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Implications of power: When the CEO can pressure the CFO to bias reports ☆

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ABSTRACT

Building on archival, anecdotal, and survey evidence on managers' roles in accounting manipulations, I develop an agency model to examine the effects of a CEO's power to pressure a CFO to bias a performance measure, like earnings. This power has implications for incentive compensation, reporting quality, firm value, and information rents. Predictions from the model provide potential explanations for the differing results from recent empirical studies on the impact of regulatory interventions like SOX and the extent to which the CEO's or CFO's incentives significantly impact on earnings management. The model also identifies conditions under which either a powerful or a non-powerful CEO can extract rents, which can help explain mixed empirical results on the association between CEO power and "excessive" compensation.

1. Introduction

Separation of productive and reporting tasks within a firm is ubiquitous. CFOs oversee and manage information and reporting systems, while CEOs are primarily charged with generating value for shareholders. While the CFO has a fiduciary duty to the shareholders and the board, he is also responsible to the CEO (Mian, 2001). This gives CEOs power over CFOs, power that can be used to promote shareholders' goals or to pressure CFOs to manipulate the reporting system and overstate performance (Feng et al., 2011).[1] In this paper, using an analytic model I investigate the consequences of the power

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[1] The CEO's power over the CFO can arise, for example, from the firm's hierarchical structure, the CEO being a blockholder, other employees' loyalty to the CEO, the CEO's personality, and the CEO's prestige (Adams et al., 2005; Feng et al., 2011; Finkelstein, 1992; Haleblian and Finkelstein, 1993; Lambert et al., 1993).

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that CEOs may possess over CFOs, focusing on consequences related to incentives, reporting quality, firm value, and information rents.

The focus on the CEO's ability to pressure the CFO is motivated by anecdotes, large-sample archival evidence, and survey responses, as well as a desire to explain inconclusive large-sample evidence on the relations between incentive compensation, managerial attributes, and reporting quality. SEC Accounting and Auditing Enforcement reports (AAERs) provide several anecdotal examples of CEOs allegedly pressuring CFOs to manipulate accounts. Regarding the high-profile accounting scandal at HealthSouth Corporation (HRC), the SEC alleged that “When HRC's earnings fell short of [Wall Street analysts'] estimates, Scrushy [the CEO] *directed* HRC's accounting personnel to ‘fix it’ by artificially inflating the company's earnings to match Wall Street expectations.” (SEC, 2003, emphasis added).[2] Feng et al. (2011) find that firms with significant accounting manipulations as indicated by SEC AAERs, when compared to matched firms, tend to have CFOs with similar equity incentives but are more likely to have powerful CEOs. Their evidence is consistent with CEO pressure being a primary driver of CFOs' involvement in accounting manipulations.[3] Dichev et al. (2013) report results of a recent survey of 169 CFOs in which 91 percent report inside pressure as a motivation to manage earnings. Based on a survey of 141 public company CFOs, Fink (2002) states that 17 percent of CFOs “report being pressured to misrepresent their results by their companies' CEOs during the past five years.” Furthermore, despite the CFO's oversight of the reporting system, large-sample evidence on who is primarily responsible for reporting quality is mixed. Feng et al. (2011) find that misconduct-based earnings management is more associated with CEO equity incentives than CFO equity incentives, while Jiang et al. (2010) find that accrual-based earnings management is more associated with the CFO's equity incentives than the CEO's.

To explore the implications of CEO power on earnings management, I develop an agency model that incorporates a CEO's power to pressure a CFO to bias reports that serve as a performance measure for both. In the model, the CEO (female) takes an action that produces valuable output for the firm. The CFO (male) controls the properties of the contractible performance measure.[4] His primary action is “reporting” effort to set up and maintain a system with effective controls that produces a performance measure useful for contractually motivating the officers. This basic setup is consistent with a growing literature focusing on CEOs and CFOs (e.g., Friedman, 2013b; Indjejikian and Matějka, 2009). As in Friedman (2013b) and Indjejikian and Matějka (2009), the CFO can bias the performance measure. I expand on these papers by incorporating the CEO's ability to apply pressure on the CFO to do so.[5]

I analyze the firm under three conditions. First, I consider the case in which the CEO cannot pressure the CFO; i.e., the CFO has full control over the reporting system. In this case, the bias in reporting is entirely driven by the CFO's incentive compensation and the costs he faces, notwithstanding that the CFO's biasing imposes an externality on the CEO. An increase in the CFO's personal cost of biasing (e.g., through provisions in SOX and Dodd–Frank that increased CFO punishments for corporate fraud, such as compensation clawbacks) causes the CFO to bias less for any given level of incentives. Because reporting effort that improves internal controls makes it harder for the CFO to bias a given amount, the CFO who anticipates biasing less will optimally exert more reporting effort, lowering the risk of errors in the reporting system. A less-risky reporting system means that risk-sharing problems introduced with incentive compensation are lessened. This enables the board to strengthen the compensation incentives for the CEO as well as the CFO, which in turn leads to greater production from the CEO and higher firm value. In short, when the CEO cannot pressure the CFO, increases in the costs the CFO faces for biasing enhance firm value.

Next, I consider the case in which the CEO can force the CFO to bias reports at a level that the CEO chooses. In this case, the amount of bias is driven by the CEO's compensation and her ability to avoid costs associated with CFO biasing, where a more powerful CEO is better able to avoid these costs (e.g., by making the CFO a scapegoat). In contrast to the first condition, an increase in the CFO's personal cost of bias leads to lower reporting effort and firm value and weaker incentive compensation for the CEO and CFO. These effects are driven by the CFO reducing reporting effort to ease the biasing he is pressured to provide. Accordingly, toughening the CFO's punishment after detection of manipulation may have unintended consequences (i.e., lead to lower reporting quality) in firms where the CEO can exert pressure.

In the first and second cases, all parties have symmetric information when they contract, and the CEO extracts no rents from her power over the CFO. To allow for rents associated with CEO power (e.g., Bebchuk et al., 2002), I introduce information asymmetry at the contracting stage. In this case, the CEO may or may not have the ability to pressure the CFO.

[2] Scrushy was not found guilty while five former CFOs pleaded guilty or were convicted and faced sentences ranging from 6 months of home detention to 5 years in prison. In another complaint against several officers of MCSi, Inc., the SEC alleged that “ Stanley [the CFO], *at the instigation of* Peppel [the CEO] resorted to simply making up revenue by means of fictitious journal entries.” (SEC, 2006, emphasis added). Examples of CEO pressure from AAERs necessarily involve SEC enforcement actions against both CEO and CFO. Evidence in Burks (2010) and Hennes et al. (2008) suggests that accounting restatements are more likely to lead to CFO turnover than CEO turnover. They do not condition on CEO power, so this turnover differential combined with the anecdotal AAER evidence implies that there are plausibly cases where restatements are the result of CEOs pressuring CFOs, where the blame and consequences subsequently fall primarily on the CFO.

[3] Schrand and Zechman (2012) find that fraud and AAER firms tend to have executives who receive higher compensation and are more likely to have been a company founder. They interpret these as indicators of confidence, although these indicators are also used as proxies for managerial power, and especially CEO power (e.g., Adams et al., 2005; Feng et al., 2011; Morck et al., 1988). Therefore an alternative interpretation of their results is that fraud and AAER firms tend to be those with more powerful CEOs.

[4] I use female pronouns for the CEO (i.e., she, her), and male pronouns for the CFO (i.e., he, him, his).

[5] As in Friedman (2013b,a), the model features a cost interaction between the CFO's biasing and reporting efforts that reflects biasing being more difficult and costly when the CFO has exerted more noise-reducing reporting effort. The interaction reflects reporting effort improving internal controls, which reduce errors and make manipulations more difficult. Nan (2008) features a similar type of interaction in a model focusing on hedging choices.

She knows her type, but this is her private information at the contracting stage. I find that, in contrast to much of the literature on adverse selection, either type of CEO (i.e., powerful or not powerful) may have the binding truth-telling constraint and extract information rents. This occurs because the CEO faces countervailing incentives related to her power. Greater power benefits the CEO because it increases her expected compensation, as the performance metric has a higher mean, all else equal. Power, though, also has a downside due to its negative effect on reporting quality. As noted in the previous case, when pressured to bias, the CFO provides less reporting effort. This lowers his cost of pressure-induced biasing but also increases the riskiness of the incentive contract for a given level of incentives. The CEO therefore faces a trade-off between the benefit of power in increasing her expected compensation and the cost of power related to risk. These trade-offs provide countervailing incentives, which allow either type of CEO to extract rents.

The results yield several empirical implications which could be operationalized around recent corporate governance policy interventions or in the cross section generally. For example, the introduction of the Dodd–Frank whistleblower awards, starting in late 2011, provides an interesting shock to the ability of CEOs to pressure their subordinates that could be used in difference-in-difference tests. The model suggests that the effects of the whistleblower provisions on reporting quality, incentive compensation, firm value, and CEOs' "excess" compensation will be stronger in firms with more powerful CEOs relative to CFOs (e.g., where the CEO has a larger professional network or is more entrenched). In the cross-section, the adverse selection results imply that risk tolerance moderates the relation between CEO power and rent extraction, which may be reflected in "excess compensation". The model predicts that CEOs are more likely to achieve "excess compensation" either when they are risk-tolerant and powerful or when they risk-averse and not powerful.[6]

The model suggests empirical tests that can help determine whether governance interventions like SOX and Dodd–Frank and changes in board and audit committee composition have helped reduce harmful CEO power or if the primary effect was simply to increase biasing costs for CFOs regardless of whether their biasing actions are driven by personal motivation or CEO pressure. In firms with powerful CEOs, reporting quality, incentive compensation strength, and firm value are predicted to increase if the main effect is a reduction in the CEO's willingness to exert pressure. In contrast, these are predicted to decrease if the main effect of the change is to increase CFO exposure to legal and job-market sanctions for a given amount of biasing. In firms with non-powerful CEOs, increasing punishments to the CFO should have positive effects on reporting quality, incentive compensation strength, and firm value. In these firms, lowering the CEO's willingness to exert pressure by increasing the externality that CFO biasing imposes on the CEO would have no effects on reporting quality or incentive compensation.

The following section introduces the moral hazard model. Section 3 analyzes the moral hazard model, while Section 4 introduces and analyzes the model with adverse selection. Section 5 discusses empirical implications and proxies for CEO power over CFOs. Finally, Section 6 concludes with a discussion of limitations and avenues for future research.

2. The moral hazard model

The model builds most directly on those in Indjejikian and Matějka (2009) and Firedman (2013a,b), which feature similar CEO–CFO-principal interactions. The models in these papers feature symmetric information at the contracting phase, precluding information rents. Distinct from these papers, this paper features CEO pressure and models information asymmetry at the contracting phase, allowing the CEO to extract information rents. This section introduces the pure moral hazard model, assuming symmetric information at the contracting phase. Section 4 expands the model by relaxing this symmetric information assumption.

The time-line consists of three dates. The principal (hereafter the board) first offers contracts to the CEO and CFO, which they may accept or decline. If they decline, they achieve their reservation utilities. If they accept the contracts, they choose actions in the second period. The CFO chooses reporting effort, $r>0$, and biasing, $b\in\Re$, while the CEO chooses production, $p\geq 0$. Within the second period, bias is chosen last, consistent with empirical evidence that earnings' management is concentrated near the end of reporting periods (Dechow and Shakespeare, 2009; Kerstein and Rai, 2007). Output and signal values are realized in the third period, and payoffs are made.

Output is not contractible. Expected output is fp, a linear function of the CEO's productive action, p, and her marginal productivity, f. The contractible performance metric is an endogenous-quality signal, y, that is normally distributed with mean $E[y]=p+b$. The mean of y is the sum of the CEO's productive action, p, and the CFO's biasing action, b, which reflects performance metric incongruity as in Feltham and Xie (1994) and Datar et al. (2001).[7]

[6] Age and gender are potential proxies for risk tolerance (e.g., Barua et al., 2010; Morin and Suarez, 1983).

[7] The bias in the model can be related empirically to options backdating, fraud, restatements, opportunistic use of accruals, or real cash flow management (see Burns and Kedia, 2006; Desai et al., 2006; Healy, 1985). Although bias activities may involve accrual accounts that mechanically reverse in the future, a subsequent period involving the reversal of bias is omitted. The bias is therefore best interpreted as an activity whose reversal either is not mechanical, as in fraud, or is expected to occur so far in the future that the discounted value is relatively low. Even with near-term reversals, the incentives to bias in the current period will be attenuated rather than eliminated. Schrand and Zechman (2012) and Beasley et al. (2010) suggest that personal gains motivate managers to engage in manipulations.

The variance of y is $Var[y] = \sigma/r$, where $\sigma > 0$ is an exogenous parameter and $r > 0$ is the costly reporting effort chosen by the CFO.[8] The CFO's reporting effort can be interpreted as efforts to improve accounting quality, for instance by investing in internal controls that reduce the risk of errors by the firm's accounting and control staff (Doyle et al., 2007). This interpretation is intuitive as reporting effort reduces the noise in the contractible performance measure. The improvement in accounting quality could also result from a reduction in errors made by the CFO or increased effort in formulating assumptions underlying components of earnings based on estimates.

The parameter σ captures the marginal impact of the CFO's action in reducing the variance, as $d\,Var[y]/dr = -\sigma/r^2$. This parameter also captures the level of performance metric variance for any given level of reporting effort provided, and may be associated with factors such as exogenous but reducible litigation risk (e.g., Armstrong et al., 2010). Greater σ implies exposure to greater risk, but also increases the benefits of reporting effort.

The costs of actions are as follows. The cost of productive action for the CEO takes a standard quadratic form, $p^2/2$. The direct cost to the CFO of reporting effort, cr, is linear with marginal cost $c > 0$.[9] Biasing costs are quadratic and depend on reporting effort. The biasing cost borne by the CFO is $qrb^2/2$, where $q > 0$ is the cost of bias parameter.[10] Positive q implies that higher reporting effort leads to higher biasing costs, and high biasing effort from the CFO causes him to anticipate high total reporting costs.[11] Maintaining the interpretation of reporting effort as the CFO's personal investments in internal controls, the cost interaction between bias and reporting reflects empirical evidence, consistent with intuition, that internal controls reduce earnings management by making earnings management more costly (Doyle et al., 2007). Several examples illustrate this intuition. Introducing segregation of duties would be costly to the CFO because he would have to hire or train a capable, independent employee. Segregation of duties can reduce errors but also makes biasing more costly because biasing now requires either coordination or additional efforts to hide the bias. Lowering the value threshold for investigating transactions would require more costly reporting effort to test a greater number of transactions. This would also make inflating revenues through fictitious transactions more costly because the CFO would have to use more lower-value transactions to hide the same level of bias. Better reporting can also involve making the assumptions underlying managers' estimates more thorough and transparent. This would make it more difficult for the CFO to adjust estimates without triggering red flags or being forced to justify changes in assumptions. The cost interaction also reflects the CFO's limited attention (Liang and Nan, 2014) in that more time spent on reporting effort is associated with a higher marginal cost of spending time on biasing, and vice versa.

The CFO's biasing activity also imposes negative externalities on the CEO and the firm related to, for instance, disgorgement of gains, costs to prove innocence, legal fees, and settlements. These negative externalities are represented by $vb^2/2$ and $kb^2/2$ for the CEO and firm, respectively, with $v, k > 0$.[12] Higher costs to the CEO represented by higher v capture a CEO who cannot credibly avoid blame for CFO biasing or who cannot reliably use the CFO as a scapegoat to avoid punishment. Reporting effort does not impact the externality to the CEO or the firm because the personal cost of actions to circumvent the internal control system is borne by the CFO alone.

The exogenous parameters for the CFO's costs of effort, c and q, are expected to be affected by the CFO's skill, financial expertise, experience, firm specific human capital, and the reporting environment, which includes auditors, regulators, legal enforcement, information intermediaries, and investors (Aier et al., 2005; Li et al., 2010). Biasing costs, q, and the externalities that the biasing imposes on the CEO and the firm, parameterized by v and k, also depend on the probability of bias being detected and the expected losses conditional on detection, including adverse effects on wealth and employment as well as criminal prosecution and the costs of legal defense (Burks, 2010; Feng et al., 2011; Goldman and Slezak, 2006; Hennes et al., 2008; Karpoff et al., 2008; Wang, 2010).

A powerful CEO is one who can force the CEO to bias at a level different from what the CFO would otherwise choose.[13] Specifically, a powerful CEO is modeled as one who can force $b = m$, where m is chosen by the CEO. The CEO's preferred level of bias will depend both on the incentive compensation tied to the manipulable performance measure and on the externality that CFO biasing imposes on the CEO, parameterized by v. A CEO with a higher externality cost, v, will force the CFO to impound less bias, all

[8] Liang et al. (2008) and Ziv (2000) incorporate monitoring agents who have a similar impact on the performance metric's variance. Indjejikian and Matějka (2009) refer to this type of effort as reducing measurement error, which is part of the CFO's fiduciary duties. Liang et al. (2008) have a "manager" who exerts effort to produce the contractible signal, noting, "while we use the term manager, we could equivalently refer to a monitor or an internal auditor" (p. 796). In some sense, the CFO's responsibilities allow him to be interpreted as the highest-rank internal auditor. The CFO's variance reduction effort could also be interpreted as hedging against the noise in the measurement of the CEO's effort, as in Nan (2008).

[9] The linear cost function is chosen as a simple representation sufficient for a concave optimization problem on r, as the benefit to the CFO of reporting effort in reducing the risk premium is concave.

[10] As Caskey et al. (2010, p. 453) note, "The reduced-form quadratic misreporting costs represent the expected ex post legal penalties (SOX Title IX) and/or the ex ante effort spent to manipulate reports such as overcoming subordinate and auditor objections."

[11] The cost interaction is consistent with Dye and Sridhar (2004), who focus on relevance-reliability trade-offs inherent in the aggregation of signals that have different precision and bias, and Stocken and Verrecchia (2004), who discuss interactions between the precision of a reporting system and the ease of manipulating it. Ewert and Wagenhofer (2005), Fischer and Verrecchia (2000), and Laux and Laux (2009) also discuss interactions between the reporting system and biasing in settings focused on accounting standards, capital markets, and board committees, respectively.

[12] The CEO bears a cost for the CFO's biasing but does not bias the performance measure directly. Including costly biasing effort from the CEO in the model, as in Friedman (2013b), would not substantially change the main results.

[13] One interpretation is that a powerful CEO may be able to scapegoat the CFO into absorbing the brunt of the costs associated with biasing that is ultimately the CEO's choice; however, the CEO still bears the externality cost, $vb^2/2$. Burks (2010), for example, finds that, after a restatement, CFOs are frequently removed from the CFO position, while CEOs are more likely to face a relatively minor reduction in pay.

else equal. In the example in the introduction involving HealthSouth, the CEO was effectively able to scapegoat the CFOs and thereby avoid legal punishments related to accounting manipulation, analogous to the CEO of HealthSouth having low v.

The CEO's ability to force bias equal to m can be thought of as the outcome of side contracting between the CFO and CEO over the amount of bias that the CFO will impound into the reporting system. Lower v reflects a CEO who faces lower costs from CFO biasing and is more comfortable with forcing a higher level of bias from the CFO. Reduced-form explicit representations of side contracts are common in the literature on reporting agents (e.g., Baiman et al. (1991) and Kofman and Lawarrée (1993) on auditors; Villadsen (1995) on supervisors; and Drymiotes (2007) on directors). Related papers focus on incentives in multi-period games that are useful for sustaining implicit side contracts between agents (e.g., Arya et al., 1997; Che and Yoo, 2001). The modeling approach in this paper uses a reduced-form explicit representation in order to allow for direct solutions that illustrate the relevant tradeoffs related to CEO pressure, incentive compensation strength, and reporting quality. Note that a powerful CEO can force the CFO not to bias, which will occur as the externality cost becomes large (i.e., as $v \to \infty$). This pressure not to bias is consistent with the board's goals and effectively constitutes the powerful CEO being an additional monitoring mechanism.

CEO power as modeled is consistent with evidence that CFO biasing can be influenced by pressure from the CEO as discussed in the introduction. The problem of the CEO pressuring the CFO to manipulate reports is both constrained and suggested by several institutional features. Whistleblower protections, bounties, and clawbacks set up by SOX and Dodd–Frank, for instance, can increase the likelihood and severity of punishments for engaging in manipulation or pressure, but the existence of these features in and of itself suggests the pervasiveness of the problem. Similar intuition applies to audit requirements that both constrain and suggest manipulation pressure, including requirements for auditors to explicitly ask if upper-echelon managers pressured employees to manipulate financial statements. The efficacy of regulatory interventions and audit strategies in preventing powerful agents from exerting pressure in the reporting process (i.e., raising v for powerful CEOs) remains an open empirical question.[14] Additionally, CFOs may be able to mitigate CEO pressure by threatening to leave the firm. However, the subsequent CFO in the existing firm is likely to be subject to CEO pressure as well.[15]

Contracts are linear in the realization of the performance metric. The CEO's pay is given by $s_E(y) = \alpha_E + \beta_E y$, and the CFO's pay is given by $s_F(y) = \alpha_F + \beta_F y$. Contingent contracts increasing in an observed signal are ubiquitous for CEOs and CFOs (Jiang et al., 2010), and linear contracts are a useful abstraction. While linearity may be a strong assumption, the β_i coefficients capture incentive compensation strength or pay-performance sensitivity up to linear approximations, much like an option delta (e.g., Core and Guay, 1999).[16]

CEO and CFO preferences over compensation and actions are summarized by negative exponential utility functions U_E and U_F with constant absolute risk aversion coefficients ρ_E and ρ_F. Preferences are defined over contractual pay, personal effort costs, and the biasing cost externality as $U_i = -e^{-\rho_i W_i}$ for $i \in \{E, F\}$, with $W_E = s_E(y) - p^2/2 - vb^2/2$ and $W_F = s_F(y) - cr - qrb^2/2$. With this structure the expected-utility-maximizing officers' objective functions are their certainty-equivalent utilities (CE_E and CE_F). They are

$$CE_E = \alpha_E + \beta_E(p+b) - \frac{p^2}{2} - \frac{vb^2}{2} - \frac{\rho_E \beta_E^2 \sigma}{2r} \quad \text{and} \tag{1}$$

$$CE_F = \alpha_F + \beta_F(p+b) - cr - \frac{qrb^2}{2} - \frac{\rho_F \beta_F^2 \sigma}{2r}. \tag{2}$$

The certainty-equivalents for each officer reflect expected compensation, $\alpha_i + \beta_i(p+b)$, net of the costs of effort undertaken and the biasing externality, $p^2/2 + vb^2/2$ or $cr + qrb^2/2$, and risk imposed by the compensation contracts, $\rho_i \beta_i^2 \sigma/2$, with $i \in \{E, F\}$. Each officer has an exogenous reservation wage that provides certainty-equivalent utility equal to 0, without loss of generality. Either officer's reservation wage can be adjusted to reflect his or her bargaining power relative to the board

[14] The legal literature suggests that the SOX whistleblower protections have not been effective at encouraging whistle-blowing, but that bounties similar to those paid under the False Claim Act and introduced by Dodd–Frank might be successful (Dworkin, 2006; Earle and Madek, 2007). Baloria et al. (2013) provide evidence that firms with more powerful CEOs (i.e., board chairs or founders) were more likely to lobby the SEC to water down Dodd–Frank whistle-blower provisions, consistent with these provisions having a negative impact on powerful CEOs. The practitioner literature suggests that CFOs may not be covered by whistleblower protections after they personally certify the financial statements (Stuart, 2003). Clawback and compensation forfeiture provisions mandated by Dodd–Frank and SOX can also provide disincentives for powerful CEOs to pressure CFOs to bias. Brown et al. (2011) find that firms with powerful CEOs (those with longer tenure and higher bonus relative to cash compensation) were less likely to adopt clawback provisions.

[15] If the CEO was able to exert pressure initially, then it is plausible that she has power within the firm and will have a say in the hiring process for the subsequent CFO, potentially enhancing the CEO pressure problem. Li et al. (2010) find that CFO turnover after an adverse SOX Section 404 opinion is not, in and of itself, associated with an improvement in the adverse opinion, so CFO turnover alone seems unlikely to fix the problem. Mian (2001) finds that CFO turnovers in which the new CFO is an internal appointment are associated with significant negative stock price reactions, consistent with the CEO pressure hypothesis. Schrand and Zechman (2012) find that misreporting and fraud tend to occur during periods of poor performance, which would make it difficult for outsiders to disentangle a CFO who leaves due to poor performance from a CFO who leaves due to CEO pressure.

[16] Sung (1995), extending Holmstrom and Milgrom (1987), provides some justification for linear contracts when an agent's unobserved effort affects variance. Demski and Dye (1999), extending the scope of acceptable contracts, use quadratic, rather than linear, contracts to examine moral hazard and project selection in a single-agent setting. In the setup here, it could be useful for the CFO to be paid using non-monotonic compensation that punishes the CFO for outliers as a way of motivating variance-reduction. Indjejikian and Matějka (2009) have a similar model with linear contracts in which the CFO exerts reporting effort. The CFO also exerts productive effort, which, while useful in motivating an increasing contract, does not significantly affect the tradeoffs in the reporting system.

Table 1
Variable definitions for the model.

Variable	Description
y	Performance metric, $y \sim N(p+b, \sigma/r)$
p	Productive action
b	Biasing action that affects the mean of y but does affect output
r	Reporting action that lowers the variance of y and increases the cost of bias
α_i	Fixed portion of each agent's contract, with $i \in \{E, F\}$
β_i	Linear coefficient on y in each agent's contract, with $i \in \{E, F\}$
f	Marginal productivity of p
q	CFO's biasing cost parameter
v	Cost of CFO biasing on the CEO parameter
k	Cost of CFO biasing on the firm parameter
c	Direct reporting cost parameter
m	Biasing that CEO forces the CFO to do
ρ_i	Constant absolute risk-aversion of each agent, with $i \in \{E, F\}$
σ	Scale parameter for the variance of y

without affecting the optimal contractual incentives and actions derived below, as long as the firm remains valuable. Firm value is defined as expected output net of compensation costs and the biasing externality cost to the firm, $V = fp - E[s_E + s_F] - kb^2/2$. Table 1 summarizes notation.

Although the model is fairly general, there are, as in any model, limitations. Two are especially worth highlighting here. First, the model assumes linear contracts and normally distributed signals. Issues related to contract convexity or concavity cannot be directly addressed (see, e.g., Healy, 1985 on nonlinear bonus schemes and Armstrong et al., 2013 on equity portfolio Vega). Second, there is only a single period, which eliminates the ability to directly address multi-period aspects of accounting quality, such as forward-looking information, earnings smoothness, accrual reversals, or reserves (e.g., Demski, 1998; Dutta and Fan, 2012; Liang, 2004). A single-period model also cannot directly examine the agents' career concerns or ex post investigations and punishments the board might undertake and enforce on the agents. While these are significant limitations, the reduced-form model allows for analytical results that provide insights into issues related to incentives, organizational design and managerial pressure when the quality of performance metrics and the compensation contracts are both endogenous. Furthermore, several of the exogenous parameters, like q, c, and v implicitly capture costs that can arise from multi-period concerns and a risk-return tradeoff between bias and variance in the reporting system. The following section presents the initial analysis of the model, when the board and officers have symmetric information when contracting.

3. Symmetric information when contracting

3.1. Non-powerful CEO

In this subsection the CEO has no direct influence on the CFO's biasing choice. Since effort is not observable, the board must provide incentives to the CEO in order to induce productive effort. These incentives, which depend on the stochastic performance measure, cause the CEO to demand a premium for the risk she bears. Reporting effort reduces the risk of the performance metric and thus reduces the risk premium that the CEO must be paid. To induce reporting effort, the board imposes risk on the CFO via incentive compensation tied to the risky performance measure. The CFO reacts to the contract by providing reporting effort to reduce the risk he faces, and by biasing the performance metric to increase the expected payment. The board's problem, denoted N for no power, is

$$N: \max_{\{s_i, p, b, r\}_{i = E,F}} fp - E[s_E] - E[s_F] - \frac{kb^2}{2} \tag{3}$$

$$\text{s.t. } CE_E \geq 0, \quad CE_F \geq 0 \tag{4}$$

$$p \in \arg\max CE_E; \quad r, b \in \arg\max CE_F \tag{5}$$

where CE_E and CE_F are defined by Eqs. (1) and (2), respectively. The first and second constraints in (4) are the participation or individual rationality (IR) constraints. The incentive compatibility (IC) constraints are in (5). The board maximizes expected output net of expected compensation and biasing costs, subject to the IR and IC constraints.

By the IR constraints, the board must offer contracts that provide at least the reservation (certainty-equivalent) utilities. The firm therefore bears, eventually, the costs of both officer's actions, but this also allows the board to remove the effects of expected bias from expected compensation, since the board knows the biasing actions that will be induced. The board therefore chooses the contracts to strike a balance between the benefit of productive incentives and the costs of production, reporting, biasing, and risk premia that result from the officers' rational reactions to the incentives provided in the contract. Proposition 1 below describes the equilibrium defined by the board's problem, N. Subscripts are added to denote optima, and all proofs can be found in Appendix A.

Proposition 1. *In the solution to Problem N, the CEO and CFO each achieve their reservation utility in expectation. The incentive coefficients and actions at the solution take the following form*:

1. *If* $(f-2\sigma\sqrt{c\rho_F\rho_E/(\rho_F\sigma-1/q)})^2>(v+k)c/(q^2(\rho_F\sigma-1/q))$ *then*:
   (a) $\beta_{E,N}=f-2\sigma\sqrt{c\rho_F\rho_E/(\rho_F\sigma-1/q)}$; (b) $\beta_{F,N}=\beta_{E,N}\sqrt{\rho_E/(2\rho_F)}$; (c) $p_N=\beta_{E,N}$; (d) $r_N=\beta_{F,N}\sqrt{(\rho_F\sigma-1/q)/(2c)}$;
   (e) $b_N=\beta_{F,N}/(\mathrm{q}\mathrm{r}_\mathrm{N})$; *and* (f) $V_N=\beta^2_{E,N}/2-(v+k)b^2_N/2$.
2. *If* $(f-2\sigma\sqrt{c\rho_F\rho_E/(\rho_F\sigma-1/q)})^2\le(v+k)c/(q^2(\rho_F\sigma-1/q))$, *then the firm cannot be made profitable in expectation and a corner solution of all endogenous parameters going to zero obtains*.

Two necessary conditions for a profitable firm are worth noting. First, it is necessary for the board to be able to efficiently motivate production; the condition in part (1) is equivalent to $V_N>0$. As $v,k\to 0$, the condition is equivalent to $\beta_{E,N}>0$. I assume that the marginal productivity of the CEO's action, f, is sufficiently high to ensure $V_N>0$. Furthermore, high direct costs of reporting effort, c, make motivating reporting effort prohibitively costly for the board. Similarly, if either the background variance, σ, or the CEO's risk aversion, ρ_E, are too high, then reporting efforts are again not cost effective, even though high values of σ and ρ_E increase the magnitude of the risk premium and amplify the benefit of reporting effort. If the externality cost of CFO bias to the firm or the CEO, k or v, is high, then these costs can also stop a firm from being valuable in expectation.

The term $\sigma\rho_F-1/q>0$ appears in Proposition 1 as a result of the CFO's optimal response to the contract. This relation must be satisfied for r to be real. The $\sigma\rho_F-1/q$ term reflects the net marginal benefit of r, per incentives, to the CFO, where $\sigma\rho_F$ represents the risk-reduction effect of reporting effort and $-1/q$ represents the effects of reporting effort on biasing costs, taking into account the subsequent choice of b. Essentially, increasing r leads to lower b and (weakly) lower overall biasing costs.[17]

Part (1a) of Proposition 1 illustrates the board's choice of incentives for the CEO, which are essentially the level of incentives, f, that would induce first-best effort, $p_{FB}=f$, net of the costs of incentives.[18] The costs include the risk premia and the CFO's reporting and biasing costs. Part (1b) shows that the optimal incentives for the CFO will be closely related to the optimal incentives for the CEO. The expression for $\beta_{F,N}$ as a function of $\beta_{E,N}$ reflects complementarity between the CFO and the CEO. Higher incentives for the CEO increase the risk premium, which increases the desirability of variance-reducing reporting effort, r, and leads to stronger incentives for the CFO. Alternatively, an increase in β_F will lower the variance of the performance metric, y, and lead to an increase in β_E through a reduction in the risk premium.

The CEO's optimal production, p, increases in the incentives she faces. If costs are minimal, $\beta_{E,N}\to f$ and the board is able to motivate near-first-best productive effort. The reporting effort, r, responds linearly to the incentive coefficient, as in (1d), but the rate of response depends on reporting costs, biasing costs, and risk. Balsam et al. (2014) find a negative relation between internal control weaknesses and CFO equity incentives, consistent with the positive relation between β_F and r in (1d), where higher r represents CFO investments in improving internal controls. The biasing action is increasing in the CFO's incentive coefficient and decreasing in r, as can be seen in part (1e), consistent with Jiang et al. (2010). Firm value is based on and increasing in $\beta_{E,N}$ as shown in part (1f). Consistent with Li et al. (2010), the benefit of a more efficient CFO (lower c) is increasing in the efficiency of the CEO (higher f), as

$$\frac{d^2V_N}{dfdc}=-\frac{\sigma}{c}\sqrt{\frac{c\rho_E\rho_F}{\rho_F\sigma-1/q}}<0.$$

Taking derivatives of the equilibrium expressions in Proposition 1 with respect to the biasing cost, q, yields the following corollary.

Corollary 1. *In the no-power case, an increase in the CFO's cost of biasing* (q) *leads to higher incentive coefficients* ($\beta_{E,N}$ *and* $\beta_{F,N}$), *reporting effort* (r_N), *and firm value* (V_N) *and lower performance metric bias* (b_N). *An increase in the externality cost of CFO biasing on the CEO* (v) *reduces firm value.*

A small increase in q causes the CFO to bias less for a given level of incentives and reporting effort, reducing the performance metric incongruity problem. The total effect lowers the gross marginal cost of reporting effort, $c+qb^2/2$. The CFO also chooses a higher level of reporting effort, for a given level of incentives, when the biasing cost parameter, q, increases. These effects lower the marginal costs of incentive provision through the contract, allowing the board to

[17] When $\sigma\rho_F-1/q<0$, the principal cannot effectively motivate reporting effort because the costs to the CFO of positive reporting effort outweigh the benefits for any β_F. So, as β_F moves away from zero in the positive direction, $r\to 0$ and $b\to\infty$, leaving y essentially useless.

[18] Derivation of the first-best effort, $p_{FB}=f$ is straightforward and omitted.

strengthen compensation coefficients, which increases production and makes the firm more valuable. Lower bias also enhances firm value by reducing the externality costs borne by the CEO and firm. Higher externality costs of CFO bias on the CEO, represented by an increase in ν, are associated with lower firm value because the board has to compensate the CEO for these costs and changing ν has no direct effect on the CFO's biasing absent CEO power.

3.2. Powerful CEO

This subsection focuses on CEO power that reduces the independence of the CFO. Recall that power is operationalized as the CEO being able to force the CFO to exert bias level m. The board's problem with power, called M, is therefore problem N with the CEO effectively choosing $b = m \in \arg\max_b CE_E$, rather than the CFO choosing $b \in \arg\max_b CE_F$. The optimal forced bias, m, for the CEO will depend on her incentive compensation coefficient, β_E, and the cost that the CFO's biasing imposes on her, ν. Note also that the CEO can force the CFO to bias either above or below the level that the CFO would otherwise choose.

As contracts are endogenous, the board's choice of the CEO's contract will determine whether the CEO will force the CFO to bias above or below what the CFO would otherwise choose. The tradeoff that the board faces is that weak or low β_E causes the CEO to deter CFO biasing, but also provides weak motivation to exert productive effort. The following proposition characterizes the equilibrium when the CEO can force the CFO to bias at $b=m$.

Proposition 2. *In the solution to Problem M, the powerful CEO and the CFO each achieve their reservation utility in expectation. The parameters of the solution take the following form:*

1. *If $f > \sqrt{2c\rho_E\sigma}$, then: (a) $\beta_{E,M}$ is defined implicitly by $0 = f - \beta_{E,M} - \beta_{E,M}(k+\nu)/\nu^2 - (2c + 2q\beta_{E,M}^2/\nu^2)\sqrt{2\rho_E\sigma/(2c + q\beta_{E,M}^2/\nu^2)}$; (b) $\beta_{F,M} = \beta_{E,M}\sqrt{\rho_E/2\rho_F}$; (c) $p_M = \beta_{E,M}$; (d) $r_M = \beta_{F,M}\sqrt{\rho_F\sigma/(2c + q\beta_E^2/\nu^2)}$; (e) $b_M = m = \beta_{E,M}/\nu$; and (f) $V_M = (\beta_{E,M}^2/2\nu^2)\,(k + \nu + \nu^2 + 2q\sqrt{2\beta_{E,M}^2\rho_E\sigma/(2c + q\beta_{E,M}^2/\nu^2)})$.*
2. *If $f \le 2\sqrt{c\rho_E\sigma}$ then the firm cannot be made profitable in expectation and a corner solution of all endogenous parameters going to zero obtains.*

Proposition 2 shows that the optimal contract for the CEO depends on her productivity relative to the externality cost she bears for the CFO's biasing and the other parameters. Fig. 1 illustrates the optimal CEO incentive coefficients and firm values derived in Propositions 1 and 2 as functions of CEO productivity, f. When CEO productivity is too low, i.e., $f \le 2\sqrt{c\rho_E\sigma}$, the agency cannot be made profitable. For low but not too low CEO productivity the optimal incentive coefficient for the powerful CEO is low enough to motivate her to force the CFO to bias less than he otherwise would. In this region, firm value is higher than it would be with a non-powerful CEO, i.e., $V_M > V_N$, as illustrated in Fig. 1(b) where the dashed curve representing V_M is above the solid curve representing V_N. When CEO productivity is high, the board benefits from offering strong production incentives to the CEO even though these motivate her to force a high level of bias from the CFO. CEO incentives are lower than in the non-powerful CEO case, however, as illustrated in Fig. 1(a) for high f. As the cost of reporting effort is increasing in bias, when the CEO pressures the CFO to bias at $b=m$, the cost interaction between reporting and biasing cause the CFO to supply lower reporting effort. This decrease in reporting effort causes the risk premia to be higher but lowers the marginal and total biasing costs borne by the CFO. Overall this is costly to the board and results in lower firm value with a powerful CEO than with a non-powerful CEO, i.e., $V_N > V_M$, as in Fig. 1(b) in the high-f region.

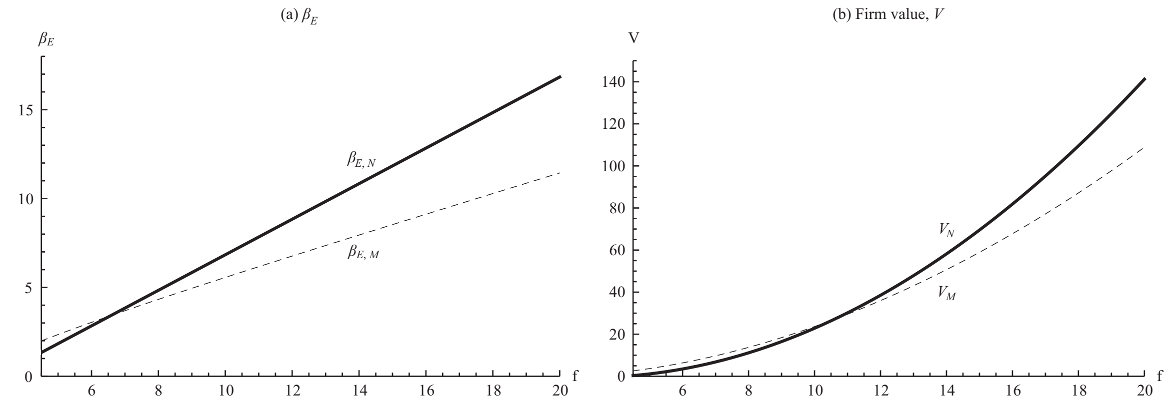

Fig. 1. Plots of the CEO's incentive compensation coefficient, β_E, and firm value, V, against CEO productivity, f, with $(c, q, \nu, k, \rho_F, \rho_E, \sigma) = (1, 5, 10, 1, 1, 1, 1)$. The dashed (solid) line represents the case of a (non)powerful CEO.

Recall that a CEO with lower ν is viewed as more powerful, e.g., because a more powerful CEO is more likely to be able to scapegoat the CFO and face lower costs associated with CFO biasing. Comparative statics related to the biasing costs (q and ν) are provided in the following corollary.

Corollary 2. *When the CEO is powerful, an increase in the CFO's cost of biasing* (q) *or an increase in CEO's power over the CFO* (*lower* ν) *leads to lower incentive coefficients* ($\beta_{E,M}$ *and* $\beta_{F,M}$), *reporting effort* (r_M), *and firm value* (V_M). *Increases in q or v both lead to lower bias,* b_M.

Corollary 2 implies that in the case with a powerful CEO, $d\beta_{E,M}/dv > 0$, meaning that an increase in the CEO's willingness to pressure the CFO, represented by lower externality cost, ν, causes a reduction in the CEO's incentive coefficient. By part (1b) of Proposition 2, the CFO will be given lower incentives as well. Incentives are lower because reducing risk is costlier. While the performance metric is also more biased when CEO productivity is high (since $m > b_N$), an increase in bias is not the main cause of the decrease in incentives. High forced bias indirectly causes the endogenous performance metric to be riskier, which acts to increase the marginal cost of productive incentives.

Comparing Corollaries 1 and 2, observe that CEO power, when exercised to pressure the CFO to bias, causes changes in the signs of the comparative statics with respect to the CFO's biasing costs. The main intuition for the sign changes involves the (in)ability of the CFO to beneficially adjust bias with changes in the costs he faces. In the no-power case, a small increase in q leads to a decrease in CFO bias, which lowers the marginal cost of reporting. With CEO-forced biasing, however, the CFO cannot reduce the total bias, $b=m$, so an increase in q essentially acts as an increase in the marginal cost of reporting effort, which is $c+qm^2/2$.

Turning attention to CEO power, an increase in her power, as reflected in a decrease in the externality cost she faces, ν, leads to an increase in the bias she is willing to force the CFO to impound, m, which directly results in an increase in bias, b_M, and a decrease in the incentive compensation coefficients, $\beta_{E,M}$ and $\beta_{F,M}$. This is in contrast to the results in Feng et al. (2011), who find a positive association between CEO equity incentives and accounting manipulations. The difference likely derives from the endogeneity of the degree of CEO power. In the model presented here, the degree of CEO power is captured by ν, an exogenous parameter that reflects the CEO's ability to avoid costs associated with CFO biasing, potentially by scapegoating. However, Daily and Johnson (1997) find that firm performance is positively associated with the number of corporate directorships the CEO subsequently holds. Sitting on multiple corporate boards enhances the CEO's prestige power (Finkelstein, 1992) and can increase the impact a CEO has on the CFO's career opportunities and human capital. Hermalin and Weisbach (1998) suggest that CEO tenure is negatively associated with board independence, implying that successful CEOs both avoid turnover and gain power through a reduction in independent monitoring from the board. These results suggest that the CEO's power should be an increasing function of her productivity, so that the costs she bears from CFO biasing are decreasing in CEO productivity. The following corollary demonstrates the implications of a more productive CEO facing lower costs of exercising pressure.

Corollary 3. *Assume the CEO is powerful and let the externality cost she faces from CFO bias be a regular decreasing function of her productivity. Specifically, let* $v=v(f)>0$, *where v is continuous in f over the range* $f\in(\sqrt{2c\rho_F}\sigma,\infty)$ *that implies a profitable firm. Let the first and second derivatives of* $v(f)$ *satisfy the regularity conditions*: $v'<0$, $v''>0$, $\lim_{f\to\sqrt{2c\rho_F}\sigma} v'(f)=-\infty$, *and* $\lim_{f\to\infty} v'=0$. *Then an increase in CEO productivity causes an increase in performance metric bias,* b_M, *and an increase* (*decrease*) *in incentive compensation coefficients,* $\beta_{E,M}$ *and* $\beta_{F,M}$, *when CEO productivity is high* (*low*).

When the CEO has high productivity, changes in her productivity lead to same-direction changes in her incentive compensation coefficient and the amount of bias in the performance measure. Based on (1b) in Proposition 2, an increase in $\beta_{E,M}$ due to a change in productivity, f, will also lead to an increase in $\beta_{F,M}$, causing a positive relation between bias and the CFO's incentive coefficient. This association, however, is driven by the CFO's incentive coefficient's dependence on the CEO's contractual incentives. Feng et al. (2011) find that accounting manipulations are more associated with CEO equity incentives than with CFO equity incentives. Their finding is consistent with the result in Corollary 3, given that cross-sectional variation in $\sqrt{\rho_E/(2\rho_F)}$ weakens the association between manipulation and CFO equity incentives relative to CEO equity incentives. Corollary 3 also highlights an empirically testable hypothesis: that the degree of bias is positively related to the interaction between CEO power and CEO productivity.

Given symmetric information regarding the CEO's power, there is no scope for power to translate into rent extraction. The next section considers a setting in which the CEO is privately informed of her type before contracting and may extract type-dependent rents.

4. Unknown power when contracting

4.1. Adverse selection on CEO power

In this section, whether the CEO is powerful or not is her private information. The CEO knows her type before contracting, while the board and the CFO only know the distribution of types before contracting. The problem now contains both adverse selection and moral hazard, implying that the CEO may be able to extract rents from private information about her type. The focus in this section is these rents, which are characterized using a revelation mechanism in which the board screens the CEO using a menu of contracts.

For simplicity, I focus on a 2-type setting.[19] Let the CEO's type $\tilde{m} \in \{m, 0\}$ be drawn at random before contracting. The type-m CEO is powerful and can force the CFO's biasing. The type-0 CEO is not powerful and has no direct influence on the CFO's biasing. To focus the analysis on the interesting case where CEO power creates a conflict between the board's desire for low biasing and the CEO's desire for high, I set $v=0$. Since this would lead to unbounded biasing for any nonzero CEO compensation coefficient ($\beta_E \neq 0$), I restrict the powerful type-m CEO such that she can only force the CFO to bias in the range $[0, m]$. In this case, with a positive compensation coefficient ($\beta_E > 0$), the CEO will optimally choose to force $b=m$. Higher m is consistent with a more powerful CEO being able to force the CFO to bias at a higher level, all else equal, which is analogous to a CEO with a lower biasing externality cost, v, optimally choosing to force the CFO to bias at a higher level.[20] To further simplify the analysis I also set $k=0$.

The CEO will be powerful and able to pressure the CFO (type-m) with probability λ and will not be powerful (type-0) with probability $1-\lambda$. The λ parameter represents residual type uncertainty after the board and CFO learn about the CEO from public information. The timing of events is as follows, with the numbers one through three corresponding to the periods in the pure moral hazard case from Section 3:

0. CEO observes her type, $\tilde{m} \in \{m, 0\}$.
1a. The board offers the CEO a menu of screening contracts. The CEO accepts a contract or declines. If she declines, the CEO and CFO get their reservation wages and the firm shuts down. The board commits to offer the CFO a contract that depends on the CEO's choice.
1b. The board offers the CFO the contract committed to in period 1a. The CFO accepts the contract or declines. If he declines, the CEO and CFO get their reservation wages and the firm shuts down.
2a. Work begins. The CFO observes the CEO's type, then the CFO exerts reporting effort, and the CEO exerts productive effort.
2b. If the CEO is type 0, then the CFO chooses biasing effort, b. If the CEO is type m, then the CFO is pressured to exert biasing effort $b=m$.
3. The performance measure, y, is realized and payoffs are made.

Elaborating on the timeline, the CEO observes her type, $\tilde{m} \in \{m, 0\}$, first, in period 0. The board then contracts with the CEO, offering a menu of screening contracts. The board commits to a specific type of contract for the CFO, conditional on the contract chosen by the CEO. Let contract s_{ij} be the contract for officer $i \in \{E, F\}$ targeted at the realization of $\tilde{m} = j \in \{0, m\}$. Then, if the CEO chooses contract $s_{E\,0}$ (s_{Em}), the board must offer contract $s_{F\,0}$ (s_{Fm}) to the CFO. This commitment is necessary for a revelation mechanism to hold, since it prevents the board from ex post opportunistically using the information revealed by the CEO when contracting with the CFO. In particular, the commitment prevents the board from exploiting the revealed information in a way that would harm the CEO after contracting. Without this commitment, the board could, through the contract with the CFO, influence the variance and bias of the performance measure in a way that would reduce the CEO's utility. Absent the commitment device, the CEO would expect this and would not be willing to provide a truthful report of her type, causing an unraveling of the revelation mechanism.

Given a revelation mechanism with CFO contracts that depend on the CEO's contract choice, the CFO will infer the CEO's type from the contract he is offered in period 1b. The board benefits from offering the CFO contracts that depend on the CEO's revealed type. Offering a contract to the CFO that is instead independent of CEO type would be inefficient for the board because it would impose costly CEO type risk on the imperfectly informed risk averse CFO and would eliminate a degree of freedom (i.e., adjusting performance metric risk through the CFO's type-dependent bonus coefficient).

After contracting, actions are chosen as in the moral hazard model. The CFO observes the CEO's type in period 2a, when the CEO and CFO start working together. The CFO is assumed to be unable to report his observation of the CEO's type in period 2a in a manner that could be incorporated into the contracts. This restriction is a common feature in theoretical models of team environments (e.g., Arya et al., 1997; Che and Yoo, 2001) and is consistent with a powerful CEO being able to influence the CFO's communication with the board, mitigating the usefulness of this communication in the contracts.[21] Finally, y is drawn, and payoffs are revealed. The pure moral hazard models analyzed in Sections 3.1 and 3.2 represent special cases of the model here with $\lambda = 0$ and $\lambda = 1$, respectively. Table 2 provides extra notation used with Problem *UP* (for unknown power) below, building on Table 1.

The board offers the CEO a menu of two contracts, along with a commitment to offer type-contingent contracts to the CFO. The contract offered to the CFO serves multiple purposes. First, it communicates the CEO's type to the CFO, thus

[19] I discuss an extension of the model to a denser type-space in Section 4.2.

[20] Indeed, the results in Section 3.2 are the same whether an increase in power is modeled as a reduction in v when the CEO faces the cost externality $vb^2/2$ or as an increase in m where m is the maximum amount of bias the CEO can force the CFO to do. Analysis of the alternative model varying m rather than v is available from the author.

[21] If the CFO were able to report this type in a contractible manner, then the principal could use that message to induce the CEO to report truthfully while avoiding rent extraction and distortions relative to the symmetric information cases (see Arya et al., 2000; Demski and Sappington, 1984; Sappington and Demski, 1983).

Table 2
Additional notation for the unknown power (*UP*) model.

Parameter	Definition
CE_{Eij}	Certainty equivalent of the CEO when $\tilde{m}=i$ and she chooses s_{Ej}
CE_{Fij}	Certainty equivalent of the CFO when $\tilde{m}=i$ and the CEO chooses s_{Ej}
u_i	Optimal action when the CEO has type i and reports truthfully, with $u \in \{p,b,r\}$
u_{ij}	Optimal action when the CEO has type i and reports having type j, with $u \in \{p,b,r\}$

reducing the expected risk borne by the CFO related to unknown CEO type. Second, it provides incentives to the CFO to exert reporting effort. Third, by affecting the variance of the performance measure, it changes the benefits to the CEO of accepting a particular contract. The certainty-equivalent utilities in (6) and (7) reflect the objective functions for the CEO, CE_{Eij}, when she is type i and chooses the contract s_{Ej}.

$$CE_{E0j} = \alpha_{Ej} + \beta_{Ej}\left(p_{0j}+b_{0j}\right) - \frac{p_{0j}^2}{2} - \frac{\rho_E \beta_{Ej}^2 \sigma}{2r_{0j}} \tag{6}$$

$$CE_{Emj} = \alpha_{Ej} + \beta_{Ej}\left(p_{mj}+m\right) - \frac{p_{mj}^2}{2} - \frac{\rho_E \beta_{Em}^2 \sigma}{2r_{mj}} \tag{7}$$

Each of these certainty equivalents consists of expected compensation net of the costs of actions and the risk premia. The certainty equivalents are different from each other not only because the contractual parameters vary (i.e., $s_{Em} \neq s_{E0}$), but also because the actions that the CFO chooses differ (i.e., $r_{mm} \neq r_{0m}$). The certainty-equivalents in (8) and (9) represent the CFO's objective functions, CE_{Fij}, when the CEO is type i and chooses the contract associated with type j. These certainty equivalents also consist of expected compensation net of the costs of action and risk premia.

$$CE_{F0j} = \alpha_{Fj} + \beta_{Fj}\left(p_{0j}+b_{0j}\right) - \frac{qr_{0j}b_{0j}^2}{2} - cr_{0j} - \frac{\rho_F \beta_{Fj}^2 \sigma}{2r_{0j}} \tag{8}$$

$$CE_{Fmj} = \alpha_{Fj} + \beta_{Fj}\left(p_{mj}+m\right) - \frac{qr_{mj}m^2}{2} - cr_{mj} - \frac{\rho_F \beta_{Fj}^2 \sigma}{2r_{mj}} \tag{9}$$

The board's screening problem, denoted *UP* for unknown power, is

$$UP: \max_{\{s_{ij},p_j,b_j,r_j\}_{i\,=\,E,F,j\,=\,0,m}} \lambda(fp_m - E[s_{Em}] - E[s_{Fm}]) + (1-\lambda)(fp_0 - E[s_{E0}] - E[s_{F0}]) \tag{10}$$

$$\text{s.t.} \quad CE_{Ejj} > 0, \quad CE_{Fjj} \geq 0, \;\; j \in \{0,m\} \tag{11}$$

$$CE_{Ejj} \geq CE_{Ejk}, \quad j,k \in \{0,m\}, \;\; j \neq k \tag{12}$$

$$p_{jk} \in \arg\max CE_{Ejk}, \quad j,k \in \{0,m\} \tag{13}$$

$$r_{jk}, b_{0k} \in \arg\max CE_{Fjk}, \quad j,k \in \{0,m\} \tag{14}$$

$$b_{mm} = b_{m0} = m \tag{15}$$

In *UP*, the board maximizes expected firm value, given the exogenous probability of facing either type of CEO. An equilibrium satisfies the following properties: both CEO and CFO accept the offered contracts; their actions maximize their individual utility subject to contracts and types; contracts maximize expected value to the board; and the CFO forms a rational conjecture, fulfilled in equilibrium, about the CEO's type in period 1b.

Participation constraints in (11) ensure that both officers accept the relevant contracts. Truth-telling constraints in (12) ensure that the CEO chooses the contract that is consistent with her type. The CFO forms correct beliefs in equilibrium about the CEO's type based on the contract he is offered. The constraints in (13)–(15) reflect each officer's optimal choice of actions given the contracts chosen and the true type of the CEO. These actions are particularly significant because they directly affect the truth-telling constraints.

In the equilibrium, characterized in Proposition 3, not all of these constraints will bind.

Proposition 3. *Assuming the parameters are such that the relevant compensation coefficients are positive, the board screens the CEO using a menu of contracts. The contract offered to the CFO depends on the type of the CEO, revealed by her contract choice.*

There is a threshold defined by

$$F \equiv 2\left(m - \frac{1}{q}\sqrt{\frac{2c}{\rho_F\sigma - 1/q}}\right) - \sigma\sqrt{2\rho_F\rho_E}\left(\sqrt{\frac{qm^2+2c}{\rho_F\sigma}} - \sqrt{\frac{2c}{\rho_F\sigma - 1/q}}\right).$$

When $F \geq 0$ $(F \leq 0)$:

1. *the powerful (non-powerful) type of CEO has a binding truth-telling constraint and may extract rents; and*
2. *the other type of CEO achieves her reservation utility in expectation and extracts no rents.*

The threshold defined in Proposition 3 defines which type of CEO has the incentive to deviate and extracts rents. Typically in a two-type model (e.g., Baron and Myerson, 1982), only one type of agent ever has the incentive to deviate. In *UP*, either type may have the incentive to deviate, depending on the exogenous parameters. This is the case because the CEO essentially faces a risk-return trade-off when deciding which contract to accept.[22] A powerful CEO benefits from higher levels of bias supplied by the CFO. But, because of pressure, it is more costly for the CFO to reduce the variance of y. The performance metric, therefore, will have a higher mean and variance when the CEO is powerful.

A powerful CEO forces the CFO to bias above and beyond what he would prefer. This increases the cost of reporting effort and leads to less of it. The performance metric is riskier due to the lower level of reporting effort, so the cost of providing compensation incentives to the CEO is greater. The incentive coefficient for the powerful type is therefore generally lower than the incentive coefficient for the non-powerful type, which can be seen in the symmetric information case. This drives either type of CEO's incentive to deviate.

The threshold defined by F captures the effects of the risk-return trade-offs, which are best illustrated through a focus on the CEO's risk-aversion, ρ_E. When the CEO is known to have low risk aversion, F will tend to be positive. In this case, the extra risk that a powerful CEO must bear for taking the non-powerful CEO's contract is inconsequential relative to the mean-increasing benefit of manipulation amplified by the higher incentive coefficient. A powerful CEO requires rents in this case to reveal her type. When risk-aversion is high, the risk premium term in the CEO's certainty equivalent dominates. A non-powerful CEO would like to take a powerful type's contract, because this allows her to face lower risk due to lower incentives. Hence, in this case, a non-powerful CEO extracts rents.

It is also possible that neither type extracts rents.[23] If the threshold F is near zero and λ is neither too high nor too low, then either type of CEO's motivation to lie about her type is relatively low. In this case, it may be optimal for the board to adjust the contracts, including the potential contracts for the CFO, in a way that reduces expected efficiency, but holds both types of CEO at their expected reservation utilities.

The threshold primarily depends on the risk-return trade-off that either type of CEO faces when choosing from the menu of contracts offered by the board. It is not affected by the productivity of the CEO, as f affects only the firm's benefit related to output.[24] The ex ante probability of types given by λ, like f, affects only the firm's expected value and has no impact on whether either type of CEO will wish to deviate. One type is drawn and observed by the CEO, so λ plays no role in her choice of contract from the menu the board offers. It will, however, affect the optimal contracts and actions as it affects how the board balances information rents against efficiency losses.

I employ comparative statics on the threshold, F, to indicate when the adverse selection problem is more likely to favor one type of CEO or the other. The following Corollary summarizes the directional predictions.[25]

Corollary 4. *In the separating equilibrium of Problem UP, an increase in the CEO's risk-aversion* (ρ_E) *lowers the threshold, F, which makes the non-powerful CEO more likely to extract rents. Increases in the costs of reporting and biasing* $(c$ *and* $q)$, *the CFO's risk aversion* (ρ_F), *the CEO's power* (m), *and the exogenous component of performance metric risk* (σ) *all have non-monotonic effects on the threshold and can increase the likelihood of either type of CEO extracting rents.*

[22] The risk-return trade-off gives the CEO countervailing incentives (as in Lewis and Sappington, 1989a) for reporting her power. In equilibrium, the principal adjusts the CFO's contractual reporting incentives in addition to the CEO's contract in order to mitigate the CEO's incentive to lie, much as the output conditional on a cost report is adjusted away from the efficient level in Lewis and Sappington (1989b). Similar to this paper, Dutta (2008) features countervailing incentives in a LEN model with adverse selection, but in Dutta (2008), countervailing incentives are driven by the correlation between a productive agent's productivity and her outside option or reservation wage.

[23] The condition for neither type to earn rents is given by the inequalities in relation (A.10) in the appendix. I expect that in a denser type-space the principal would not be able to eliminate rents under any circumstances. For instance, consider an additional type with intermediate (but still significant) power. Let the two significant power levels be m_1 and m_2, with $b_{NP} < m_1 < m_2$. I would expect rents to be paid only for more or less powerful types, but there would be cases where m_2 or 0 will earn rents while the other two CEOs will not. If the parameters are such that neither the 0-type nor the m_2-type earn rents, then it may be possible for the middle type, m_1, to earn rents by accepting either the most powerful or the non-powerful type's contract.

[24] If power, m, is a function of productivity, f, as in Corollary 3, then f will affect the threshold through its effect on m.

[25] The non-monotonicities can be shown using numerical examples, which are available from the author upon request.

The results in Corollary 4 are driven by the CEO's risk-return trade-off. To focus on this trade-off, separate F into F_{ret} and F_{risk} where $F = F_{ret} + F_{risk}$,

$$F_{ret} \equiv 2\left(m - \frac{1}{q}\sqrt{\frac{2c}{\rho_F\sigma - 1/q}}\right) \quad \text{and}$$

$$F_{risk} \equiv -\rho_E\sigma\sqrt{\frac{2\rho_F}{\rho_E}}\left(\sqrt{\frac{qm^2+2c}{\rho_F\sigma}} - \sqrt{\frac{2c}{\rho_F\sigma - 1/q}}\right).$$

F_{ret} captures the return benefit of pressure, since the difference in CFO bias between the two types is $m-(1/q)\sqrt{2c/(\rho_F\sigma-1/q)}$. F_{risk} reflects the loss due to changes in reporting effort driven by pressure. The difference in reporting effort for a given contract is represented by $\sqrt{2\rho_F/\rho_E}(\sqrt{(qm^2+2c)/(\rho_F\sigma)} - \sqrt{2c/(\rho_F\sigma-1/q)})$. F_{risk} captures the impact of reporting effort on the CEO through the risk premium, represented by the $\rho_E\sigma$ term. In selecting a contract, the CEO is selecting both risk and return. Changes in c, q, ρ_F, σ and m have opposing effects on F_{ret} and F_{risk}, leading to non-monotonic effects of each of these parameters on F. The comparative statics show that ρ_E is the only exogenous variable with a monotonic effect on F. A higher ρ_E increases the importance of the CFO's reporting effort to the CEO, making it more expensive for a powerful type to deviate.

4.2. Discussion of unknown power

The above results offer a novel explanation for ambiguity in the relation between CEO power and "excessive" compensation in the form of rent extraction. A traditional view is that CEOs exercise power in bargaining with the board and that greater power translates unambiguously into greater rent extraction (e.g., Bebchuk et al., 2002; Core et al., 2005; Hwang and Kim, 2009). In the present model, where the CEO's power relates to pressuring the CFO to favorably bias reports upon which compensation is based, and the CEO's type is her private information, several outcomes regarding rent seeking are possible: either a powerful or non-powerful type may be in a position to extract rents, or neither type is able to do so. These results cast a different perspective on the relation between CEO power and compensation that may help explain mixed empirical findings (see Frydman and Jenter, 2010 for a review).

Stepping back, consider which type of CEO the board might prefer. If type was observable, then the board would generally prefer a non-powerful CEO since the constraint that a powerful type imposes on the firm is costly. If type is unobservable, the non-powerful type has the binding truth-telling constraint, and both types are in supply, then the board could offer only the symmetric information contract targeted at the non-powerful type, knowing that only that type would accept. All the non-powerful (powerful) CEO candidates would accept (reject) the contract. Given some CEO arrival process, the board could simply wait for a non-powerful type to arrive and accept the contract.

When the threshold from Proposition 3 is positive, the powerful types would accept the non-powerful CEO contract and extract rents, leading to an adverse selection problem. In the equilibrium described by Proposition 3, the board adjusts the contract for the non-powerful CEO away from the optimal symmetric-information contract for that type. The adjustment discourages the powerful CEO from taking the contract, reducing the rents she is able to extract. This adjustment naturally also lowers the value of the firm when the non-powerful type accepts the contract. Given the characterization of contracts in the equilibrium described by Proposition 3, I conjecture that there will be regions of the parameter-space in which the board will prefer to hire the powerful type, because the loss of efficiency from adjusting the non-powerful CEO's contract will dominate the loss in value from the powerful type constraining the CFO's biasing choice. I expect these regions to be characterized by a high threshold. Optimal contracts under an alternative productive type arrival process are almost surely not the same as those in the equilibrium described by Proposition 3, but I expect the general intuition to hold. I expect that in some regions of the parameter-space, the board will prefer to hire the non-powerful type, while in other regions the board will prefer to hire the powerful type, and the regions where the powerful (non-powerful) type is preferred will be characterized by a high (small or negative) threshold.

5. Empirical implications and proxies

5.1. Empirical implications

The results from the models can help explain existing mixed empirical results and imply further testable empirical implications. First, variation in CEO power can help explain the apparently conflicting results of Jiang et al. (2010) and Feng et al. (2011). Both papers investigate the associations between CEO and CFO equity incentives and earnings management. The former paper finds that CFO equity incentives are more associated with accruals-based earnings management and the latter paper finds that CEO equity incentives are more associated with misconduct-based earnings management. If CEO power is more likely to be exercised in earnings management involving misconduct rather than earnings management involving accruals, then this pattern of results is consistent with Propositions 1 and 2 and Corollary 3. Whether CEO power plays a larger role in misconduct- or accruals-based earnings management, however, is an open empirical question.

Proposition 2 and Corollaries 1 and 2 suggest that cross-sectional variation in CEO power over the CFO can cause predictable variation in how firms respond to regulatory interventions like SOX that increase the CFO's cost of bias. When a CEO lacks power over the CFO, an increase in the cost of bias leads to stronger incentive compensation, a more precise performance measure, and greater firm value. When the CEO has significant power over the CFO, the implications reverse, and an increase in the CFO's cost of bias tends to reduce firm value, performance metric precision, and incentive compensation strength. These predictions can be used to help explain mixed results from empirical studies of the effects of SOX that did not control for variation in CEO power over the CFO (e.g., Engel et al., 2007; Leuz, 2007; Jain and Rezaee, 2006; Zhang, 2007).

Corollary 2 also suggests that the effects of corporate governance interventions that reduce the CEO's ability to pressure the CFO (i.e., by increasing the cost externality imposed by CFO biasing on the CEO) will depend on both the CEO's productivity and the pre-intervention power. For example, the potential benefits of the Dodd–Frank whistleblower awards (e.g., improved reporting quality) are expected to be greater in firms with higher-productivity CEOs and weaker CFOs.

Empirical implications from Section 4 relate to CEO rents which may be reflected in "excess" compensation. Corollary 4 implies that CEO power is expected to be associated with greater excess compensation when the CEO is more risk tolerant or has lower risk aversion. Corollary 4 also implies that changes in the costs the CFO faces for reporting, c, and biasing, q, each have mixed effects on powerful CEOs' ability to extract rents because these changes affect both the return-related benefit from power and the risk-related cost. Specifically, stronger regulations or corporate governance, which increase the likelihood or severity of punishment for biasing actions from the CFO, or deteriorations in CFO quality or qualifications (e.g., Li et al., 2010), which reflect reductions in reporting costs, are expected to be associated with powerful CEOs extracting greater (lesser) rents when they are more (less) risk tolerant. This may help explain some of the concurrent increase in both CEO compensation and corporate governance since the 1970s (Frydman and Jenter, 2010).

5.2. *Empirical proxies for the CEO's power to pressure the CFO*

The CEO's power to pressure the CFO is based on the CEO's power relative to the CFO. Existing proxies for CEO power often capture CEO power relative to the board. These and similar measures could be adjusted and enhanced to reflect CEO power relative to the CFO instead. Consider CEOs who are founders, block holders, board chairs, or otherwise entrenched in their firms. Their entrenchment can confer the ability to exercise power over both the board and other executives, e.g., CFOs. However, a CEO's power over the CFO would be mitigated if the CFO also was entrenched due to his own founder status, ownership interest in the firm, or presence on the board. This suggests that a reasonable proxy for CEO power to pressure the CFO would be CEO's entrenchment adjusted for CFO entrenchment: X_E/X_F, where X_E and X_F are measures of the CEO's and CFO's entrenchment in the firm.

Abundant data on various sources of power for both the CEO and CFO allow for the construction of numerous comparison-based proxies for CEO power over the CFO. These include: relative entrenchment based on founder status, durations of tenure at the firm, economic performance during the executives' tenure at the firm; relative connections based on social (e.g., school or club) ties to the firm's board members or boards of other firms; relative status power based on executives' service on other firms' boards, educational pedigrees, or positive press mentions (Badolato et al., 2013); relative structural power based on ownership in executives' own firms, presence on the board (Bedard et al., 2014) and in particular committees or positions; relative knowledge-based power as reflected in relative accounting or financial expertise; and relative concern for turnover as reflected in age as a proxy for years to retirement. Each of these proxies captures a dimension of power in general and is constructible from existing data sources (e.g., ExecuComp, BoardEx, RiskMetrics, and the Corporate Library). For measuring CEO power over the CFO, the crucial step is taking a difference between the two executives' power-conferring traits or experience.

Power could also be reflected in the hiring history at the firm. A CFO who was an internal hire and/or hired during the CEO's tenure would be expected to have less power relative to the CEO, consistent with the evidence in Geiger and North (2006) that externally appointed CFOs are associated with lower discretionary accruals. Similarly, if several directors and top-5 executives were hired during the current CEO's tenure, then that CEO is likely to have significant influence and be powerful relative to the CFO. If a prior CFO recently faced involuntary turnover but the CEO stayed on, then that would indicate a firm with a CEO who has high power relative to the CFO. Taking a forward-looking perspective, a CFO who eventually becomes CEO at the same or a similar or better firm could be thought of as one who was less susceptible to CEO pressure while CFO.

Additionally, corporate governance interventions, like whistleblower provisions recently introduced by Dodd–Frank could provide time-series variation in the average ability of CEOs to pressure CFOs. While legislative corporate governance interventions (e.g., SOX and Dodd–Frank) can have simultaneous effects on CEO power and other factors, like the CFO's costs of biasing, an empirical study could still identify the intervention's effect related to CEO power by focusing on variation in pre-intervention compliance. For the Dodd–Frank whistleblower provisions, the effects of the reduction in CEO power would be expected to be stronger for firms that had weaker or nonexistent whistleblower protections before Dodd–Frank, since the change in whistleblower protections would be greater for these firms.

6. Conclusion

I model the effects of a CEO's power to compromise the independence of a CFO who is responsible for reports upon which performance is assessed. Evidence from anecdotes, large-sample empirical studies, and surveys discussed in the introduction speak to the need for further theoretical inquiry. Toward that end, I show how CEO power can influence incentive compensation, reporting quality, and information rents.

The results suggest that variation in CEO power can help explain mixed empirical results and imply empirically testable hypotheses. For example, the model suggests that firms' responses to governance interventions like SOX and Dodd–Frank will vary in the cross-section with the CEO's ability to pressure the CFO, with greater CEO power causing more negative responses (e.g., lower reporting quality, more biasing, and lower firm value) to interventions that primarily expose the CFO to greater liability for biasing. If the primary effect of a policy shift instead reduces the powerful CEO's willingness to apply pressure, then firms with more powerful CEOs are expected to have more positive responses to the policy's introduction (e.g., higher reporting quality, less biasing, and higher firm value).

Of particular interest is a non-monotonic relation between CEO power and rents. When a CEO's power is her private information, either powerful, non-powerful, or neither type of CEO may extract information rents in equilibrium. Countervailing incentives are the cause. A powerful CEO benefits from higher expected compensation, but the effect of pressure on reporting effort increases the risk of the performance metric, essentially resulting in a risk-return trade-off. Either risk or return can dominate. If the dominance is significant, one type of CEO will extract rents; if not, neither will.

The model offers several avenues for future theoretical research. First, the linear contracts assumption could be relaxed, in order to address the desirability and effects of contracts with convexity, concavity, kinks, or discontinuities. Second, the model could be generalized to multiple periods, which would allow for accruals-related reversals of bias, implicit relational contracts based on repeated interaction, long-term contracting, learning about types, and career concerns related to turnover. The reduced form costs are meant to capture some of these features, but explicitly modeling them could provide greater insight. Third, the potential positive implications of CEO power and the interactions between power and productivity could be further explored. Fourth, the CFO could be responsible for production, where CFO production could provide a motive for team-based incentives or mutual monitoring between executives, consistent with the evidence in Li (2013). Fifth, restrictions on communication in the adverse selection model could be relaxed, which would allow the board a broader range of mechanisms for addressing asymmetric information. And sixth, the side contracting between the CEO and CFO could be modeled more explicitly than the reduced-form approach here where the CEO's disutility from pressuring the CFO is reduced to a parameter. For example, in a multi-period interaction, the CEO and CFO could bargain over the amount of bias, with equilibrium biasing sustained by threats of future shirking and the CEO's bargaining power potentially influenced by prior realizations of the performance measure or horizon effects and discounting.

Appendix A. Proofs

A.1. Proof of Proposition 1

The solution approach begins with the officers' actions in period two, which are defined by their incentive compatibility constraints. The optimal biasing chosen by the CFO is $b_N = \beta_F/(qr) = \arg\max_b CE_F$, given by the FOC with respect to b. Optimal reporting effort is $r_N = \beta_F\sqrt{(\rho_F\sigma - 1/q)/(2c)}$ given by $r_N = \arg\max_r CE_F|_{b=b_N}$. The CEO chooses production as $p_N = \beta_E = \arg\max_p CE_E$. The board's problem is, substituting from the IR constraints and the derived optimal actions is,

$$\max_{\beta_E,\beta_F} f\,\beta_E - \frac{\beta_E^2}{2} - \frac{\beta_E^2\rho_E\sigma}{2\beta_F\sqrt{(\rho_F\sigma-1/q)/(2c)}} - \beta_F\rho_F\sigma\sqrt{\frac{2c}{(\rho_F\sigma-1/q)}} - \frac{c(v+k)}{q^2(\rho_F\sigma-1/q)} \tag{A.1}$$

which has FOCs:

$$\beta_E{:}\, f - \beta_E - \frac{\rho_E\beta_E\sigma}{\beta_F\sqrt{(\rho_F\sigma-1/q)/(2c)}} = 0 \quad \text{and} \quad \beta_F{:}\, \frac{\rho_E\beta_E^2\sigma}{2\beta_F^2\sqrt{(\rho_F\sigma-1/q)/(2c)}} - \rho_F\sigma\sqrt{\frac{2c}{(\rho_F\sigma-1/q)}} = 0$$

The second order conditions for a local maximum implied by the FOC are satisfied. Solving the FOC yields the optimal β_E and β_F as

$$\beta_{F,N} = \beta_{E,N}\sqrt{\frac{\rho_E}{2\rho_F}} \quad \text{and} \quad \beta_{E,N} = f - 2\sigma\sqrt{\frac{c\rho_F\rho_E}{\rho_F\sigma-1/q}}. \tag{A.2}$$

Substituting (A.2) into the maximand in (A.1) yields firm value as

$$V_N = \frac{\beta_E^2}{2} - \frac{(v+k)c}{q^2(\rho_F\sigma-1/q)}.$$

A.2. Proof of Proposition 2

If the CEO is powerful, then she effectively chooses m as $\beta_E/v = \arg\max_b CE_E$. The choice of production is as in the no-pressure case, which implies $p_M = \beta_E$. When choosing reporting effort, the CFO maximizes CE_F, taking into account the CEO's anticipated choice of m and that $b=m$. Define CE_F as a function of r and v. When the CEO is powerful,

$$CE_F = \alpha_F + \beta_F(\beta_E + \beta_E/v) - cr - qr(\beta_E/v)^2/2 - \rho_F\beta_F^2\sigma/(2r) \tag{A.3}$$

The FOC on $\max_r CE_F$, with CE_F defined in (A.3) is $\beta_F^2\rho_F\sigma/(2r^2) - (c + q\beta_E^2/(2v^2)) = 0$, implying a local maximum at

$$r_M = \beta_F\sqrt{\frac{\rho_F\sigma}{2c + q\beta_E^2/v^2}}$$

The board's problem is, substituting from the IR constraints and the derived optimal actions is,

$$\max_{\beta_E,\beta_F} f\beta_E - \frac{\beta_E^2}{2} - \frac{(k+v)\beta_E^2}{2v^2} - \left(\frac{\rho_E\beta_E^2\sigma}{2\beta_F} + \beta_F\rho_F\sigma\right)\sqrt{\frac{2c + q\beta_E^2/v^2}{\rho_F\sigma}}. \tag{A.4}$$

The FOC with respect to β_F gives $\beta_{F,M} = \beta_{E,M}\sqrt{\rho_E/(2\rho_F)}$. The FOC with respect to β_E, after substituting $\beta_{F,M} = \beta_E\sqrt{\rho_E/(2\rho_F)}$, is $G=0$, where

$$G = f - \beta_{E,M} - \beta_{E,M}(k+v)/v^2 - \left(2c + 2q\beta_{E,M}^2/v^2\right)\sqrt{\frac{2\rho_E\sigma}{2c + q\beta_{E,M}^2/v^2}} = 0 \tag{A.5}$$

and the SOC implies a local maximum.

Substituting (A.5) and $\beta_{F,N} = \beta_{E,M}\sqrt{\rho_E/2\rho_F}$ into the maximand of (A.4) yields firm value,

$$\begin{aligned} V_M &= f\beta_E - \beta_E\sqrt{2\sigma\rho_E(2c + q\beta_E^2/v^2)} - \frac{\beta_E^2}{2} - \frac{(k+v)\beta_E^2}{2v^2} \\ &= \frac{\beta_{E,M}^2}{2v^2}\left(k + v + v^2 + 2q\sqrt{\frac{2\beta_{E,M}^2\rho_E\sigma}{2c + q\beta_{E,M}^2/v^2}}\right) \end{aligned}$$

So $V_M = 0$ when $\beta_{E,M} = 0$. From (A.5), $\beta_{E,M} = 0 \Leftrightarrow f - 2\sqrt{c\rho_E\sigma} = 0$, so the firm will optimally shut down if $f < 2\sqrt{c\rho_E\sigma}$ and operate otherwise. The limiting case with a powerful benevolent (forcing no bias) CEO implies firm value of $(f - 2\sqrt{c\rho_E\sigma})^2/2$.

A.3. Proof of Corollary 2

Let G be defined as in (A.5), and let x be one of the model parameters. The chain rule implies $d\beta_{E,M}/dx = -(\partial G/\partial x)/(\partial G/\partial\beta_{E,M}) \propto \partial G/\partial x$, as

$$\frac{\partial G}{\partial\beta_{E,M}} = -1 - (k+v)/v^2 - \frac{2q\beta_E^*\sqrt{2\rho_E\sigma}(3c + q\beta_{E,M}^2/v^2)}{v^2(2c + q\beta_{E,M}^2/v^2)^{3/2}} < 0.$$

This implies $d\beta_{E,M}/dv > 0$ and $d\beta_{E,M}/dq < 0$. For $\beta_{F,M} = \beta_{E,M}\sqrt{\rho_E/(2\rho_F)}$, the chain rule implies $d\beta_{F,M}/dv > 0$ and $d\beta_{F,M}/dq < 0$. For reporting effort,

$$r_M = \beta_{F,M}\sqrt{\frac{\rho_F\sigma}{2c + q\beta_{E,M}^2/v^2}} = \sqrt{\frac{\rho_E\sigma}{4c/\beta_{E,M}^2 + 2q/v^2}},$$

so $dr_M/dv = (q\beta_{E,M}^3/v^3 + 2c(d\beta_{E,M}/dv))\sqrt{\rho_E\sigma/2(2c + q\beta_{E,M}^2/v^2)^3} > 0$ and

$$\frac{dr_M}{dq} = -\frac{1}{2}\frac{\sqrt{\rho_E\sigma}\left(2/v^2 - 2{*}4c\beta_{E,M}^{-3}\frac{d\beta_{E,M}}{dq}\right)}{(4c\beta_{E,M}^{-2} + 2q/v^2)^{3/2}} < 0.$$

Total bias is $b_M = \beta_{E,M}/v$. With a transformation of variables, let the board choose b_M rather than $\beta_{E,M}$, so the FOC is

$$G_b = f - b_M v - b_M - \sqrt{\frac{2\rho_E\sigma}{(2c + qb_M^2)}}\left(2c + 2qb_M^2\right) = 0 \quad \text{and}$$

$$\frac{\partial G_b}{\partial b_M} = -v - 1 - b_M q\frac{3c + b_M^2 q}{\rho_E\sigma}\left(\frac{2\rho_E\sigma}{2c + qb_M^2}\right)^{3/2} < 0. \tag{A.6}$$

Then the chain rule implies $db_M/dv = -(\partial G_b/\partial v)/(\partial G_b/\partial b_M) = b_M/(\partial G/\partial b_M) < 0$ and $db_M/dq \propto \partial G_b/\partial q < 0$, where it is straightforward to show $\partial G_b/\partial q < 0$. Effects on firm value are implied by applying the envelope theorem to the board's maximization problem in (A.4), with

$$\frac{dV_M}{dv}=\frac{\beta_{E,M}^2}{2v^2}+\frac{q\beta_{E,M}^2(\rho_E\beta_{E,M}^2\sigma/(2\beta_{F,M})+\beta_{F,M})}{v^3\sqrt{\rho_F\sigma(2c+q\beta_{E,M}^2/v^2)}}>0 \quad \text{and}$$

$$\frac{dV_M}{dq}=-\frac{\beta_{E,M}^2(\rho_E\beta_{E,M}^2\sigma/(2\beta_{F,M})+\beta_{F,M})}{2v^2\sqrt{\rho_F\sigma(2c+q\beta_{E,M}^2/v^2)}}<0.$$

A.4. Proof of Corollary 3

The chain rule applied to (A.5) with v replaced by $v(f)$ gives

$$\frac{d\beta_{E,M}}{df}=-\left(\frac{\partial G}{\partial f}\right)\Bigg/\left(\frac{\partial G}{\partial\beta_{E,M}}\right)\propto\frac{\partial G}{\partial f}=\left(\frac{\partial G}{\partial f}+\frac{\partial G}{\partial v}\frac{dv}{df}\right).$$

$$\frac{\partial G}{\partial f}=1+v'(f)\frac{\beta_{E,M}}{v^2}\left(\frac{2k+v}{v}+\frac{4q\beta_{E,M}\sigma\rho_E(3cv^2+q\beta_{E,M}^2)}{(2cv^2+q\beta_E^2)\sqrt{2\sigma\rho_E(2cv^2+q\beta_{E,M}^2)}}\right)$$

As $f\to\sqrt{2c\rho_F\sigma}$, $v'(f)\to-\infty$, implying $d\beta_{E,M}/df<0$. As $f\to\infty$, $v'(f)\to 0$, implying $d\beta_{E,M}/df>0$. The change in b_M is given by $db_M/df=-(\partial G_b/\partial f)/(\partial G_b/\partial b_M)\propto\partial G_b/\partial f=1-b_Mv'>0$, where G_b is defined in (A.6).

A.5. Proof of Proposition 3

A.5.1. Optimal actions and certainty equivalents

The expected values of compensation under the separating/truth-inducing equilibrium are

$$E[s_m]=\alpha_{Fm}+\alpha_{Em}+(\beta_{Em}+\beta_{Fm})(\beta_{Em}+m)$$

$$E[s_0]=\alpha_{F0}+\alpha_{E0}+(\beta_{E0}+\beta_{F0})\left(\beta_{E0}+\frac{1}{q}\sqrt{\frac{2c}{\rho_F\sigma-1/q}}\right).$$

The following table summarizes the optimal actions for the combinations of CEO type and contract. The first (second) row provides the productive, biasing, and reporting actions when the CEO is type $\tilde{m}=m(0)$, and takes contract s_{Ej}, with $j\in\{0,m\}$, which causes the board to offer contract s_{Fj} to the CFO.

CEO type\actions	p	b	r
$\tilde{m}=m$	β_{Ej}	m	$\beta_{Fj}\sqrt{\rho_F\sigma/(qm^2+2c)}$
$\tilde{m}=0$	β_{Ej}	$\frac{1}{q}\sqrt{2c/(\rho_F\sigma-1/q)}$	$\beta_{Fj}\sqrt{(\rho_F\sigma-1/q)/(2c)}$

The certainty-equivalents can now be rewritten in terms of the contractual parameters by substituting the relevant induced actions. For the CEO, these are

$$CE_{E0j}=\alpha_{Ej}+\beta_{Ej}\frac{1}{q}\sqrt{\frac{2c}{\rho_F\sigma-1/q}}+\frac{\beta_{Ej}^2}{2}-\frac{\beta_{Ej}^2\rho_E\sigma}{2\beta_{Fj}}\sqrt{\frac{2c}{\rho_F\sigma-1/q}} \quad \text{and}$$

$$CE_{Emj}=\alpha_{Ej}+\beta_{Ej}m+\frac{\beta_{Ej}^2}{2}-\frac{\beta_{Ej}^2\rho_E\sigma}{2\beta_{Fj}}\sqrt{\frac{qm^2+2c}{\rho_F\sigma}}.$$

For the CFO, the certainty equivalents are

$$CE_{F0j}=\alpha_{Fj}+\beta_{Fj}\beta_{Ej}-\beta_{Fj}\sqrt{2c(\rho_F\sigma-1/q)} \quad \text{and}$$

$$CE_{Fmj}=\alpha_{Fj}+\beta_{Fj}(\beta_{Ej}+m)-\beta_{Fj}\sqrt{\rho_F\sigma(qm^2+2c)}.$$

With these expressions, the participation and truth-telling constraints on the CEO must be re-examined, to determine which will bind and which will be slack.

A.5.2. Which constraints bind: an exploration

Recall the participation and truth-telling constraints for the CEO are IR_{Em}: $CE_{Emm}\geq 0$; IR_{E0}: $CE_{E00}\geq 0$; TT_m: $CE_{Emm}\geq CE_{Em0}$; and TT_0: $CE_{E00}\geq CE_{E0m}$. Let $b_0=(1/q)\sqrt{2c/(\rho_F\sigma-1/q)}$ and $\kappa=\sqrt{(qm^2+2c)/(\rho_F\sigma)}$. Recall that $m>b_0$, which implies $\kappa>qb_0$. Substitution yields

$$IR_{Em}: \alpha_{Em}+\beta_{Em}m+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}\kappa\geq 0$$

$$IR_{E0}: \alpha_{E0}+\beta_{E0}b_0+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}qb_0 \geq 0$$

$$TT_m: \alpha_{Em}+\beta_{Em}m+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}\kappa \geq \alpha_{E0}+\beta_{E0}m+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}\kappa$$

$$TT_0: \alpha_{E0}+\beta_{E0}b_0+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}qb_0 \geq \alpha_{Em}+\beta_{Em}b_0+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}qb_0$$

Assume that the 0-type has the incentive to deviate, so TT_0 is binding, and the m-type is held to zero rents, then the constraint set would be,

$$IR_{Em}: \alpha_{Em}+\beta_{Em}m+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}\kappa = 0$$

$$IR_{E0}: \alpha_{E0}+\beta_{E0}b_0+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}qb_0 \geq 0$$

$$TT_m: \alpha_{Em}+\beta_{Em}m+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}\kappa \geq \alpha_{E0}+\beta_{E0}m+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}\kappa$$

$$TT_0: \alpha_{E0}+\beta_{E0}b_0+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}qb_0 = \alpha_{Em}+\beta_{Em}b_0+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}qb_0$$

Call this constraint set Ξ_0 because the 0 type extracts rents here. Start with IR_{Em},

$$\begin{aligned}0 &= \alpha_{Em}+\beta_{Em}m+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}\kappa = \alpha_{Em}+\beta_{Em}(m-b_0+b_0)+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}(\kappa-qb_0+qb_0)\\ &= \alpha_{Em}+\beta_{Em}b_0+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}qb_0-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}(\kappa-qb_0)+\beta_{Em}(m-b_0)\\ (\text{by } TT_0) &= \alpha_{E0}+\beta_{E0}b_0+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}qb_0-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}(\kappa-qb_0)+\beta_{Em}(m-b_0)\\ (\text{by } IR_{E0}) &\geq \beta_{Em}(m-b_0)-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}(\kappa-qb_0) \end{aligned} \tag{A.7}$$

Assume that the FOC on β_{Fm} in the board's problem, after substituting in all of the relevant α's is such that $\beta_{Em}/\beta_{Fm} = A_{m1}$, where A is a function of the parameters. In the case without adverse selection, $A = \sqrt{2\rho_F/\rho_E}$. In the present model, with adverse selection, this remains a reasonable assumption, as the only terms involving β_F have β_F or β_E^2/β_F. When these are the only types of terms in which β_F will enter into the board's unconstrained (derived) maximization problem, the FOC will imply $\beta_{Fm} = \beta_{Em}/A_{m1}$. Relation (A.7) can therefore be simplified as

$$0 \geq \beta_{Em}\left((m-b_{F0})-A_{m1}\frac{\rho_E\sigma}{2}(\kappa-qb_{F0})\right) = \beta_{Em}B_{m1}$$

where $B_{m1} = (m-b_{F0})-A_{m1}(\rho_E\sigma/2)(\kappa-qb_{F0})$. Since $\beta_{Em} > 0$ is necessary for a profitable firm when the CEO is of the powerful type, relation (A.7) entirely hinges on whether $B_{m1} \gtrless 0$. For $B_{m1} > 0$, relation (A.7) is not satisfied, which implies that at least one of the assumed constraint relations cannot hold. So, $B_{m1} < 0$ is a necessary condition for the non-powerful type to extract rents.

Now assume instead that the m-type has the incentive to deviate, so TT_m is binding, and the 0-type is held to zero rents, then the constraint set would be

$$IR_{Em}: \alpha_{Em}+\beta_{Em}m+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}\kappa \geq 0$$

$$IR_{E0}: \alpha_{E0}+\beta_{E0}b_0+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}qb_0 = 0$$

$$TT_m: \alpha_{Em}+\beta_{Em}m+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}\kappa=\alpha_{E0}+\beta_{E0}m+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}\kappa$$

$$TT_0: \alpha_{E0}+\beta_{E0}b_0+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}qb_0\geq\alpha_{Em}+\beta_{Em}b_0+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}qb_0$$

Call this constraint set Ξ_m because the m type extracts rents here. Start with $IR_{E\,0}$,

$$\begin{aligned}0&=\alpha_{E0}+\beta_{E0}b_0+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}qb_0=\alpha_{E0}+\beta_{E0}(b_0-m+m)+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}(qb_0-\kappa+\kappa)\\&=\alpha_{E0}+\beta_{E0}m+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}\kappa+\beta_{E0}(b_0-m)-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}(qb_0-\kappa)\end{aligned}$$

$$(\text{by } TT_m)=\alpha_{Em}+\beta_{Em}m+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}\kappa+\beta_{E0}(b_0-m)-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}(qb_0-\kappa)$$

$$(\text{by } IR_{Em})\geq-\beta_{E0}\left((m-b_0)-\frac{\beta_{E0}\rho_E\sigma}{2\beta_{F0}}(\kappa-qb_0)\right) \tag{A.8}$$

Again assume that the FOC on β_{Fm} in the board's problem, after substituting in all of the relevant α's is such that $\beta_{Em}/\beta_{Fm}=A_{02}$ (the 2 subscript is used to differentiate from the case where the non-powerful type extracts rents). Relation (A.8) can therefore be rewritten as

$$0\leq\beta_{E0}\left((m-b_0)-\frac{A_{02}}{2}\rho_E\sigma(\kappa-qb_0)\right)=\beta_{E0}B_{02}$$

where $B_{02}=(m-b_{F0})-(A_{02}/2)\rho_E\sigma(\kappa-qb_{F0})$. Since $\beta_{E0}>0$ is necessary for a profitable firm when the CEO is of the non-powerful type, $B_{02}>0$ is a necessary condition for the powerful type to extract rents.

The following section shows that $B_{m1}<0$ is sufficient for the non-powerful type to extract rents and solves the board's problem when $B_{m1}<0$, also solving for $B_{m\,1}$ in terms of the exogenous parameters. The section after next shows that $B_{02}>0$ is sufficient for the powerful type to extract rents and solves the board's problem in that case, also characterizing B_{02} in terms of the exogenous parameters.

A.5.3. $B_{m1}<0$

The goal is to show that $B_{m1}<0\Rightarrow\Xi_0$. First show that $IR_{E\,0}$ is slack.

$$\begin{aligned}TT_0: \alpha_{E0}+\beta_{E0}b_0+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}qb_0&\geq\alpha_{Em}+\beta_{Em}b_0+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}qb_0\\&=\alpha_{Em}+\beta_{Em}m+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}\kappa-\beta_{Em}\left((m-b_0)-\frac{\beta_{Em}\rho_E\sigma}{2\beta_{Fm}}(\kappa-qb_0)\right)\end{aligned}$$

$$(\text{by } IR_{Em})\geq0-\beta_{Em}B_{m1}$$

$$(\text{by } B_{m1}<0)>0$$

so that

$$\alpha_{E0}+\beta_{E0}b_0+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}qb_0>0$$

Now, IR_{Em} must be binding, otherwise the board could reduce α_{E0} and α_{Em} simultaneously without violating any of the other constraints, since α_{Em} and α_{E0} appear on both sides of the TT inequalities. Furthermore, TT_0 must bind, because otherwise α_{E0} could be reduced, as $IR_{E\,0}$ is slack and α_{E0} does not appear in IR_{Em}. Adding the TT constraints and simplifying gives

$$\beta_{Em}m-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}\kappa+\beta_{E0}b_0-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}qb_0\geq\beta_{Em}b_0-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}qb_0+\beta_{E0}m-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}\kappa$$

$$\beta_{Em}(m-b_0)-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}(\kappa-qb_0)\geq\beta_{E0}(m-b_0)-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}(\kappa-qb_0)$$

$$\Rightarrow\beta_{Em}B_{m1}\geq\beta_{E0}B_{01}$$

$$\Rightarrow\beta_{Em}B_{m1}-\beta_{E0}B_{01}\geq0 \tag{A.9}$$

Now show that TT_m is redundant when this condition holds

$$\alpha_{Em}+\beta_{Em}m+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}\kappa=\alpha_{Em}+\beta_{Em}b_0+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}qb_0+\beta_{Em}B_{m1}$$

$$(\text{by } TT_0)=\alpha_{E0}+\beta_{E0}b_0+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}qb_0+\beta_{Em}B_{m1}=\alpha_{E0}+\beta_{E0}m+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}\kappa+\beta_{Em}B_{m1}-\beta_{E0}B_{01}$$

$$(\text{by (A.9)})\geq\alpha_{E0}+\beta_{E0}m+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}\kappa$$

With Ξ_0, solve for α_{E0} and α_{Em}:

$$IR_{Em}\colon -\alpha_{Em}=+\beta_{Em}m+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2}{2\beta_{Fm}}\kappa$$

$$TT_0\colon -\alpha_{E0}=-\alpha_{Em}-(\beta_{Em}-\beta_{E0})b_0-\frac{(\beta_{Em}^2-\beta_{E0}^2)}{2}+\rho_E\sigma\left(\frac{\beta_{Em}^2}{2\beta_{Fm}}-\frac{\beta_{E0}^2}{2\beta_{F0}}\right)qb_0$$
$$=\beta_{Em}(m-b_0)-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}(\kappa-qb_0)+\beta_{E0}b_0+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}qb_0.$$

IR_{Fm} and $IR_{F\,0}$ both bind, so

$$\alpha_{F0}+\beta_{F0}(p_0+b_0)=\frac{qr_0b_0^2}{2}+cr_0+\frac{\rho_F\beta_{F0}^2\sigma}{2r_0}$$
$$\alpha_{Fm}+\beta_{Fm}(p_m+m)=\frac{qr_mm^2}{2}+cr_m+\frac{\rho_F\beta_{Fm}^2\sigma}{2r_m}.$$

At the optimal actions, this implies

$$\alpha_{F0}+\beta_{F0}(p_{E0}+b_0)=\beta_{F0}\rho_F\sigma\sqrt{\frac{2c}{\rho_F\sigma-1/q}}\quad\text{and}$$
$$\alpha_{Fm}+\beta_{Fm}(p_{Em}+m)=\beta_{Fm}\sqrt{\rho_F\sigma(qm^2+2c)}.$$

So, the board's problem, given $B_{m1}<0$ is, B:

$$\max_{\{s_i,p,b,r\}_{i=E,F}}\lambda(fp_{Em}-E[s_m])+(1-\lambda)(fp_{E0}-E[s_0])$$
$$=\max_{\{\beta_{ij}\}}\left[\begin{array}{c}\lambda\left(f\beta_{Em}-\frac{\beta_{Em}^2}{2}-\beta_{Fm}\sqrt{\rho_F\sigma(qm^2+2c)}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}\sqrt{\frac{qm^2+2c}{\rho_F\sigma}}\right)\\ +(1-\lambda)\left(\begin{array}{c}f\beta_{E0}-\frac{\beta_{E0}^2}{2}-\beta_{F0}\rho_F\sigma\sqrt{\frac{2c}{\rho_F\sigma-1/q}}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}\sqrt{\frac{2c_F}{\rho_F\sigma-1/q}}\\ +\beta_{Em}\left(m-\frac{1}{q}\sqrt{\frac{2c}{\rho_F\sigma-1/q}}\right)-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}\left(\sqrt{\frac{qm^2+2c}{\rho_F\sigma}}-\sqrt{\frac{2c}{\rho_F\sigma-1/q}}\right)\end{array}\right)\end{array}\right]$$

where $i\in\{E,F\}$ and $j\in\{m,0\}$. The FOC's are

$$\beta_{Fm}\colon\left[\begin{array}{c}\lambda\left(-\sqrt{\rho_F\sigma(qm^2+2c)}+\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}^2}\sqrt{\frac{qm^2+2c}{\rho_F\sigma}}\right)\\ +(1-\lambda)\left(\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}^2}\left(\sqrt{\frac{qm^2+2c}{\rho_F\sigma}}-\sqrt{\frac{2c}{\rho_F\sigma-1/q}}\right)\right)\end{array}\right]=0$$

$$\beta_{F0}\colon -\rho_F\sigma\sqrt{\frac{2c}{\rho_F\sigma-1/q}}+\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}^2}\sqrt{\frac{2c}{\rho_F\sigma-1/q}}=0$$

$$\beta_{Em}\colon\left[\begin{array}{c}\lambda\left(f-\beta_{Em}-\frac{\beta_{Em}\rho_E\sigma}{\beta_{Fm}}\sqrt{\frac{qm^2+2c}{\rho_F\sigma}}\right)\\ +(1-\lambda)\left(m-\frac{1}{q}\sqrt{\frac{2c}{\rho_F\sigma-1/q}}-\frac{\beta_{Em}\rho_E\sigma}{\beta_{Fm}}\left(\sqrt{\frac{qm^2+2c}{\rho_F\sigma}}-\sqrt{\frac{2c}{\rho_F\sigma-1/q}}\right)\right)\end{array}\right]=0$$

$$\beta_{E0}\colon f-\beta_{E0}-\frac{\beta_{E0}\rho_E\sigma}{\beta_{F0}}\sqrt{\frac{2c}{\rho_F\sigma-1/q}}=0$$

Letting hats denote optima,

$$\widehat{\beta}_{Fm1}=\beta_{Em}\sqrt{\frac{\rho_E}{2\rho_F\lambda\kappa}}\sqrt{(\kappa-qb_0)+\lambda qb_0}$$

The relevant threshold for $B_{m1}<0$ defined by F (derived below) in this appendix requires that $\rho_E\leqslant 0$, so that the incentive coefficient for β_{Fm} as a function of β_E will be higher than in the firm without adverse selection. For the CEO,

$$\widehat{\beta}_{Em1}=\left(f-\sigma\sqrt{2\rho_F\rho_E\kappa}\sqrt{(\kappa-qb_0)+\lambda qb_0}+\frac{1-\lambda}{\lambda}(m-b_0)\right)$$

Clearly the $((1-\lambda)/\lambda)(m-b_0)$ term pushes $\widehat{\beta}_{Em}$ upwards relative to $\beta_{E,M}=f-\sigma\sqrt{2\rho_E\rho_F\kappa}$, the optimal incentive coefficient in the full-information case. The $\sqrt{(\kappa-qb_0)+\lambda qb_0}$ term can push $\widehat{\beta}_{Em}$ up or down depending on whether $(\kappa-qb_0)+\lambda qb_0 \gtrless 1$.

The compensation coefficients when the CEO is of the non-powerful type are the same as in the full-information case: $\widehat{\beta}_{F0}=\beta_{E0}\sqrt{\rho_E/(2\rho_F)}$, and $\widehat{\beta}_{E0}=f_E-2\sigma\sqrt{c\rho_F\rho_E\sigma/(\rho_F\sigma-1/q)}$. Based on these, $A_{01}=\sqrt{2\rho_F/\rho_E}$ and $A_{m1}=A_{01}\sqrt{\lambda\kappa/((\kappa-qb_0)+\lambda qb_0)}$. Note that $\lim_{\lambda\to 1}A_{m1}=A_{01}$ and $dA_{m1}/d\lambda>0$ so that $A_{m1}<A_{01}$.

Recall this section began with the condition, $B_{m1}<0$ which is true, with substitution, if

$$2\left(m-\frac{1}{q}\sqrt{\frac{2c_F}{\rho_F\sigma-1/q}}\right)<\sigma\sqrt{2\rho_F\rho_E\times\frac{\lambda\kappa}{(\kappa-qb_0)+\lambda qb_0}}\left(\sqrt{\frac{qm^2+2c}{\rho_F\sigma}}-\sqrt{\frac{2c}{\rho_F\sigma-1/q}}\right)$$

which will be true for high values of ρ_E. Furthermore, $B_{01}=B_{m1}+(A_{m1}-A_{01})\rho_E\sigma/2(\kappa-qb_0)$ and $A_{m1}\le A_{01}$ (since $\lambda<1$), so $B_{m1}\le 0\Rightarrow B_{01}<0$ and $B_{01}\ge 0\Rightarrow B_{m1}>0$.

A.5.4. $B_{02}>0$

In this subsection, assume $B_{02}>0$. Using this assumption, the solution to the board's problem (10) is derived. Begin by showing that IR_{Em} is slack:

$$\alpha_{Em}+\beta_{Em}m+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}\kappa$$

$$(\text{by } TT_m)\ge\alpha_{E0}+\beta_{E0}b_0+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}qb_0+\beta_{E0}B_{02}$$

$$(\text{by } IR_{E0})\ge\beta_{E0}B_{02}>0$$

As before, IR_{Em} slack implies that $IR_{E\ 0}$ binds, because otherwise both α_{Em} and α_{E0} could be lowered. TT_m must also bind because otherwise α_{Em} could be lowered. Adding the TT constraints gives

$$\beta_{Em}(m-b_0)-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}(\kappa-qb_0)\ge\beta_{E0}(m-b_0)-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}(\kappa-qb_0)$$

$$\Rightarrow\beta_{Em}B_{m2}\ge\beta_{E0}B_{02}$$

TT_0 can be shown to be redundant with the condition $\beta_{Em}B_{m2}\ge\beta_{E0}B_{02}$ as

$$\alpha_{E0}+\beta_{E0}b_0+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}qb_0=\alpha_{E0}+\beta_{E0}m+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}\kappa-\beta_{E0}B_{02}$$

$$(\text{by } TT_m)=\alpha_{Em}+\beta_{Em}m+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}\kappa-\beta_{E0}B_{02}=\alpha_{Em}+\beta_{Em}b_0+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}qb_0+\beta_{Em}B_m-\beta_{E0}B_{02}$$

$$(\text{by condition})\ge\alpha_{Em}+\beta_{Em}b_0+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}qb_0.$$

So, the CEO's fixed pay is defined by $IR_{E0}=0$, implying

$$-\alpha_{E0}=\beta_{E0}b_0+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}qb_0.$$

TT_m binds, so

$$\alpha_{Em}+\beta_{Em}m+\frac{\beta_{Em}^2}{2}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}\kappa=\alpha_{E0}+\beta_{E0}m+\frac{\beta_{E0}^2}{2}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}\kappa$$

$$\Rightarrow \alpha_{Em}=\alpha_{E0}+(\beta_{E0}-\beta_{Em})m+\frac{(\beta_{E0}^2-\beta_{Em}^2)}{2}-\left(\frac{\beta_{E0}^2}{2\beta_{F0}}-\frac{\beta_{Em}^2}{2\beta_{Fm}}\right)\kappa\rho_E\sigma$$

$$=-\beta_{E0}b_0+\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}(qb_0-\kappa)+\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}\kappa+\beta_{E0}m-\beta_{Em}m-\frac{\beta_{Em}^2}{2}$$

$$\Leftrightarrow -\alpha_{Em}=\beta_{E0}b_0-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}(qb_0-\kappa)-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}\kappa-\beta_{E0}m+\beta_{Em}m+\frac{\beta_{Em}^2}{2}.$$

The CFO's *IR* constraints bind, as before, with

$$\alpha_{F0}+\beta_{F0}(p_0+b_0)=\beta_{F0}\rho_F\sigma\sqrt{\frac{2c}{\rho_F\sigma-1/q}}$$

and

$$\alpha_{Fm}+\beta_{Fm}(p_m+m)=\beta_{Fm}\sqrt{\rho_F\sigma(qm^2+2c)}.$$

The board's problem is thus,

$$\max_{s_E,s_F,p,b,r}\lambda(fp_m-E[s_m])+(1-\lambda)(fp_0-E[s_0])$$

$$=\max_{\beta_{ij}}\begin{bmatrix}\lambda(f\beta_{Em}-\alpha_{Fm}-\alpha_{Em}-(\beta_{Em}+\beta_{Fm})(\beta_{Em}+m))\\ +(1-\lambda)\left(f\beta_{E0}-\alpha_{F0}-\alpha_{E0}-(\beta_{E0}+\beta_{F0})\left(\beta_{E0}+\frac{1}{q}\sqrt{\frac{2c}{\rho_F\sigma-1/q}}\right)\right)\end{bmatrix}$$

again with $i\in\{E,F\}$ and $j\in\{m,0\}$. Substitution yields

$$=\max_{\beta_{ij}}\begin{bmatrix}\lambda\begin{pmatrix}f_E\beta_{Em}-\frac{\beta_{Em}^2}{2}-\beta_{Fm}\sqrt{\rho_F\sigma(qm^2+2c_F)}-\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}}\sqrt{\frac{qm^2+2c}{\rho_F\sigma}}\\ +\beta_{E0}\left(\frac{1}{q}\sqrt{\frac{2c}{\rho_F\sigma-1/q}}-m\right)-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}\left(\sqrt{\frac{2c}{\rho_F\sigma-1/q}}-\sqrt{\frac{qm^2+2c}{\rho_F\sigma}}\right)\end{pmatrix}\\ +(1-\lambda)\left(f\beta_{E0}-\frac{\beta_{E0}^2}{2}-\beta_{F0}\rho_F\sigma\frac{1}{q}\sqrt{\frac{2c}{\rho_F\sigma-1/q}}-\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}}\sqrt{\frac{2c}{\rho_F\sigma-1/q}}\right)\end{bmatrix}$$

The FOC's are

$$\beta_{Fm}:-\sqrt{\rho_F\sigma(qm^2+2c)}+\frac{\beta_{Em}^2\rho_E\sigma}{2\beta_{Fm}^2}\sqrt{\frac{qm^2+2c}{\rho_F\sigma}}=0$$

$$\beta_{F0}:\begin{bmatrix}\lambda\left(\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}^2}\left(\sqrt{\frac{2c}{\rho_F\sigma-1/q}}-\sqrt{\frac{qm^2+2c}{\rho_F\sigma}}\right)\right)\\ +(1-\lambda)\left(-\rho_F\sigma\sqrt{\frac{2c}{\rho_F\sigma-1/q}}+\frac{\beta_{E0}^2\rho_E\sigma}{2\beta_{F0}^2}\sqrt{\frac{2c}{\rho_F\sigma-1/q}}\right)\end{bmatrix}=0$$

$$\beta_{Em}:\left[\lambda\left(f-\beta_{Em}-\frac{\beta_{Em}\rho_E\sigma}{\beta_{Fm}}\sqrt{\frac{qm^2+2c}{\rho_F\sigma}}\right)\right]=0$$

$$\beta_{E0}:\begin{bmatrix}\lambda\left(\left(\frac{1}{q}\sqrt{\frac{2c}{\rho_F\sigma-1/q}}-m\right)-\frac{\beta_{E0}\rho_E\sigma}{\beta_{F0}}\left(\sqrt{\frac{2c}{\rho_F\sigma-1/q}}-\sqrt{\frac{qm^2+2c}{\rho_F\sigma}}\right)\right)\\ +(1-\lambda)\left(f-\beta_{E0}-\frac{\beta_{E0}\rho_E\sigma}{\beta_{F0}}\sqrt{\frac{2c}{\rho_F\sigma-1/q}}\right)\end{bmatrix}=0$$

So, again letting hats denote optima,

$$\widehat{\beta}_{Fm}=\beta_{Em}\sqrt{\frac{\rho_E}{2\rho_F}},$$

$$\widehat{\beta}_{Em}=f_E-\sqrt{2\rho_E\sigma(qm^2+2c)},$$

$$\widehat{\beta}_{F0}=\beta_{E0}\sqrt{\frac{\left(\lambda\left(\sqrt{\frac{2c}{\rho_F\sigma-1/q}}-\sqrt{\frac{qm^2+2c}{\rho_F\sigma}}\right)\rho_E\sigma+(1-\lambda)\sqrt{\frac{2c}{\rho_F\sigma-1/q}}\rho_E\sigma\right)}{2(1-\lambda)\rho_F\sigma\sqrt{\frac{2c}{\rho_F\sigma-1/q}}}},$$

$$=\beta_{E0}\sqrt{\frac{\rho_E}{2\rho_F}\left(\frac{qb_0-\lambda\kappa}{qb_0-\lambda qb_0}\right)}=\beta_{E0}/A_{02}\quad\text{and}$$

$$\widehat{\beta}_{E0}=f-A_{02}\rho_E\sigma qb_0+\frac{\lambda}{(1-\lambda)}A_{02}\rho_E\sigma(\kappa-qb_0)-\frac{\lambda}{(1-\lambda)}(m-b_0)$$

$A_{02}\in\mathbb{R}_+$ if and only if $qb_0-\lambda\kappa>0$, otherwise the term under the radical is negative. As $\lambda\to 1$, $qb_0-\lambda\kappa\to qb_0-\kappa<0$. As $\lambda\to 0$, the condition is identically true. For intermediate values of λ, the condition is true only for small-enough values of m which imply that κ is not too much bigger than qb_0.

Recall the condition $B_{02}>0\Leftrightarrow(m-b_0)-(A_0\rho_E\sigma/2)(\kappa-qb_0)>0$. Note that $A_{02}=A_{m2}\sqrt{(qb_0-\lambda qb_0)/(qb_0-\lambda\kappa)}$, and the limit of A_{02} as $\lambda\to 0$ is $A_{m2}=\sqrt{2\rho_F/\rho_E}$. Also, $dA_{02}/d\lambda>0$ so $A_{02}\geq A_{m2}$. $B_{m2}=B_{02}+(A_{02}-A_{m2})(\kappa-\mathrm{q}b_0)\rho_E\sigma/2$ so $B_{02}\geq 0\Rightarrow B_{m2}>0$ because the additive term after B_{02} is always (weakly) positive. By the contrapositive we have $B_{m2}\leq 0\Rightarrow B_{02}<0$. A necessary condition on in this section is $B_{m2}>0$, because $B_{m2}<0$ implies $B_{02}<0$, which contradicts the initial assumption in this section. Furthermore, this is the exact opposite of the condition on B_{01} from the previous section. If $B_{m2}=0$ then $B_{02}\leq 0$.

A.6. Description and further analysis of the thresholds

The previous sections characterize necessary and sufficient conditions for either CEO to extract rents. Also, they show that $B_{m2}=B_{01}$, since $A_{m2}=A_{01}$. The conditions are

$$B_{m1}<0\Leftrightarrow 0\text{–type extracts rents}$$
$$B_{02}>0\Leftrightarrow m\text{–type extracts rents}$$

When $\lambda\in(0,1)$, which is necessary for an adverse selection problem to exists, we have

$$B_{m2}=B_{01}\geq 0\Rightarrow B_{m1}>0\Leftrightarrow 0\text{–type extracts no rents}$$
$$B_{m2}=B_{01}\leq 0\Rightarrow B_{02}<0\Leftrightarrow m\text{–type extracts no rents}$$

Since $B_{m\ 2}$ and B_{01} exist somewhere on the real line, only one type of CEO will extract rents in equilibrium.

It is also possible for neither CEO to extract rents, as would be implied by $B_{m2}=B_{01}=0$. In fact, for $P=(c,q,\rho_E,\rho_F,\sigma,m,\lambda)=(1,1,1,10,3,1,0.3)$, $B_{02}<0$ and $B_{m1}>0$ so that neither CEO extracts rents. More generally, neither CEO will extract rents when $B_{02}<0$ and $B_{m1}>0$, or

$$\begin{aligned}&B_{02}<0<B_{m1}\\&\Leftrightarrow(m-b_0)-\frac{A_{02}}{2}(\kappa-qb_0)\rho_E\sigma<0<(m-b_0)-\frac{A_{m1}}{2}(\kappa-qb_0)\rho_E\sigma\\&\Leftrightarrow A_{m1}<\frac{2(m-b_0)}{(\kappa-qb_0)\rho_E\sigma}<A_{02}\end{aligned}$$

which can be true. Substitution for the A's gives

$$\sqrt{\frac{2\rho_F}{\rho_E}\times\frac{\lambda\kappa}{(\kappa-qb_0)+\lambda qb_0}}<\frac{2(m-b_0)}{(\kappa-qb_0)\rho_E\sigma}<\sqrt{\frac{2\rho_F}{\rho_E}\times\frac{qb_0-\lambda qb_0}{qb_0-\lambda\kappa}}\tag{A.10}$$

Rearranging, (A.10) is

$$\sqrt{\frac{\lambda\kappa}{(\kappa-qb_0)+\lambda qb_0}}<\frac{(m-b_0)}{(\kappa-qb_0)\sigma}\sqrt{\frac{2}{\rho_F\rho_E}}<\sqrt{\frac{qb_0-\lambda qb_0}{qb_0-\lambda\kappa}}\tag{A.11}$$

Then verify that (A.11) is plausible. The limit as $\lambda\to 0$ is

$$0<\frac{(m-b_0)}{(\kappa-qb_0)\sigma}\sqrt{\frac{2}{\rho_F\rho_E}}<1$$

which is true and allows for intermediate values of

$$\frac{2(m-b_0)}{(\kappa-qb_0)\sigma}\in\left(0,\sqrt{\frac{\rho_F\rho_E}{2}}\right).$$

For $\lambda \to qb_0/\kappa$, $A_{02} \to \infty$ and (A.11) is

$$\sqrt{\frac{qb_0}{(\kappa - qb_0) + (qb_0)^2/\kappa}} < \frac{(m-b_0)}{(\kappa - qb_0)\sigma}\sqrt{\frac{2}{\rho_F \rho_E}} < \infty$$

which is allows for intermediate values of

$$\frac{2(m-b_0)}{(\kappa - qb_0)\sigma}\sqrt{\frac{2}{\rho_F \rho_E}} > A_{m1}|_{\lambda = qb_0/\kappa} = \sqrt{\frac{qb_0}{(\kappa - qb_0) + (qb_0)^2/\kappa}}.$$

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