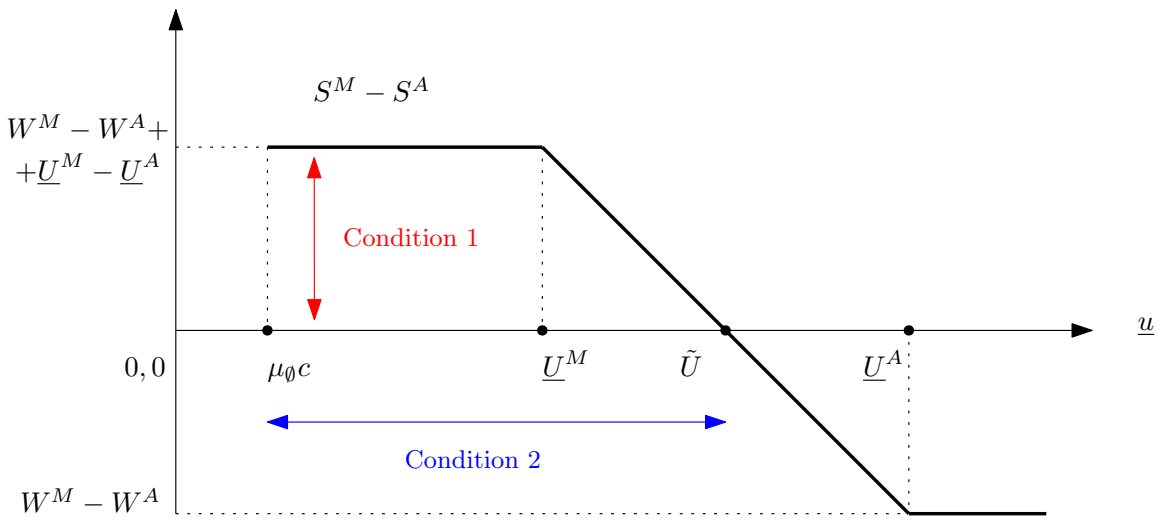

Figure 4: The shareholders' regime choice when Condition 1 holds

Lastly, we consider the effect of parameters on the regime choice. By Proposition 1, we need to look at the effects on Conditions 1 and 2. Again, we can visualize this in the plot of the shareholders' payoff difference, $S^M - S^A$, as a function of $\underline{u}$. There are two kinks, X and Y. The intersection of the XY line and the horizontal axis yields the cutoff $\widetilde{U}$. The effects of parametrical changes on the shape of $S^M - S^A$ are fully characterized by the changes in locations of the kinks X and Y. Figure 5 illustrates the changes in locations of the kinks with each parametrical change.[10]

Table 1 summarizes the effects of the parameters on the location of the kinks X and Y and on the resulting cutoff $\widetilde{U}$. In the last Column 6, we provide a summary of the effects on Conditions 1 and 2, which is the summary of the effects in Column 1 and Column 5. The former effect pertains to the *existence* of the cutoff, and the latter to the *level* of the cutoff. The table illustrates that the parameters affect the existence and the level of the

[10]This illustration covers the case when Condition 1 is satisfied. If not, the effect of the prior μ has an opposite sign. As illustrated in the figure, the prior serves only as a multiplier, and the slope of the effect is given by the slope of the line that connects the origin with the point X.

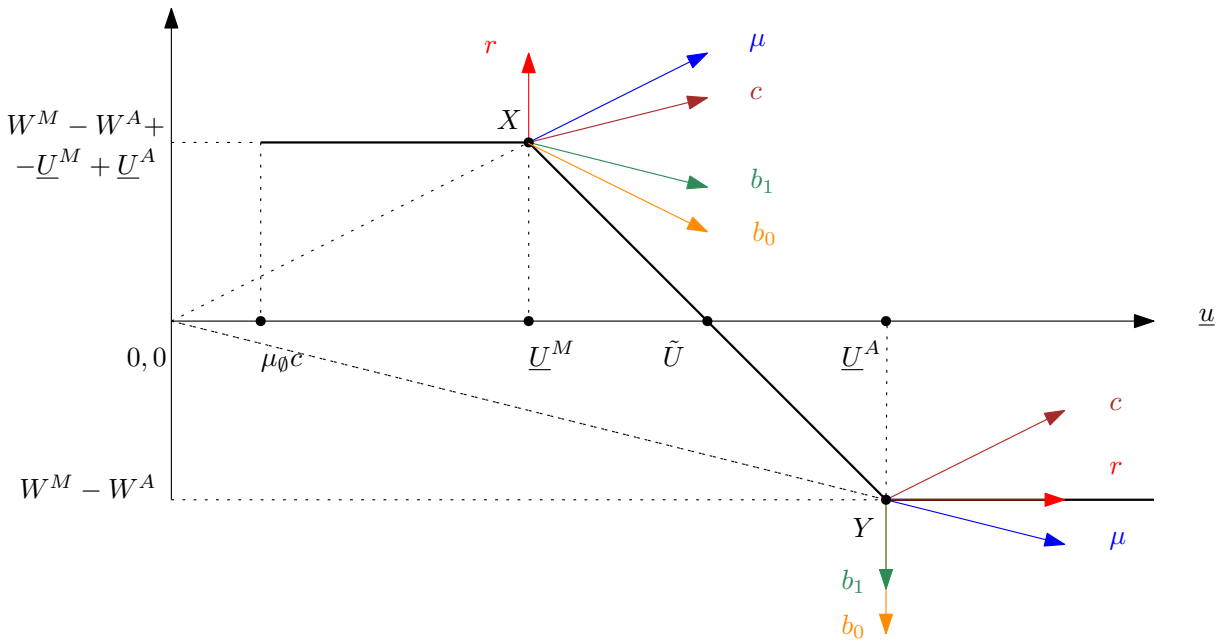

Figure 5: The effect of the parameters on the points X and Y when Condition 1 holds

cutoff in the same direction. In particular, the M-form is more likely optimal when the project has a high prior probability of success or a larger return in the event of success, and when the CEO's empire-building bias is stronger. The M-form is less likely optimal when the board's reputation benefit from a project success increases (large b_1).

Parameter	Kink X		Kink Y		Cutoff	M-form
	$W^M - W^A - \underline{U}^M + \underline{U}^A$	$\underline{U}^M$	$W^M - W^A$	$\underline{U}^A$	$\widetilde{U}$	(Conditions 1,2)
μ	$+$	$+$	$-$	$+$	$+$	$+, +$
r	$+$	0	0	$+$	$+$	$+, +$
c	$+$	$+$	$+$	$+$	$+$	$+, +$
b_0	$-$	$+$	$-$	0	$-$	$-, -$
b_1	$-$	$+$	$-$	0	$-$	$-, -$

Table 1: The effect of the parameters when Condition 1 holds

Most importantly, when the board's reputation cost from a project failure is more severe (low b_0), the M-form is paradoxically *more likely* optimal. Intuitively, reputation costs affect the attractiveness of the M-form by increasing total profits and by reducing total rents: (i) The positive effect on profits is associated with higher prudence of the board and a larger reputation cost increases this prudence, which increases the quality of information conveyed by the CEO and consequently also profits under the M-form. (ii) The second effect is on rents: a larger reputation cost decreases the CEO's minimum

in case of success and lower CEO's outside option decrease the quality of information. In contrast, the effects of the board's non-financial concerns are *non-monotonic*: Within the M-form, a larger board's reputation benefit of approving a successful project and a lower reputation cost of approving a failing project (a larger b_0 or a larger b_1) decrease the board's prudence, which reduces information quality. However, at the same time, the two changes that increase board's prudence also increase the willingness of the shareholders to implement the A-form, which implies a step-wise increase in the quality of information.

Parameter	Regime switch	Within A-form	Within M-form
μ	$-$	0	0
r	$-$	0	0
c	$-$	0	0
b_0	$+$	0	$-$
b_1	$+$	0	$-$
$\underline{u}$	$+$	0	0
$\underline{v}$	0	0	0

Table 2: The effect of the parameters on the equilibrium quality of information, μ_h

To summarize, when the board's non-financial concerns change such that board's prudence decreases (a larger b_0 or a larger b_1), the quality of information initially decreases as the board is more willing to approve the pet projects. But at some point, the shareholders begin to financially motivate the CEO and this replaces the weaker board's motivation. Board's non-financial incentives and the CEO's financial incentives are thus substitutes. Given the non-monotonicity, the equilibrium quality of information is high when non-financial concerns make the board's prudence either extremely low or extremely high. In the former case, the shareholders find the board too weak to counter persuasion of the CEO, and rather discipline the CEO directly through offering financial incentives. In the latter case, the prudent board is very effectively disciplining the CEO through her high prudence. Only when the board's prudence is moderate, the shareholders task the board with disciplining the CEO's overinvestments, but the board's prudence is relatively weak

to achieve this objective.

3.4 The board's non-financial bias

In this section, we consider the shareholders' preference over board's non-financial characteristics. To that end, we derive how the shareholders' equilibrium payoff, $S^* = \max\{S^A, S^M\}$, depends on the board's non-financial (reputation) cost of project failure, $-b_0$, and the board's non-financial (reputation) benefit from project success, b_1.

Let us first recall that, under the A-form, the shareholders' payoff is $S^A = W^A - \max\{\underline{U}^A, \underline{u}\} - \max\{\underline{V}^A, \underline{v}\}$. Since the CEO's minimal continuation payoff, $\underline{U}^A$, is invariant in the board's type, it is sufficient to evaluate the difference between total surplus and board's payoff:

$$W^A - \max\{\underline{V}^A, \underline{v}\} = \begin{cases} \mu(c + r + b_1) - \underline{v}, & \text{if } \mu b_1 \leq \underline{v}, \\ \mu(c + r), & \text{if } \mu b_1 > \underline{v}. \end{cases}$$

The shape of S^A is as follows: (i) Since the project never fails under the A-form, the board never suffers a reputation damage and the shareholders' payoff S^A is constant in $-b_0$. (ii) The payoff is increasing in the reputation benefit from approving a successful project, b_1, but only up to $\underline{v}/\mu$. Any further increase has no effect on the shareholders payoff. In this case, the payoff becomes constant because the shareholders lose the ability to extract the board's reputation benefit by offering a lower fixed salary.

Under the M-form, the shareholders' payoff is $S^M = W^M - \max\{\underline{U}^M, \underline{u}\} - \max\{\underline{V}^M, \underline{v}\}$. The board's minimal continuation payoff is zero, $\underline{V}^M = 0$, and therefore to analyze S^M it is sufficient to evaluate the difference between total surplus and CEO's payoff.

$$W^M - \max\{\underline{U}^M, \underline{u}\} = \begin{cases} \mu\left(\frac{b_1}{b_0}(1 - c) + c + r\right), & \text{if } \frac{\mu c}{\tau} \leq \underline{u}, \\ \mu\left(\frac{b_1}{b_0} + r\right) - \underline{u}, & \text{if } \frac{\mu c}{\tau} > \underline{u}. \end{cases}$$

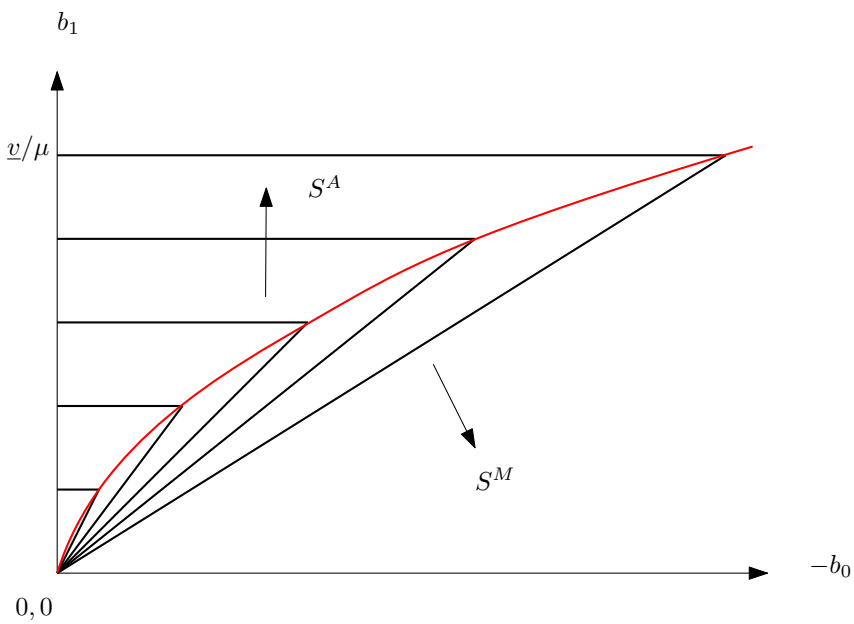

Figure 6: The constant levels of shareholders' equilibrium payoff, $S^* = \max\{S^A, S^M\}$

The level of S^M is increasing in the level of $\frac{b_1}{b_0}$.

We are now ready to evaluate the shape of the shareholders' equilibrium payoff, S^*, in $(-b_0, b_1)$, which is graphically represented in Figure 6. The contour levels are kinked at a point where the shareholders are indifferent between the A-form and the M-form. These points are on the red line. Several implications stand out: (i) If the board is highly non-financially concerned about approving a profitable project (high b_1), the shareholders implement the A-form and are better off when b_1 is as high as possible. (ii) In contrast, if the board is highly non-financially concerned about avoiding a failing project (high $-b_0$), the shareholders implement the M-form and are better off when $-b_0$ is as high as possible. This observation is paradoxical as the M-form involves a positive frequency of project failures, whereas under the A-form, projects never fail. It also suggests that if the shareholders can change the board only slightly (e.g., by appointing a few additional directors), they tend to *strengthen the dominating non-financial concerns* in the board. Even in the absence of board's control over re-appointments, existing directors' preferences influence endogenous segmentation of companies into two distinctly different types: A-form com-

panies with directors privately caring about project success and M-form companies with directors privately interested in avoiding reputation losses from project failures.

4 Empirical predictions

Our model generates several testable empirical predictions. First, we predict a higher level of investments and larger inefficiencies (defined as the difference between realized and maximum project returns) in companies with large potential returns and ex ante success rates, i.e., in growing industries. Second, we predict that CEOs receive large variable compensation if their outside opportunities are more attractive and they have only weak empire-building tendency. Otherwise, they are compensated with fixed wages.

Third, our model predicts that stocks are superior to options in compensation packages because they expose to downside risk. This prediction is consistent with Bhagat and Bolton (2019) who find director stock ownership to be strongly and consistently related to future performance. However, we also identify why, in spite of stock superiority, the optimal contract for the board often involves zero stocks. The first reason is *substitution* between the payments to CEOs and boards, and the second reason is *substitution* between directors' financial and non-financial incentives. The existence of these effects provides a new perspective on the links between career concerns and financial compensation (i.e., incentive payments in the form of stocks). In the literature, the link is negative as financial incentives and non-financial incentives are substitutes. The absence of financial compensation helps to build credibility of directors' decisions as financial incentives don't interfere with boards' non-financial incentives (Fama and Jensen, 1983). In our model, the second substitution effect goes in the opposite direction. As a result, when career concerns increase, the shareholders are motivated to switch from the A-form to the M-form. As a result, boards receive more shares.

Fourth, we predict that boards with higher career concerns (i.e., high directors' age,

high number of independent directors, and high media exposure as documented in Jiang, Wan and Zhao 2016) have a non-monotonic effect on the company value: (i) Within the M-form, higher career concerns make the board more prudent which improves the quality of the CEO's information. Thus reputation incentives improve the accuracy of information or corporate transparency (Sila, Gonzalez and Hagendorf 2017) and the company value typically increases. (ii) However, higher career concerns also imply that the M-form is more likely optimal—if there is a switch from the A-form to the M-form, the company value drops. In particular, the company value is U-shaped in the career concerns: it is low when concerns are sufficiently large that the shareholders sacrifice profits for rents in the regime choice, but at the same time not large enough to discipline the CEO.

Lastly, our results demonstrate that when both managers' and directors' contracts are set simultaneously, the effect of a change in parameters on the optimal directors' compensation depends on whether a change of the CEO's contract is also induced or whether the CEO's contract remains intact.

5 Concluding remarks

Why do shareholders offer contracts where CEOs and boards do not maximize the quality of decision-relevant information about investment opportunities? In this paper, we identify two main reasons: limited board's liability and limited bargaining power of shareholders. In particular, when the players' private benefits or costs from investment decisions are in conflict with profit maximization, the shareholders need to incorporate profit considerations into the players' objectives. Doing so through piecewise linear instruments (stocks and options) is, however, imperfect because these instruments limit the size of liability payments (penalties) imposed on the players.

Furthermore, the shareholders can extract surplus from the players through take-it-or-leave-it offers. However, there are constraints to their bargaining power. We focus on

the limits of bargaining power that arise only when the players are provided monetary incentives. In our setting, these limits arise when a minimum base payment (salary) must be paid to the agent. Our results continue to hold even if the shareholders' bargaining power is limited for other reasons as long as the decrease in bargaining power is associated with attempts to incentivize the players. In other words, we model a case when provision of hard incentives automatically generates a transfer from the shareholders to the players.

Appendix

A Extensions

A.1 Delegated contracting

In this extension, we assume that the shareholders offer a contract to the board, and the board subsequently offers a contract to the CEO. In other words, the shareholders delegate the CEO's contracting task to the board. We call this setup *delegated contracting*, and compare it with the *centralized contracting* as studied in the main part of our paper. Even in this setting, we can represent the shareholders' optimal contracting as a regime-selection problem. As we show below, the loss of direct control over the CEO's contract changes the regime-selection problem by changing the shareholders' regime-specific optimal contracts.

We analyze delegated contracting under two assumptions. First, when the shareholders offer a contract to the board, the contractible outcomes are characterized by the ex post project profits, $(-1, 0, r)$. Second, when the board is indifferent over a set of CEO's contracts, it selects the one that minimizes the ex ante monetary transfer to the CEO.

A.1.1 Board's contracting

We begin with the board's regime-selection choice. We know that the board is normal for any contract, i.e., the board's continuation payoffs satisfy $v_0 < \widehat{v} < v_1$. The board selects CEO's contracting variables to maximize the expected continuation payoff $V = (1 - p_h)\widehat{v} + p_h[(1 - \mu_h)v_0 + \mu_h v_1]$ subject to the limit on the maximum number of shares and call options, $\alpha_B + \alpha_C + \beta_B^{call} + \beta_C^{call} \leq 1$.

The board's expected continuation payoff is increasing in μ_h, so the board is maximizing μ_h subject to the limit above. We are primarily interested in whether the maximum $\mu_h = 1$ can be achieved. To that purpose, we say that the A-form is feasible if the board's contract makes it possible that the CEO becomes normal, i.e., if there exist feasible $(\alpha_C, \beta_C^{call}, \beta_C^{put}, K^{call}, K^{put})$ such that $\widehat{u} - u_0 > 0$.

Lemma 6 (Board's regime choice)**.** *Under delegated contracting, if the A-form is feasible, then the board offers the CEO a share-based contract,* $(\alpha_C, \beta_C^{call}, \beta_C^{put}) = (c, 0, 0)$*, and the equilibrium regime is A-form. If not, then the board offers the CEO a contract with zero financial instruments,* $(\alpha_C, \beta_C^{call}, \beta_C^{put}) = (0, 0, 0)$*, and the equilibrium regime is M-form.*

A.1.2 Shareholders' choice

Since the shareholders lose control over the CEO's contract, and the transfer of control to the board doesn't change the set of feasible CEO's contracts, the set of pairs of contracts that are feasible to the shareholders under delegated contracting is a subset of the set under centralized contracting. The shareholders' contracting problem under delegated contracting is therefore a constrained version of the contracting problem under centralized contracting.

Proposition 2 (Shareholders' regime implementation)**.** *If the optimal contract under centralized contracting implements the M-form with $\overline{\alpha}_B = 1$ or the A-form, then the optimal contracts under delegated contracting are identical. If they implement the M-form with $\overline{\alpha}_B = 0$, then the optimal contracts under delegated contracting are different and the shareholders' payoff under delegated contracting is lower than that under centralized contracting.*

Proposition 2 shows that the only difference between centralized and delegated contracting is that the shareholders may lose the option to implement the M-form with regime-specific optimal contracts when the A-form is feasible to the board. Intuitively, the board internalizes the interest of shareholders over maximum profits, but doesn't internalize their interest over minimum rents to the players. Therefore, the board is biased to higher quality but also higher rents for the CEO. When the shareholders anticipate that the M-form with $\overline{\alpha}_B = 0$ cannot be implemented, they have two options: (i) Make the A-form feasible to the board—then, the A-form is selected by the board and the profits increase. (ii) Increase α_B to make the A-form infeasible to the board—then, profits decrease because α_B is no longer the profit-maximizing amount of board's shares. Therefore, the effect of delegation is ambiguous.

A.2 Board's learning option

A.2.1 Assumptions

In this extension, we assume that the board can learn additional information, where the cost of information is measured in reducing Shannon entropy (learning option with rational inattention) and is proportional to $\lambda > 0$. In particular, after observing the realization r and forming interim belief μ_N, the board may obtain additional evidence (report) T. We denote $\psi_{r,t} \equiv \Pr(T = t \mid R = r)$ the probability that after observing the CEO's report r, the additional report realization is t. The properties of the additional report are characterized similarly to the public report. Again, it is sufficient to consider a binary report, $t \in \{l, h\}$, and the report can be characterized either as a pair of the interim beliefs induced by the report, $(\mu_{r,l}, \mu_{r,h})$, where $\mu_{r,l} \leq \mu_r \leq \mu_{r,h}$, or as a distribution over the report realizations, $(\psi_{r,l}, \psi_{r,h})$. The two characterizations are for each r linked by the martingale (Bayes-plausibility) property, i.e., by a constraint $\psi_{r,l}\mu_{r,l} + \psi_{r,h}\mu_{r,h} = \mu_r$.

The difference between the CEO's persuasion problem and the board's information acquisition problem is that learning additional information is costly to the board. This assumption could reflect the fact that directors have limited time and attention (especially if boards consist of directors with multiple positions). The cost may reflect also the industry maturity in a sense that there are more available information sources to learn from in more mature industries. In line with the rational inattention literature, we assume that the board's cost of obtaining the additional signal is proportional to the reduction of the (expected) Shannon entropy (Matějka and McKay, 2015) so that learning a more informative private signal is costlier for the board. Formally, the Shannon entropy of the

two-dimensional interim belief μ_ρ (for given r before observing t) is given by:

$$H(\mu_\rho) = -\mu_\rho \ln \mu_\rho - (1-\mu_\rho)\ln(1-\mu_\rho),$$

where $0 \ln 0 = 0$ holds by convention. The total entropy-based cost of an additional signal distributed by $(\psi_{r,l}, \psi_{r,h})$ when the interim belief is μ_N is $\psi_{r,l}H(\mu_{r,l}) + \psi_{r,h}H(\mu_{r,h})$. Then, the board's private (entropy-based) cost of the additional signal is

$$\lambda \left\{ H(\mu_\rho) - \psi_{r,l}H(\mu_{r,l}) - \psi_{r,h}H(\mu_{r,h}) \right\},$$

where $\lambda \geq 0$ is the marginal cost of reducing the entropy.[11] The lower λ, the easier it is for the board to learn additional information.

A.2.2 Optimal CEO's report

Following Caplin, Dean and Leahy (2019) and Matysková and Montes (2021), the solution to the CEO's persuasion problem in the presence of the board's learning option is to send a binary signal that is a (Bayes-plausible) lottery over posteriors $(\mu_l, \mu_h) = (0, \mu_L)$, where μ_L is the lowest belief under which the board is willing to *not learn* and approve the project (hence non-learning belief, labelled 'L'). Solving the board's learning problem with Shannon entropy[12] as in Caplin, Dean and Leahy (2019), the belief is as follows:

$$\mu_L \equiv \frac{e^{\frac{v_1 - v_0}{\lambda}} - e^{\frac{v_1}{\lambda}}}{e^{\frac{v_1 - v_0}{\lambda}} - 1} > \tau. \tag{3}$$

Ex ante, the board receives a low signal $r = l$ (that leads to a posterior $\mu_l = 0$) with frequency $1 - p_L$ and a high signal $r = h$ (that leads to a posterior $\mu_h = \mu_N$) with frequency $p_L = \mu/\mu_L$.

Again, the belief generated by the high signal realization, μ_L, is sufficient to characterize the precision of evidence and therefore measures the quality of the CEO's information. Like in the absence of board's learning option, the quality of information is increasing in board's prudence.

A.2.3 Regime-specific contracts

As Lemmas 1 and 2 apply to both absence and presence of board's learning option, the cheapest profit-maximizing contracts involve only shares and fixed wages. The optimal

[11] To fix ideas, consider an example with an intermediate belief $\mu_N = \frac{1}{2}$ so that the Shannon entropy is $H(\mu_\rho) = -\frac{1}{2}\ln\frac{1}{2} - \frac{1}{2}\ln\frac{1}{2} = \ln 2$. If the additional signal is perfectly informative, it eliminates all uncertainty and thereby results in Shannon entropy of zero. Thus, the board's cost of acquiring such signal is $\lambda \ln 2$.

[12] Formally, the slopes of board's value functions at corners of non-learning regions, M and L, must be equal. This implies $v_1 - \lambda \ln \mu_L = -\lambda \ln \mu_M$ and $v_0 - \lambda \ln(1-\mu_M) = -\lambda \ln(1-\mu_L)$. The corner of the non-learning region in which the board doesn't learn and rejects the project is $\mu_M = \frac{e^{\frac{1}{\lambda}-v_0}-1}{e^{\frac{1}{\lambda}(v_1-v_0)}-1} < \tau$.

amount of CEO's shares under the A-form doesn't change since board's learning is irrelevant under this regime. Setting the optimal amount of board's shares under M-form is however more nuanced, since the effect of board's shares on the quality of information (and company profits) is different in the absence and in the presence of board's learning option. In the absence of board's learning option, giving the board more shares affects the quality only through the effect on board's prudence τ. In the presence of board's learning option, μ_L depends not only on board's prudence, τ, but also on the stakes and therefore a change in α_B may have a non-monotonic effect on the quality of information (and company profits). In the following Lemma 7, we prove that effect of stakes dominates if and only if the stakes are large enough, and therefore the quality of information is either monotonic or U-shaped in α_B. Therefore, like in the absence of board's learning option, the cheapest profit-maximizing board's contract involves either giving zero shares to the board, $\overline{\alpha}_B^M = 0$, or selling the company to the board, $\overline{\alpha}_B^M = 1$.

Lemma 7 (M-form: Extreme board's incentives maximize company profits)**.** *Suppose that, under M-form, the board is compensated solely with shares. The quality of information (company profits) is maximized either when the project is sold to the board, $\overline{\alpha}_B^M = 1$, or when the board is offered zero shares, $\overline{\alpha}_B^M = 0$.*

In the absence of board's learning option, we observed that the cheapest profit-maximizing contract for M-form was also the regime-specific contract for M-form. The argument was that the CEO's positive report realization made the board exactly indifferent over accepting and rejecting the project, and the board thus had zero continuation payoff. With zero continuation payoff, the board couldn't earn any rent. Therefore, the shareholders could focus on maximizing total value (and profits) only. With board's learning option, this is not always the case. Given board's threat of learning, the CEO's positive report realization is more precise and the board earns a positive continuation payoff. As a result, the board potentially earns a rent. When the shareholders prepare a regime-specific contract, they may face a tradeoff between profits maximization and rent minimization. However, this tradeoff doesn't exist if the profits maximization overrides rent minimization, i.e., if the changes in rents are of second-order importance to the changes in profits.

Formally, we will assume that for any $\alpha_B \in [0, 1]$,

$$W^M(\overline{\alpha}_B^M) - U_p^M(\overline{\alpha}_B^M) - V_p^M(\overline{\alpha}_B) \geq W^M(\alpha_B) - U_p^M(\alpha_B) - V_p^M(\alpha_B), \tag{4}$$

where $U_p^M(\alpha_B)$ and $V_p^M(\alpha_B)$ denote continuation (project-related) payoffs of the agents in M-form when the board receives $\alpha_B \in [0, 1]$ shares, i.e., $U_p^M \equiv (1-p_h)\hat{u}+p_h[(1-\mu_h)u_0+\mu_h u_1]$ and $V_p^M \equiv (1-p_h)\hat{v} + p_h[(1-\mu_h)v_0 + \mu_h v_1]$.

Like in the final part of Proof to Lemma 4, it is now sufficient to prove that the regime-specific optimal contract is profit-maximizing, i.e., generating a maximum μ_h.[13]

[13]When (4) holds, rents of the agents are irrelevant in the context of within-regime contract choice; they become relevant only in the context of the regime choice (i.e., across-regime contract choice). To relax this condition means to extend the shareholders' tradeoff between high profits and low rents from the choice between two regime-specific contracts also to the choice of the regime-specific contract out of contracts available in each regime.

In the presence of board's learning option, the condition in inequality (4) implies that the shareholders' objective S^k in (6) is maximized at $\overline{\alpha}_B^M$.

A.2.4 Optimal regime

In the presence of board's learning option, we exploit the shape of the shareholders' payoff in (1) to demonstrate that the shareholders' tradeoff has a similar structure to the one in the absence of board's learning option. It only additionally takes into account the board's rent (which was zero when the board could not learn).

Proposition 3 (Optimal regime, learning option)**.** *In the presence of board's learning, the shareholders prefer M-form to A-form if $\overline{\alpha}_B^M = 0$ and inequality* (2) *holds, or if $\overline{\alpha}_B^M = 1$ and*

$$W^M - \max\{\underline{u}, \underline{U}^M\} - \max\{\underline{V}^M - \underline{v}, 0\} > W^A - \max\{\underline{u}, \underline{U}^A\}. \tag{5}$$

A.2.5 The effect of learning

An interesting corollary is that endowing the board with a learning option may decrease company profits. Consider a scenario in which the shareholders in the presence of board's learning option ($\mu_h = \mu_L$) prefer the M-form because $\overline{\alpha}_B^M = 0$ and inequality (2) holds, and suppose that they prefer the M-form by a negligible margin, $\epsilon > 0$. When we denote the respective total value W_L^M and the CEO's minimal continuation payoff $\underline{U}_L^M$, it yields

$$W_L^M - \max\{\underline{u}, \underline{U}_L^M\} = W^A - \underline{U}^A + \epsilon.$$

In the absence of learning ($\mu_h = \tau$), we denoted the respective total value W^M and the CEO's minimal continuation payoff $\underline{U}^M$. The total value is lower because the quality of information is lower, $W^M < W_L^M$ and the CEO's minimal continuation payoff is larger, $\underline{U}^M > \underline{U}_L^M$. As a result, the shareholders prefer the A-form,

$$W_L^M - \max\{\underline{u}, \underline{U}_L^M\} = W^A - \underline{U}^A + \epsilon > W^M - \max\{\underline{u}, \underline{U}^M\}.$$

In this scenario, introducing board's learning option means that the M-form becomes more attractive. The relative distortion to the A-form is lower and also the CEO's rent under the A-form is now a relatively more pressing problem. The shareholders begin to tolerate the M-form even if the quality of information decreases, the approval rate increases, and the company profits decrease. An opposite scenario exists when the board prefers the M-form both with and without the learning option. Then, since the quality of information increases, $\mu_L > \tau$, also the company profits increase.

B Proofs

Proof of Lemma 1: The CEO changes her identity from empire-builder to a normal player when $\widehat{u} - u_0 = 0$. For each instrument, we will derive the exact amount of the instrument that switches the CEO's identity, and subsequently derive the ex ante transfer to the CEO (the shareholders' cost) associated with provision of the instrument at the required amount. When calculating the ex ante transfer, recall that in A-form, the rejection outcome (with the CEO's payoff $\widehat{u}$) occurs with probability $1 - \mu$, and the approval of a successful project (with the CEO's payoff u_1) occurs with complementary probability μ.

- Shares: The required amount is $\alpha_C = c$, and the ex ante transfer is $\mu\alpha_C r = c\mu r$.
- Single-event call options, $\overline{K}^{call} > 0$: It is impossible to make the CEO normal because $\widehat{u} - u_0 = -c < 0$ for any amount of the options.
- Shares and single-event put options, $\underline{K}^{put} < 0$: Without loss of generality, put options cover all shares. The required amounts are $\alpha_C = \beta_C^{put} = -\frac{c}{\underline{K}^{put}} > c$. Since single-event put options are not exercised in A-form, the ex ante transfer is $\mu\alpha_C r > c\mu r$.
- Two-event call options, $\underline{K}^{call} < 0$: The required amount is $\beta_C^{call} = -\frac{c}{\underline{K}^{call}} > c$. In A-form, the call option is exercised always. The ex ante transfer is $\beta_C^{call}(1 - \mu)(-\underline{K}^{call}) + \beta_C^{call}\mu(r - \underline{K}^{call}) > (1 - \mu)c + c\mu(r - \underline{K}^{call}) > (1 - \mu)c + c\mu r > c\mu r$.
- Shares and two-event put options, $\overline{K}^{put} > 0$: Without loss of generality, put options cover all shares, $\alpha_C = \beta_C^{put}$. It is impossible to make the CEO normal because $\widehat{u} - u_0 = \beta_C^{put}\overline{K}^{put} - [-\alpha_C + \beta_C^{put}(\overline{K}^{put} + 1)] - c = -c < 0$ for any amount of options.

The lowest ex ante transfer is when the CEO receives the amount of shares $\alpha_C = c$ and the contract is $(\alpha_C, \beta_C^{call}, \beta_C^{put}) = (c, 0, 0)$.

Proof of Lemma 2: We proceed in two steps. First, we show that two-event options involve a suboptimally large monetary transfer. We change the contract with two-event options such that (i) we eliminate the options and (ii) introduce other financial instruments such that the board's stakes don't change, and therefore the quality of information doesn't change. Then, we show that these contract modifications decrease the ex ante monetary transfer to the board.

- (Two-event) call options with a strike price $\underline{K}^{call} < 0$ are provided at amount β_B^{call}: This contract is improved by eliminating call options, providing shares $\alpha_B = \beta_B^{call}$, and by providing single-event put options that cover all shares, $\beta_B^{put} = \beta_B^{call}$, with a strike price $\underline{K}^{put} = \underline{K}^{call} < 0$. The two contracts give identical board's stakes and thus identical quality of information. The outcome-contingent payments for the initial contract are $\beta_B^{call} \cdot (0, -\underline{K}^{call}, r - \underline{K}^{call})$, and for the modified contract are $\beta_B^{put} \cdot$

$(\underline{K}^{put}, 0, r) = \beta_B^{call} \cdot (\underline{K}^{call}, 0, r) = \beta_B^{call} \cdot [(0, -\underline{K}^{call}, r - \underline{K}^{call}) + (\underline{K}^{call}, \underline{K}^{call}, \underline{K}^{call})]$. Therefore, the ex ante transfer for the modified contract is like the ex ante transfer for the initial contract plus $\beta_B^{call}\underline{K}^{call} < 0$; i.e., the transfer has decreased.

- (Two-event) put options with a strike price $\overline{K}^{put} > 0$ are provided at amount β_B^{put}. In addition, shares that are covered by put options are, $\alpha_B = \beta_B^{put}$ (otherwise, put options are irrelevant): This contract is improved by eliminating both put options and the equivalent amount of shares, and by providing single-event call options, $\beta_B^{call} = \beta_B^{put}$, with a strike price $\overline{K}^{call} = \overline{K}^{put} > 0$. The two contracts give identical board's stakes and thus identical quality of information. The outcome-contingent payments for the initial contract are $\beta_B^{put} \cdot (\overline{K}^{put}, \overline{K}^{put}, r)$, and for the modified contract are $\beta_B^{call} \cdot (0, 0, r - \underline{K}^{call}) = \beta_B^{put} \cdot [(\overline{K}^{put}, \overline{K}^{put}, r) + (-\overline{K}^{put}, -\overline{K}^{put}, -\overline{K}^{put})]$. Therefore, the ex ante transfer for the modified contract is like the ex ante transfer for the initial contract plus $-\beta_B^{call}\underline{K}^{put} < 0$; i.e., the transfer has decreased.

Second, we are left with a contract based on single-event call options, and a contract based on single-event put options (and shares). For each of the two contracts, we construct a purely share-based contract that preserves the quality of information and show that the ex ante transfer is lower with the share-based contract. We obtain this contract indirectly. We begin with finding an *intermediate* share-based contract doesn't affect $\widehat{v}$ and v_1; only v_0 decreases. The intermediate contract has a higher quality of information (if v_0 decreases, both board's prudence and total stakes increase) and a lower ex ante transfer (if v_0 decreases, the only effect is a lower payment to the board contingent on the approval of a failing project). The intermediate contracts are as follows:

- (Single-event) call options with a strike price $\overline{K}^{call} > 0$ are provided at amount β_B^{call}: This contract is improved by an intermediate contract that eliminates call options and offers shares, $\alpha_B = \beta_B^{call}\frac{r-\overline{K}^{call}}{r}$. This modification doesn't affect $\widehat{v}$ and v_1; only v_0 decreases by α_B. As a result, board's prudence τ as well as board's total stakes $v_1 - v_0$ increase, and therefore also the equilibrium quality of information μ_h increases.

  The effect on the ex ante transfer is as follows: In the initial contract, the outcome-contingent payments are $(0, 0, \beta_B^{call}(r - \overline{K}^{call}))$; in the intermediate contract, the outcome-contingent payments are $(-\alpha_B, 0, \alpha_B r) = (-\alpha_B, 0, \beta_B^{call}(r - \overline{K}^{call}))$. Therefore, the only difference is that for the initial contract, the payment in the event of approving a failed project is zero, whereas for the modified contract, the payment in the event of approving a failed project is negative. Therefore, the ex ante transfer is lower. Precisely, the initial ex ante transfer was $\mu\beta_B^{call}(r - \overline{K}^{call})$, and the new ex ante transfer is

  $$\mu(p_h - \mu)(-\alpha_B) + \mu\alpha_B r = \mu(p_h - \mu)(-\alpha_B) + \mu\beta_B^{call}(r - \overline{K}^{call}) < \mu\beta_B^{call}(r - \overline{K}^{call}).$$

- (Single-event) put options with a strike price $\underline{K}^{put} < 0$ are provided at amount β_B^{put}. In addition, shares that are covered by put options are $\alpha_B = \beta_B^{put}$ (otherwise, put

options are irrelevant): This contract is improved by an intermediate contract that eliminates put options. This modification doesn't affect $\widehat{v}$ and v_1; only v_0 decreases from $\beta_B^{put}\underline{K}^{put} = \alpha_B\underline{K}^{put} < 0$ to $-\alpha_B$. As a result, board's prudence τ as well as board's total stakes $v_1 - v_0$ increase, and therefore also the equilibrium quality of information μ_h increases.

The effect on the ex ante transfer is as follows: In the initial contract, the outcome-contingent payments are $\alpha_B \cdot (\underline{K}^{put}, 0, r)$; in the intermediate contract, the outcome-contingent payments are $\alpha_B \cdot (-1, 0, r)$. As a result, the modification decreases the outcome-contingent payment by $\alpha_B(\underline{K}^{put} + 1) > 0$. Therefore, the ex ante transfer is lower.

Finally, we decrease the amount of shares in the intermediate contract $(-\alpha_B, 0, \alpha_B r)$. This affects both the quality of information and the ex ante monetary transfer. We use that by Lemma 3, the quality of information is either increasing in α or is U-shaped in α. Thereby, we can decrease the amount of information down to the level at which the quality of information is like for the initial contract. At the same time, we use that decreasing the amount of shares is decreasing the ex ante monetary transfer, because the ex ante expected project value at μ_h is positive, $(1 - \mu_h)(-1) + \mu_h r > 0$.

Proof of Lemma 3: The project quality is $\mu_h = \tau$. We begin with a special case $b_0 = b_1 = 0$. The board's prudence is $\tau = \frac{1}{1+r}$, and therefore it is constant. When $b_0 < 0$ and/or $b_1 > 0$, the monotonicity of τ in α_B is straightforward.

Proof of Lemma 4: We first rewrite the shareholders' program in general, and then solve the program for each regime separately. In regime k, suppose financial instruments are determined and shareholders only select wages u_w and v_w. The shareholders then maximize $S^k = W^k - (U_p^k + u_w) - (V_p^k + v_w)$ subject to $u_w \geq 0$, $v_w \geq 0$, $U_p^k + u_w \geq \underline{u}$, and $V_p^k + v_w \geq \underline{v}$, or equivalently, $u_w \geq \max\{0, \underline{u} - U_p^k\}$ and $v_w \geq \max\{0, \underline{v} - V_p^k\}$. The salaries of the players are minimized when the constraints are binding, and the maximized objective is

$$S^k = W^k - \max\{U_p^k, \underline{u}\} - \max\{V_p^k, \underline{v}\}. \tag{6}$$

This shows that shareholders benefit from, ceteris paribus, an increase in total value and a decrease in players' continuation payoffs. We now proceed to contracts in each specific regime. In A-form, W^A is constant for any pair of contracts that is consistent with A-form. Therefore, the shareholders only minimize players' continuation payoffs; as the distribution of outcomes is invariant to contracts (i.e., expected non-financial payoffs are constant), it means to minimize players' monetary transfers. This concludes that the A-form-specific optimal contracts are the cheapest profit-maximizing contracts.

In M-form, take a set of contracts that generates an identical distribution of outcomes, and therefore an identical μ_h. For both players, the expected non-financial values are identical in all the contracts, and minimization of the players' continuation values is therefore equivalent to minimization of monetary transfers provided to the players. By Lemma 2, the regime-specific optimal contracts involve only shares to the board.

It only remains to prove that the regime-specific optimal contract is also profit-maximizing, i.e., generating a maximum μ_h. In the absence of board's learning option, see that $V_p^M(\alpha_B^M) = 0$. Also, recall that $U_p^M(\overline{\alpha}_B^M) \leq U_p^M(\alpha_B^M)$ for any $\alpha_B^M \in [0,1]$, because the board's expected non-financial payoff is decreasing in quality μ_h (as the project approval rate is decreasing) and $\overline{\alpha}_B^M$ maximizes project quality. Therefore, as $W^M(\overline{\alpha}_B^M) \geq W^M(\alpha_B^M)$ for any $\alpha_B^M \in [0,1]$, we have that the shareholders' objective S^k in (6) is maximized at $\overline{\alpha}_B^M$.

Proof of Lemma 5: Under the A-form, the board does not receive any shares, and its minimum continuation value consists only of the non-financial gain associated with a successful project, $\underline{V}^A \equiv \mu b_1$. Under the M-form, the CEO receives no shares but is privately motivated, which implies provision of minimum value $\underline{U}^M \equiv p_h c = \frac{\mu}{\mu_h} c$ to the CEO. The board receives shares $\overline{\alpha}_B$ and is privately motivated, which implies provision of minimum value $\underline{V}^M \equiv p_h \left\{(1-\mu_h)(-\overline{\alpha}_B + b_0) + \mu_h(\overline{\alpha} r + b_1)\right\}$.

In all cases, we again derive the rent of a player by minimizing the salary such that the ex ante expected value of the player exceeds the minimum value (participation constraint) and the salary is non-negative.

Proof of Proposition 1: First, we derive total values. Under the A-form, $W^A = \mu(c + b_1 + r)$. Under the M-form, we use that the board is indifferent if $\mu_h = \tau$, i.e., $(1-\mu_h)(-\overline{\alpha}_B^M + b_0) + \mu_h(\overline{\alpha}_B^M r + b_1) = 0$. By subtracting this zero term from

$$W^M = \frac{\mu}{\mu_h} \left\{(1-\mu_h)(-1 + b_0 + c) + \mu_h(r + b_1 + c)\right\},$$

we obtain

$$W^M = \frac{\mu}{\tau} \left\{c + (1 - \overline{\alpha}_B^M)[(1-\tau)(-1) + \tau r]\right\}.$$

This yields

$$W^M = \begin{cases} \mu\left(\frac{b_1 - b_0}{-b_0} c + \frac{b_1}{b_0} + r\right) & \text{if } \overline{\alpha}_B^M = 0, \\ \mu \frac{1 + r + b_1 - b_0}{1 - b_0}\, c & \text{if } \overline{\alpha}_B^M = 1. \end{cases}$$

Second, we derive the CEO's rents, $R_C^A = \max\{\underline{U}^A - \underline{u}, 0\} = \max\{\frac{\mu}{\tau_F} c - \underline{u}, 0\}$ and $R_C^M = \max\{\underline{U}^M - \underline{u}, 0\} = \max\{\frac{\mu}{\tau_I} c - \underline{u}, 0\}$.

We have two structurally different cases. When shares are productive in raising board's prudence, we have $\overline{\alpha}_B^M = 1$, and $\underline{U}^M > \underline{U}^A$, therefore $R_C^M \geq R_C^A$ for any $\underline{u}$, and consequently A-form is optimal ($S^A > S^M$) for any $\underline{u}$.

The more interesting case is when shares are counterproductive in raising board's prudence, $\overline{\alpha}_B^M = 0$ and $\underline{U}^A > \underline{U}^M$. The difference between the rents under the A-form and the M-form is (weakly) decreasing in the CEO's outside option,

$$R_C^A - R_C^M = \begin{cases} \underline{U}^A - \underline{U}^M, & \text{if } \mu c \leq \underline{u} \leq \underline{U}^M, \\ \underline{U}^A - \underline{u}, & \text{if } \underline{U}^M \leq \underline{u} \leq \underline{U}^A, \\ 0, & \text{if } \underline{U}^A \leq \underline{u}. \end{cases}$$

Therefore, the shareholders' payoffs difference, $S^M - S^A = W^M - W^A + R_C^A - R_C^M$, is also (weakly) decreasing in $\underline{u}$. Notice that the payoffs difference is negative when the outside option is sufficiently high and CEO's rents cease to exist, namely $S^M - S^A = W^M - W^A < 0$ when $\underline{u} \geq \underline{U}^A$.

From the (weakly decreasing) shape of the payoffs difference $S^M - S^A$, we identify two necessary conditions for strict preference of the M-form. The first necessary condition is that the payoffs difference is positive when the CEO's outside option is very low, and the payoffs difference is therefore maximum. (If not, $W^A - W^M > \underline{U}^A - \underline{U}^M$, then $S^M - S^A < 0$ for any $\underline{u}$, and shareholders prefer A-form for any admissible CEO's outside option.)

$$W^A - W^M = \mu b_1 \left(1 + \frac{c-1}{b_0}\right) < \mu c \left(r + \frac{b_1}{b_0}\right) = \mu c \left(\frac{1}{\tau_F} - \frac{1}{\tau_N}\right) = \underline{U}^A - \underline{U}^M. \tag{7}$$

In terms of parameters, the first necessary condition in (7) can be written as $b_1(1-b_0) + b_0 cr > 0$. Notice that this condition implies that the CEO's minimum continuation value is higher in A-form than in M-form, $\underline{U}^A - \underline{U}^M \geq 0$, because $\underline{U}^A - \underline{U}^M \geq W^A - W^M > 0$, and therefore implies the condition $\tau_I > \tau_F$ (equivalently, $\underline{U}^A - \underline{U}^M \geq 0$). The condition $\tau_I > \tau_F$ therefore becomes redundant.

When the first necessary condition in (7) is satisfied, there exists a cutoff level of the CEO's outside option, $\widetilde{U}$, where $S^M > S^A$ if $\underline{u} < \widetilde{U}$ and $S^M < S^A$ if $\underline{u} > \widetilde{U}$. Precisely, the shareholders' payoffs difference $S^M - S^A$ is positive if $\underline{u} = \underline{U}^M$ (due to the necessary condition in (7)) and negative if $\underline{u} = \underline{U}^A$ (as both rents are then equal zero). Given monotonicity of the payoffs difference $S^M - S^A$, the cutoff level lies within an interval, $\widetilde{U} \in (\underline{U}^M, \underline{U}^A)$. The cutoff level is

$$\widetilde{U} \equiv \underline{U}^A + W^M - W^A = \mu \left\{ c(r+1) + \frac{b_1}{b_0}(1-c) - b_1 \right\}.$$

Therefore, $\underline{u} < \widetilde{U}$ is the second necessary condition for strict preference of M-form. It is straightforward that the two necessary conditions are also (jointly) sufficient. Finally, since M-form is preferred only if $\underline{u} < \widetilde{U} < \underline{U}^A$, we can insert $\max\{\underline{U}^A, \underline{u}\} = \underline{U}^A$ and obtain a simplified condition in (2).

Proof of Lemma 6: Part 1 (A-form is feasible): Under the A-form, the board achieves quality $\mu_h = 1$ and her expected payoff is $V = (1-\mu)\widehat{v} + \mu v_1$. Therefore, the board is indifferent over any CEO's contracts that implements A-form. When indifferent, the board in delegated contracting (by assumption) offers a contract that minimizes the ex ante monetary transfer to the CEO. By Lemma 1, this is a contract $(\alpha_C, \beta_C^{call}, \beta_C^{put}) = (c, 0, 0)$.

Notice that this contract is feasible, i.e., $c + \alpha_B + \beta_B^{call} \leq 1$. We prove by contradiction: Suppose the contract is not feasible, $\alpha_B + \beta_B^{call} > 1 - c$ and A-form is implementable, $\widehat{u} - u_0 > 0$. When implementing A-form, we know that put options always decrease $\widehat{u} - u_0$ and therefore we can disregard put options; we can only check if A-form can be implemented with call options and shares. The board's continuation payoff under rejection is $\widehat{u} = \beta_C^{call} \max\{0, -K^{call}\}$, where $-K^{call} \leq 1$. The board's continuation payoff for a failed

project is $u_0 = -\alpha_C + c$. Therefore, $\widehat{u} - u_0 = \beta_C^{call} \max\{0, -K^{call}\} + \alpha_C - c < \beta_C^{call} + \alpha_C - c$. By the constraint on maximum number of shares and options, $\alpha_C + \beta_C^{call} \leq 1 - \alpha_B - \beta_B^{call}$ and therefore, using $\alpha_B + \beta_B^{call} > 1 - c$,

$$\widehat{u} - u_0 < \alpha_C + \beta_C^{call} - c \leq 1 - \alpha_B - \beta_B^{call} - c < 0.$$

This implies that the board is not normal, $\widehat{u} - u_0 < 0$ and A-form is not implementable, which is the contradiction.

Part 2 (A-form is infeasible): When the A-form is not feasible, any feasible CEO's contract implies that the regime is M-form. In M-form, the CEO's contract doesn't affect μ_h. Therefore, the board is indifferent over all CEO's contracts. When indifferent, the board in delegated contracting (by assumption) offers a contract that minimizes the ex ante monetary transfer to the CEO, which is $(\alpha_C, \beta_C^{call}, \beta_C^{put}) = (0, 0, 0)$.

Proof of Proposition 2: Depending on the optimal contracts in centralized contracting, there are three cases:

- A-form in centralized contracting: The shareholders' optimum in the unconstrained problem is feasible, and therefore is again implemented by the shareholders. Precisely, the shareholders select an identical board's contract like in delegated contracting (zero financial instruments), and board offers the CEO an identical contract like in delegated contracting (by Lemma 6, a share-based contract).

- M-form with $\overline{\alpha}_B = 1$ in centralized contracting: The shareholders' optimum in the unconstrained problem is feasible, and therefore is again implemented by the shareholders. Precisely, the shareholders select an identical board's contract like in delegated contracting ($\overline{\alpha}_B = 1$). This contract makes A-form infeasible to the board. By Lemma 6, the board offers the CEO an identical contract like in delegated contracting, i.e., zero financial instruments to the CEO.

- M-form with $\overline{\alpha}_B = 0$ in centralized contracting: The shareholders' optimum in the unconstrained problem is not feasible, because if the board receives $\overline{\alpha}_B = 0$, then A-form becomes feasible to the board, and by Lemma 6, the board offers the CEO a share-based contract, where the regime is A-form. This also proves that the optimal contracts are not identical (giving the board an identical contract implies a different contract for the CEO). Given that the shareholders' optimum is no longer feasible in the restricted set of pairs of contracts, the shareholders' payoff is lower.

Proof of Proposition 3: Part 1 ($\underline{\alpha}_B^M = 0$ and (2) imply $S^M > S^A$): First, we derive two implications of $\underline{\alpha}_B^M = 0$: (i) We know that μ_L is either increasing or U-shaped. A necessary condition for $\underline{\alpha}_B^M = 0$ is that μ_L is U-shaped. By Lemma 5, $\underline{U}^M < \underline{U}^A$. (ii) In addition, since the board receives zero monetary transfers in any regime, $\alpha_B^A = \alpha_B^M$, board's minimal continuation payoffs reflect only board's non-financial benefits; the expected non-financial

benefit $p_h[(1-\mu_h)b_0+\mu_h b_1])$ is increasing in the quality of evidence, and therefore $\underline{V}^M < \underline{V}^A = \mu b_1 \leq \underline{v}$. This implies $R_B^M = 0$.

Second, notice that with $R_B^M = R_B^A$, the shareholders prefer the M-form over the A-form if and only if (2) holds.

Part 2 ($\underline{\alpha}_B^M = 1$ and (5) imply $S^M > S^A$): This only uses characterization of shareholders' payoff in (1) and $R_B^A = 0$ (or, equivalently, $\max\{\underline{V}^k, \underline{v}\} = \underline{v}$).

Proof of Lemma 7: We prove that the quality is either (i) monotonic in α_B or (ii) decreasing and then increasing in α_B. Therefore, the maximum is in a boundary. To begin with, in the presence of board's learning ($\lambda > 0$), the project quality is $\mu_h = \mu_L$, where μ_L is defined in (3). Again, we begin with a special case $b_0 = b_1 = 0$, where the board's prudence is constant, $\tau = \frac{1}{1+r}$. Then, by simple algebra, μ_L is increasing in α_B.

When $b_0 < 0$ and/or $b_1 > 0$, an increase in α_B has two effects on μ_L: (i) An increase in α_B increases the stakes which increases μ_L. (ii) An increase in α_B affects board's prudence. As the two effects on μ_L are in the same direction and one is strict, μ_L increases.

Lastly, $\operatorname{sgn} \frac{d\mu_L}{d\alpha_B} = \operatorname{sgn} T(\alpha_B)$, where,

$$T(\alpha_B) \equiv re^{\frac{\alpha_B(1+r)-b_0+b_1}{\lambda}} + 1 - (1+r)e^{\frac{\alpha_B r+b_1}{\lambda}}.$$

Next, we show that the function $T(\alpha)$ is increasing in α_B,

$$\frac{dT(\alpha_B)}{d\alpha_B} = r(1+r)e^{\frac{\alpha_B r+b_1}{\lambda}}\left(e^{\frac{\alpha_B-b_0}{\lambda}} - e^0\right) > 0.$$

Therefore, either the sign of the marginal effect $\operatorname{sgn} \frac{d\mu_L}{d\alpha_B}$ doesn't change for $\alpha_B \in [0,1]$, or it is negative and then positive.

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