Competition for Talent under Performance Manipulation: CEOs on Steroids*

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Abstract

We study how competition for talent affects CEO compensation, taking into consideration that CEO decisions and CEO skills or talent are not observable, and CEOs can manipulate performance as measured by outsiders. Firms compete by offering contracts that generate rents for the CEO. We derive the equilibrium compensation contract, and we describe how competition changes that contract and the outcome. Intuitively, competition increases realized CEO compensation. It also strengthens the incentive power of the contracts. While competition mitigates inefficiencies caused in its absence, it also generates inefficiencies of its own. Competition replaces a downward distortion by an upwards distortion (incentive power is excessively strong), and it switches the focus of equilibrium effort distortions from low-talent CEOs to high-talent CEOs. Competition leads to higher effort but also to more manipulation of measured performance. If the cost of manipulating performance is low, the distortions can outweigh those that are mitigated, and competition for talent may *reduce* the overall surplus. We discuss possible remedies, including regulatory limits to incentive compensation.

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1 Introduction

Recent contributions to the literature on executive compensation (for recent surveys, see Frydman and Jenter (2010) or Murphy (2013)) focus on the role of competition in CEO labor markets in allocating talent (see, e.g., Gabaix and Landier (2008), Terviö (2008), or Edmans et al. (2009)). These models abstract from frictions that make it hard to identify good CEOs and monitor their performance. How such frictions affect incentive problems and compensation contracts has only been studied in single-firm models. In this paper, we ask how *competition* for CEOs affects the equilibrium contract, the decisions a CEO makes, and the outcome of those decisions. How does competition change the incentive compensation offered to CEOs? How do their incentives change? Does competition mitigate the inefficiencies created in single-firm setups? Does competition create new distortions that do not arise in single-firm setups? If so, can regulation be used to address those distortions?

We use a model that incorporates important and realistic frictions: CEOs have unknown talent; their actions are unobservable; and they can manipulate performance measures. We use a single-firm setup as a benchmark, and our focus is on how competition changes the contract and the results. Competition complicates the contracting problem, because when offering rents to to attract a CEO candidate, the incentive problems put constraints on the structure of the incentive compensation that can be offered. Furthermore, the CEO's reservation payoff is endogenous: a firm must offer rents at least as large as those offered by rival firms.

Due to the incentive problems, distortions of the CEO's decisions are unavoidable in equilibrium. In the single-firm setup, the firm trades off surplus creation against rent extraction, and its profits are maximized by providing inefficiently weak incentives for a low-talent CEO. Under competition for talent, the distortions are reversed. The firms find it optimal to maximize the surplus generated by a CEO, since that makes it possible to offer larger rents. But since a low-talent CEO could mimick a high-talent CEO (by manipulating the performance measure), a high-talent CEO must be given excessively strong incentives to perform (making it too costly for a low-talent CEO to mimick that performance). In other words, competition switches the target of the equilibrium distortion (from the low-talent CEO to the high-talent CEO), and it also switches the direction of the distortion (excessively strong incentives, instead of weak incentives). Competition thus eliminates a distortion while creating a new one, and it is possible that the net effect is negative, i.e., the surplus created is lower in the competitive setup, compared with the single-firm setup. We therefore study to what extent regulation can mitigate the inefficiencies caused by competition.

Note the role of the frictions that we incorporate in the model: Without the ability to manipulate performance, a low-talent CEO would find it much harder to mimick a high-talent CEO (manipulation is relatively less costly than effort for her), and in equilibrium, efficient effort levels would be induced. Similarly, if effort was observable, it would be easier to separate types, again leading to efficient effort. Finally, if talent was observable, it would also be easy to induce efficient effort levels. It is only in the presence of the three frictions and of competition that our results obtain: Incentives to invest effort are excessive in equilibrium, possibly causing a reduction in the surplus generated.

Competition for talent and the contractual frictions are key to the results, and they are also realistic assumptions. First, competition for CEOs has strengthened over the past few decades, fueled by the availability of information on compensation offered by other firms (provided either by compensation consultants, or available because of disclosure requirements), and by changes in the demand for executives (managers are increasingly regarded as transferable across industries; boards are increasingly willing to appoint outsiders as CEOs; and firms increasingly compete for the services of executives with "star" qualities, often poaching them from other firms).[1]

Second, the assumption that a CEO's decisions are unobservable is standard in the literature. Given informational asymmetries, shareholders can literally not observe what a CEO does, and how those actions affect the value of the firm. As is common, we model this as an effort choice problem: Effort is costly to the CEO and unobservable to investors.

Third, we assume that CEO candidates differ in their ability to make good decisions, and we assume that their ability ("talent") cannot be observed by others. Specifically, their cost of exerting effort is unobservable. This can be interpreted in various ways. In

[1] We discuss empirical support for our assumptions (including the increase in competition for CEOs over the past few decades) and for our predictions below, in Section 5.

terms of a costly-effort model, a CEO's willingness to make certain decisions may change over time, for example because fame (due to past successes) causes hubris (Malmendier and Tate (2009)), because pet projects become more important (a CEO may wish to run a national newspaper, or a management fad may influence M&A ambitions), or because priorities change in other ways (Bill Gates' interests in charity work may have caused distractions; political ambitions may have been distractions for Mitt Romney, Meg Whitman, and others; and a renewed interest in media appearances, socializing or leisure activities may be distracting, too). An alternative interpretation is that CEO performance is not transferable across companies, so a CEO's ability to make good decisions can vary from one firm to another. For example, young growing companies require skills and interests that are quite different from those required by a firm that is mature, or from a firm in decline. Founders may be good CEOs at startup firms, but they may be less good at managing those firms when they reach a more mature stage, with cost control and cash flow becoming more important than growth (Andrew Mason's departure from Groupon is an example). Under both interpretations, the important feature of CEO searches is that past successes at other firms do not predict future success at the next firm, so a board should not rely on a CEO candidate's track record at other firms. Given how often CEOs are replaced, and given how often boards regret an appointment,[2] it is realistic to assume that identifying the "right" CEO is both important and difficult.

Finally, we assume that the CEO can manipulate the performance measure, at a cost. A large literature argues that measuring a CEO's performance is difficult because the measures that are observable can be manipulated by the CEO.[3] A CEO can thus improve her performance, as measured by investors, either by exerting effort, or through manipulation. The ability to manipulate performance must be anticipated by the firms, and it must be reflected in the equilibrium contract. Incorporating a CEO's ability to manipulate performance in our model is important, given how much emphasis investors put on earnings reports, and given how common it is for firms to manage earnings and other

[2] Examples include John Thain at Merrill Lynch, Bob Nardelli at Home Depot, Léo Apotheker at Hewlett Packard, and Ron Johnson at J.C. Penney.

[3] See, e.g., Lacker and Weinberg (1989), Graham et al. (2005), Bergstresser and Philippon (2006), Burns and Kedia (2006), Peng and Röell (2008*a*), or Kartik (2009).

accounting measures.[4] Many cases of significant accounting fraud have been uncovered in the recent past, motivating regulators and legislators to make it costlier for firms to produce misleading financial statements. We discuss what effect such a change has on the equilibrium with competition, and how our model may explain recent stylized facts (see Section 5).

If competition can cause excessively strong incentives and reduce surplus, the question arises whether this can be mitigated using regulation.[5] A cap on total compensation can mitigate the inefficiencies caused by competition, by making it harder for firms to compete away the surplus generated, and reducing the CEOs' incentive to manipulate performance beyond a certain level. A progressive tax on incentive compensation can implement such a cap, but such a tax schedule may have to be firm-specific. (A simpler policy would impose one cap on the total compensation for *all* firms and CEOs, but such a cap would be a blunt tool.) Another drawback is that such regulation is effective only if it covers all firms seeking to hire a CEO. If some industries or countries are not affected, the main effect of a cap would be a brain drain.[6]

Our paper is related to Beyer et al. (2011), whose model is similar to our single-firm model. There is no competition for CEOs in their model, so it cannot generate our results.

Two closely related papers are Benabou and Tirole (2012) and Bijlsma et al. (2012). Benabou and Tirole (2012) study how firms compete to hire employees to fulfil two tasks, one of which is not observable, so incentive compensation can only focus on the measurable task. There is no performance manipulation decision in their model. The agents have an "intrinsic" motivation for investing effort in the unobservable task, which depends on how much effort they invest in the observable task. Like in our paper, competition leads to excessively strong incentive provision (which they call "bonus culture"). Bijlsma et al. (2012) study risk-taking incentives by traders, and how competition among banks to recruit traders affects the equilibrium contract offered to traders with heterogeneous but

[4] A candid account of how acceptable it is to manage earnings can be found in Jack Welch's memoir (Welch and Byrne (2001), ch. 15).

[5] Legislators and regulators in several countries have in recent years introduced limits to executive compensation, limiting the size of bonuses and other performance-linked compensation.

[6] For example, executives may move from regulated banks to the unregulated shadow banking sector, or to unregulated offshore financial centres.

unobservable talent, and the traders' risk-taking. The equilibrium contract also generates excessively strong incentives (to take risk).

Less closely related are papers that incorporate some but not all of our assumptions (competition for talent, unobservable talent and effort, performance manipulation), leading to different results (either efficient decisions, or decisions distorted downward; upward distortions arise only in our setting).

Setups with competition under adverse selection are studied in (among others) Rothschild and Stiglitz (1976), Stole (1995), and Armstrong and Vickers (2001). These papers do not incorporate moral hazard or manipulation of information about the value created. Competition may eliminate distortions caused by a monopolist's price discrimination, but that is not necessarily the case. These distortions caused by a monopolist (it is optimal to restrict the decisions and surplus creation of the types that are less able to generate surplus) are analyzed in Mussa and Rosen (1978) (see also Laffont and Tirole (1986) and Melumad and Reichelstein (1989)). We introduce effort choice and performance manipulation to the competition model, changing the results as described before.

Competition *for talent* in frictionless labor markets has been analyzed in Lucas (1978), Rosen (1981), and Terviö (2008). The distribution of talent determines the CEOs' compensation in equilibrium, such that more skilled CEOs earn larger rents if lower-skill CEOs are less productive, because competition focuses on the higher-skill CEOs. Gabaix and Landier (2008) extend this work by assuming that talent is more productive in larger firms, such that in equilibrium the most talented CEOs are employed by the largest firms and earn the highest rents. Competition generates *efficient* outcomes in these models, due to the absence of frictions, and the focus is on studying how the surplus is allocated.

The role of costly performance manipulation has been emphasized in many papers. Maggi and Rodriguez-Clare (1995), Dutta and Gigler (2002), Liang (2004), and Crocker and Slemrod (2007) show how allowing for some misreporting helps reduce a CEO's rents and can therefore be part of an optimal contract. (Shareholders can even benefit from a CEO's manipulation, see Bolton et al. (2006).) The equilibrium contract distorts incentives downward, since providing incentives is costly due to the deadweight cost of manipulation. Introducing competition would change the results as described above.

Acharya and Volpin (2010), Dicks (2012), and Acharya et al. (2012) study the idea that weaker governance can be traded off against higher compensation (and the externalities this creates). Talent is observable in these papers, which is not the case in our model. In equilibrium, there is no misreporting, and the CEO's decisions are undistorted (the only cost is a deadweight cost of creating "governance"); the CEO's decisions would be distorted (upwards) if her talent was unobservable, as in our model.

A large accounting literature on earnings manipulation exists; see, e.g., Baiman et al. (1987), Dye (1988), Demski (1998). Some authors have emphasized that incentive compensation creates an incentive to manipulate performance measures; see, e.g., Goldman and Slezak (2006) or Peng and Röell (2008*b*). That effect is incorporated in our analysis.

In sum, our model generates results that have not been analyzed before. All assumptions are necessary for this result: If there is competition for talent, talent is unobservable, effort is unobservable, and performance can be manipulated at a cost that is not too high, then the equilibrium contract provides excessively strong incentives to exert effort and to manipulate performance, and the distortions in the equilibrium decisions are targeted at the high-talent CEO. If any of those assumptions are dropped, the results do not obtain, and the outcome is either (second-best) efficient, or there are downward distortions in the low-talent CEO's decisions.

The rest of the paper is organized as follows. Section 2 introduces the model and two benchmark contracts, the "efficient" contract and the single-firm optimal contract. Section 3 discusses the properties of competitive contracts. Section 4 compares the optimal contracts and the outcomes in the two setups. Section 5 discusses empirical implications. Section 6 discusses how regulation may change the outcome under competition. Section 7 discusses an alternative model, in which firms are uncertain about CEOs' costs of manipulation instead of their talent. Section 8 concludes. All proofs are in the Appendix.

2 Model

There are $N \geq 2$ firms seeking to hire a CEO and one CEO candidate. The firms offer compensation contracts to attract the CEO candidate. Once hired, a CEO must choose a costly action that affects the future value of the firm and then report performance information relevant for the valuation of the firm by outside investors (for example, current earnings or earnings forecasts). The chosen action is not observable to outsiders, creating a moral hazard problem. Also, the CEO's talent is not observable to outsiders, creating an adverse selection problem. Finally, the CEO can misreport her performance, albeit at a cost.[7] As described in the introduction, these frictions are realistic and important, and they are essential for our main results.

The sequence of events is the following. First, the manager privately observes her talent (productivity), measured by $\tau \in \{\tau_\ell, \tau_h\}$, with $\tau_\ell < \tau_h$ and probabilities $p_h \in (0,1)$ and $p_\ell = 1 - p_h$. For convenience, we formalize talent inversely, as a cost-of-effort parameter $\theta = \frac{1}{\tau}$: A manager who realizes a higher value of θ has a higher cost of effort and is thus less talented or productive (notice that $\tau_\ell < \tau_h$ implies $\theta_\ell > \theta_h$).

Next, $N \geq 2$ firms simultaneously offer contracts to the manager, who can accept at most one of the contracts. A contract is a compensation rule $w(\cdot) : \mathbb{R} \to \mathbb{R}$ that depends on the performance r she will later report (if hired as CEO). After accepting a contract, the CEO chooses an action $q \in \mathbb{R}_+$ (most easily interpreted as effort), which affects the future value of the firm. For simplicity, the future value of the firm equals the CEO's effort q. Simultaneously with the choice of effort, the CEO reports the future value of the firm, but may misreport it.

The CEO must bear two nonpecuniary costs: choosing effort q causes disutility $\frac{\theta}{2}q^2$; and reporting a future value r different from the true value q causes disutility $\frac{c}{2}(r-q)^2$.[8]

Based on the chosen report r, and consistent with the contract, the CEO receives a transfer $w(r)$. Finally, the future value of the firm q is realized.

The firms (and their shareholders) and the CEO are risk neutral, so given a contract $w(\cdot)$ the CEO's payoff is

$$w(r) - \frac{c}{2}(r-q)^2 - \frac{\theta}{2}q^2,$$

[7] The cost of misreporting can be interpreted as the effort required to falsify information, or the expected cost of being caught and punished.

[8] Similar cost functions can be found in, e.g., Lacker and Weinberg (1989) or Kartik (2009). If manipulation additionally caused a cost that accrues to the firm, the provision of incentive compensation would become generally more expensive, but the results would be qualitatively unchanged.

and the profit of the firm hiring the CEO is

$$q - w(r).$$

If the manager rejects all contracts, her expected payoff is normalized to zero.[9]

The firms must resolve several incentive problems using an imperfect tool: incentive compensation contingent on the CEO's possibly misreported performance. The contract $w(\cdot)$ must induce the CEO to choose a high value of q, while ensuring that the compensation for different levels of talent is not unnecessarily high. Choosing a high q is costly, but less so for a more productive or talented CEO (with a lower θ), so it may be optimal to induce higher effort q from a more talented CEO. In addition to these adverse selection and moral hazard problems, the firm's future value is not contractible, and the firm can only use the CEO's *report* about her performance to link compensation to output. Since misreporting performance is costly for the CEO, this makes it possible to link the compensation to the CEO's reported performance. However, strong performance incentives also encourage misreporting of performance, without any benefits for the principal.

The model is stylized, but it captures the key trade-offs, and it can easily be extended to more complex and more realistic setups. For example, the future value of the firm could be assessed by investors as a function of the CEO's earnings announcement, and other information revealed along with it. The CEO's compensation could then be based on this assessed value using stock and stock option awards. As long as the CEO's compensation cannot be made fully contingent on the firm's realized value in the distant future, such a more complicated setup merely adds notation without offering any additional insights. Similarly, with risk neutral agents, the model can easily be extended to allow for uncertainty about the future value, given a chosen action q and report r.

A key parameter that affects the cost of misreporting is c. We assume that c is common knowledge and identical across firms, capturing the quality of the accounting and audit-

[9] If the manager's reservation payoff was type-dependent, the derivation of the optimal contract would be more complicated, potentially entailing some pooling (see Jullien (2000)). Of course, if the outside option was higher, the firms might prefer not to employ the low-talent manager. Similarly, type-dependent costs of manipulation would complicate the analysis; if high-talent CEOs had a lower cost of manipulation, it would be easier to separate types; in contrast, if low-talent CEOs had a lower cost of manipulation, it would be harder to separate types.

ing rules, the usefulness of disclosure requirements and other regulations, the legal rights of directors and minority shareholders when dealing with CEOs, and the effectiveness of the market for corporate control and the legal system. An extension to the case in which c varies across firms is beyond the scope of this paper; however, at the end of Section 3, we sketch what effects that would have, and in Section 7, we discuss a model in which the CEO's talent is observable and c is the unknown parameter.

Finally, the assumptions that the costs of effort and misreporting are quadratic are obviously not essential, but they simplify the exposition and analysis.

2.1 Preliminary Results

The joint presence of hidden action and adverse selection makes the analysis potentially involved. However, by addressing the CEO's effort choice in isolation, the model can be represented as an adverse selection model with a single observable action (i.e., reported performance) and then solved using standard techniques. While the CEO chooses q and r simultaneously in the model, it is convenient to treat her decision problem as if she chose her report r first, and *then* her action q.

For a given report r, CEO $\theta's$ optimal effort is defined by

$$\begin{aligned} q(r,\theta) &\equiv \arg\min_q \left\{ \frac{\theta}{2}q^2 + \frac{c}{2}(r-q)^2 \right\} \\ &= \frac{c}{c+\theta} r. \end{aligned} \tag{1}$$

The indirect cost function associated with the CEO's cost minimization problem is

$$\begin{aligned} C(r,\theta) &\equiv \min_q \left\{ \frac{\theta}{2}q^2 + \frac{c}{2}(r-q)^2 \right\} \\ &= \frac{1}{2}\frac{\theta c}{\theta + c} r^2 \end{aligned} \tag{2}$$

So the CEO chooses effort to minimize the total cost she bears from issuing the report r. This combines the cost of effort and the cost of misreporting information. Given the quadratic costs, it is never optimal for the CEO to achieve a certain performance r exclusively through either effort or misreporting. That is, for any report the CEO is planning to release she always finds it optimal to combine some effort with some misreporting, with the relative intensity of effort increasing in c. Naturally, the report r is always higher than its associated output $q(r, \theta)$ and the magnitude of misreporting

$$b(r, \theta) \equiv r - q(r, \theta) \tag{3}$$

decreases in c.

Having characterized the CEO's optimal effort as a function of her report, the problem becomes more tractable, since we can focus on how competitive contracts affect the CEO's reporting behavior. We represent the CEO's preferences in terms of money t and reports r (with corresponding q, as given by (1)) by the indirect utility function

$$v(t, r, \theta) \equiv t - C(r, \theta).$$

In general, a contract $w(\cdot)$ will induce an allocation $\{r(\theta), t(\theta)\}$ consisting of a reporting schedule $r(\theta)$ and a monetary transfer $t(\theta)$. Alternatively, the allocation will be represented as consisting of reporting and payoff schedules $\{r(\theta), u(\theta)\}$ where

$$u(\theta) \equiv v(t(\theta), r(\theta), \theta).$$

In the following, we simplify notation by writing u_ℓ and u_h instead of $u(\theta_\ell)$ and $u(\theta_h)$.

We define the social surplus arising when a CEO type θ reports r (and then chooses $q(r, \theta)$ according to (1)) as

$$S(r, \theta) \equiv q(r, \theta) - C(r, \theta). \tag{4}$$

Before solving for the competitive equilibrium, we consider two benchmarks: An efficient contract $w^*(\cdot)$ and the single-firm contract $\hat{w}(\cdot)$.

The Efficient Contract

Definition 1 *A contract $w(\cdot)$ inducing a reporting schedule $r(\theta)$ is **efficient** if*

$$r(\theta) \equiv \arg\max_{r} S(r,\theta) \quad \forall\theta.$$

The social surplus measures how much value is created, net of all costs, including the CEO's effort and manipulation costs. A contract is efficient if it maximizes this surplus, under the constraints that unobservable talent, effort and manipulation impose on the contractual relationship. It is not a "first-best" measure, which would require that these incentive problems can be controlled simultaneously.

The following lemma considers the existence of an efficient contract, which a benevolent planner, purely concerned with the maximization of social surplus but uninformed about θ, would choose.

Lemma 2 *There exist an efficient contract $w^*(\cdot)$ inducing the reporting schedule r_i^*,*

$$r_i^* = \theta_i^{-1} \text{ for } i \in \{L, H\},$$

and the payoff schedule u_i^*,

$$\begin{aligned} u_h^* &= S(r_\ell^*, \theta_\ell) + C(r_h^*, \theta_\ell) - C(r_h^*, \theta_h), \\ u_\ell^* &= S(r_\ell^*, \theta_\ell) = \frac{c}{2\theta_\ell\,(c+\theta_\ell)}. \end{aligned}$$

In fact, there is a continuum of efficient contracts indexed by the size of the rents the low-talent CEO obtains, with $u_\ell^* \in [0, S(r_\ell^*, \theta_\ell)]$. From all the allocations that implement efficient reporting, the allocation characterized in Lemma 2 is the allocation that maximizes the agents' payoffs subject to the firm getting non-negative profits on each CEO type. The competitive setup we discuss below requires that these type-dependent break-even constraints are satisfied. At the opposite end of the continuum of efficient contracts, the payoff for the low-talent manger is zero. However, that is not the contract that a single firm would offer if the firm had all bargaining power, as we show next. That contract creates distortions to extract additional rents from the high-talent CEO.

The Single-Firm Contract

As a second benchmark, we analyze the single-firm case (similar results are derived in Beyer et al. (2011), in a model with a continuum of types). Consider the firm's optimal contract, recalling that any contract can depend only on the CEO's performance report r but not her effort q. The firm's choice set is the set of all possible functions that can be used to reward performance r. To characterize the optimal contract we solve for the optimal direct mechanism.[10] A direct mechanism can be represented by a menu of pairs $\{t_i, r_i\}$ where r_i is the report of type $i \in \{L, H\}$ and t_i is the monetary transfer associated with the report of that CEO.

The optimal mechanism must maximize the firm's expected profits,

$$\hat{\mathcal{P}} : \max_{\{r_i,t_i\}} \sum_{i\in\{h,\ell\}} [q(r_i, \theta_i) - t_i]\, p_i, \tag{5}$$

subject to the the incentive compatibility constraints for the report r,

$$u_h - u_\ell \geq C(r_\ell, \theta_\ell) - C(r_\ell, \theta_h), \tag{6}$$

$$u_\ell - u_h \geq C(r_h, \theta_h) - C(r_h, \theta_\ell), \tag{7}$$

and the CEO's individual rationality constraints for both types (it is easy to show that the firm always wants to hire both types in equilibrium),

$$u_h \geq 0, \tag{8}$$

$$u_\ell \geq 0. \tag{9}$$

The above program implicitly incorporates the CEO's effort incentive compatibility constraint, as captured by the definition of $q(r, \theta)$. Unlike standard screening problems, the value $q(r, \theta)$ received by the principal depends not only on the CEO's observable report r but also on her hidden type θ. Some intermediate results help simplify the program. First, the two incentive compatibility constraints imply that the equilibrium

[10] By the Revelation Principle we can restrict attention to direct mechanisms, namely mechanisms that are both individually rational and incentive compatible.

reporting schedule $\hat{r}(\theta)$ must be decreasing in θ for it to be incentive compatible.[11] Second, the high-talent CEO must earn strictly positive rents, since she can always take the contract of the low-talent CEO and derive a greater utility than u_ℓ, which itself is non-negative. Hence, optimality requires that the low-talent participation constraint (9) is binding. Third, observe that $\frac{\partial C(r,\theta)}{\partial r \partial \theta} > 0$. Taken together, these three results imply that only the high-talent incentive compatibility constraint (6) binds in equilibrium. We are thus left with the following simplified program:

$$\hat{\mathcal{P}} = \max_{\{r_h, r_\ell\}} p_h S(r_h, \theta_h) + p_\ell \Big\{ S(r_\ell, \theta_\ell) - \pi \underbrace{[C(r_\ell, \theta_\ell) - C(r_\ell, \theta_h)]}_{u_h} \Big\},$$

where $\pi \equiv \frac{p_h}{p_\ell}$. The firm maximizes the expected social surplus net of the high-talent CEO's information rents. Solving this problem allows us to determine both the reporting schedule $\hat{r}(\theta)$ and the payoff schedule $\hat{u}(\theta)$ induced by the single-firm contract.

Lemma 3 *The single-firm contract $\hat{w}(\cdot)$ induces the reporting schedule $\hat{r}(\theta)$,*

$$\hat{r}_h = \theta_h^{-1}, \tag{10}$$

$$\hat{r}_\ell = \left[\theta_\ell + \pi \frac{c\Delta}{\theta_h + c} \right]^{-1}, \tag{11}$$

where $\Delta = \theta_\ell - \theta_h$, and the payoff schedule $\hat{u}(\theta)$,

$$\hat{u}_h = C(\hat{r}_\ell, \theta_\ell) - C(\hat{r}_\ell, \theta_h),$$
$$\hat{u}_\ell = 0.$$

As usual, the optimal contract entails *no distortion at the top* (high talent) but a downward distortion of the report and effort exerted by the low-talent CEO. The optimal contract depresses the low-talent CEO's report, relative to the efficient level r_ℓ^*, thereby also

[11] Adding the incentive compatibility constraints yields

$$C(r_\ell, \theta_\ell) - C(r_h, \theta_\ell) + C(r_h, \theta_h) - C(r_\ell, \theta_h) \leq 0$$

The left hand side equals $\frac{1}{2}(\eta_\ell - \eta_h)(r_\ell^2 - r_h^2)$ where $\eta_i = \frac{c\theta_i}{c+\theta_i} \Rightarrow (\eta_\ell - \eta_h) > 0$. This in turn means that $r_\ell \leq r_h$, to satisfy the above inequality.

depressing the CEO's effort. The source of the distortion is the principal's ability to make a take-it-or-leave-it offer, along with her rent extraction concern: She benefits from lowering the equilibrium effort of the low-talent CEO, such that it becomes more costly for the high-talent CEO to claim to be a low-talent CEO. That, in turn, makes it possible to reduce the high-talent CEO's information rent. This comes at the cost of reducing the surplus generated by a low-talent CEO, which limits the extent of the distortion applied in equilibrium.

Intuitively, the distortion is more severe if π is higher, i.e., the probability p_h of facing a high-talent CEO is higher. It is also more severe if c is higher, i.e., misrepresentation is more costly, because it is then optimal to induce higher effort, which in turn creates a higher surplus that the firm wants to extract. For the same reason, the distortion is more severe if θ_h is lower, i.e., the high-talent CEO is more productive and creates a larger surplus.

Note that the distortion introduced by the single-firm equilibrium contract is not driven by the CEO's ability to misreport $r > q$. In the limit as c grows large, such that effort becomes *de facto* verifiable, but the report induced from the low-talent CEO (and therefore also her effort) remains strictly below the efficient level,

$$\lim_{c \to \infty} \hat{r}_\ell = [\theta_\ell + \pi\Delta]^{-1} < \theta_\ell^{-1}.$$

This implies that the expected surplus generated by the single-firm contract is strictly lower than that induced by the efficient contract:

$$\lim_{c \to \infty} \mathbb{E}_\theta S(\hat{r}(\theta), \theta) < \mathbb{E}_\theta S(r^*(\theta), \theta).$$

So the distortion on the low-talent CEO's behavior induced by the single-firm contract is present even as effort becomes contractible. This is because the source of the distortion is not the lack of verifiability of effort but instead the principal's ability to make offers.

3 Competition for Talent

Introducing competition for talent (multiple firms competing to hire one CEO) dramatically changes the analysis. Intuitively, the firms will compete away all rents that are available in the single-firm setting. However, this does not happen merely as a transfer to the CEO. The firms are limited in their ability to offer larger rents, because incentive compatibility constraints must remain satisfied. Rents can therefore be offered only by changing both the transfers that depend on reported performance *and* the effort levels induced by the equilibrium contracts.[12] In equilibrium, this leads to a reversal of the distortions: The equilibrium competitive contract distorts the high-talent CEO's decisions instead of the low-talent CEO's, and the decisions are distorted upwards instead of downwards.

Under competition, the CEO's participation constraint becomes both endogenous and *type-dependent*: The firms must ensure that their contract is at least as attractive as what that CEO, given her type, could earn at a competing firm. Thus, one firm's contract offer serves as the CEO's outside option when considering a competing firm's offer. The payoff earned under a given contract will tend to increase in the CEO's talent, so a high-talent CEO must be offered a larger rent simply to keep up with competitors.

The analysis is complicated by equilibrium existence problems, since the firm value $q(r, \theta)$ depends not only on reported performance r but also on the CEO's unknown talent. These problems are similar to those analyzed by Rothschild and Stiglitz (1976) in the context of competition between insurance firms facing households with unobservable loss risks. Separating equilibria invite deviations to pooling contracts if there are too many low-risk individuals; but pooling equilibria generally do not exist.[13] To ensure the existence of a competitive equilibrium we assume that the probability of facing a high-talent manager is not too large (formally, we assume that $p_h \leq p^o$, where p^o is described in the Appendix, after the proof of Proposition 4).

Formally, a competitive equilibrium can be characterized as the solution of the follow-

[12] We abstract from complications that arise if a mechanism can ask a manager for information on the competitors' offers or can specify messages to be sent to competing mechanisms; see Peters (2001) and Martimort and Stole (2002).

[13] The problems are more severe when the distribution of types is continuous: in that case, there are no pure strategy equilibria in the Rothschild and Stiglitz model (see Riley (1979)).

ing program:

$$\tilde{\mathcal{P}} : \max_{\{\mathbf{r},\mathbf{u}\}} u_h$$

subject to

$$u_\ell \geq S(r_\ell^*, \theta_\ell) \tag{12}$$

$$u_h - u_\ell \geq C(r_\ell, \theta_\ell) - C(r_\ell, \theta_h) \tag{13}$$

$$u_\ell - u_h \geq C(r_h, \theta_h) - C(r_h, \theta_\ell) \tag{14}$$

$$u_h \leq S(r_h, \theta_h) \tag{15}$$

$$u_\ell \leq S(r_\ell, \theta_\ell). \tag{16}$$

There are several ingredients to this program. First, the program ensures that the utility of the high-talent CEO is maximized. If u_h was not maximized by the competitive contract, a firm could attract the high-talent manager by offering larger rents. Second, condition (12) implies that the utility of the low-talent CEO is no lower than the utility she gets from her efficient contract (characterized in Lemma 2). Otherwise, a firm could offer the contract $\left\{r_\ell^*, t_\ell^* - \varepsilon\right\}$ for ε small enough, attract the low-talent manager with probability one, and make strictly positive profits from hiring that manager.

Conditions (13) and (14) are the classic incentive compatibility constraints. Together, they imply that the reporting schedule must be increasing in talent.

Finally conditions (15) and (16) are participation constraints for the firms. Note that the firms must break even for every type, which is a stronger requirement than breaking even in terms of *expected* payoffs. This is necessary because if a firm makes a loss with one type, it must make a profit with the other type to break even on average; but then, the competing firm will try to lure away the type that lets the first firm make a profit, leaving only the type that causes a loss.

Proposition 4 *The competitive contract $\tilde{w}(\cdot)$ induces the reporting schedule $\tilde{r}(\theta)$*

$$\tilde{r}_h = \begin{cases} \frac{\theta_\ell + c + \sqrt{\theta_\ell^2 + 2c\Delta - \theta_h^2}}{c+\theta_h}\theta_\ell^{-1} & \text{if} \quad c < \bar{c} = \theta_h \frac{\theta_h + \theta_\ell}{\Delta} \\ r_h^* & \text{if} \quad c \geq \bar{c} \end{cases} \tag{17}$$

$$\tilde{r}_\ell = r_\ell^*, \tag{18}$$

and the payoff schedule $\tilde{u}(\theta)$:

$$\tilde{u}_h = S(\tilde{r}_h, \theta_h) \tag{19}$$

$$\tilde{u}_\ell = S(r_\ell^*, \theta_\ell) \tag{20}$$

The competitive reporting schedule $\tilde{r}(\theta)$ is the one that induces the least costly separation across types and that satisfies the firms' zero-profit conditions. Incentive compatibility requires that this schedule is decreasing in θ. Contrary to the single-firm case, the competitive solution induces no downward distortion of the low-talent CEO's report (and effort), but instead an *upward* distortion in the report (and effort) exerted by a *high-talent* CEO.[14] Also, unlike in the single-firm case, the report distortion is independent of the distribution of talent. (The reason is that the firms' profits are reduced to zero in equilibrium, for both types.)

Notice, however, that when $c \geq \bar{c}$, the competitive distortion disappears and the competitive equilibrium is efficient. The reason is that a higher misreporting cost amplifies the talent difference across types, thus relaxing the incentive compatibility constraint that generates the distortion. As c increases, mimicking high talent becomes harder for the low-talent CEO, and when c goes above $\bar{c}$, the distortion in $\tilde{r}_h$ is no longer needed to ensure separation of types.

The competitive equilibrium is represented in Figure 1. The thin upward-sloping lines represent the firm value q that the CEO produces, given a report r, if she is more talented (the higher line) or less talented (the lower line). The curved, thicker lines are indifference

[14] As we show in Section 7, if the unknown parameter was c rather than θ, the competitive equilibrium would distort the reports downwards. Private information about c corresponds to a situation where the CEO's misreporting costs are unknown to the firm. In that context, CEOs experience incentives to prove their honesty by reporting less than they would have reported when c is known.

curves of the two types. They represent the payoffs earned in equilibrium: The low-talent CEO's effort is undistorted, so in equilibrium the induced report is r_ℓ, where the low-talent CEO's indifference curve is tangent to the line describing possible firm values she can produce. In the case of the high-talent CEO, the equilibrium contract induces excessive reports and effort.

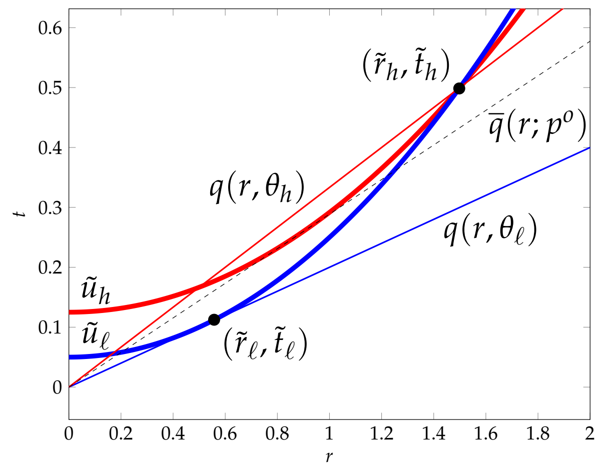

Figure 1: *The competitive equilibrium.*

The straight dashed line is the average output from pooling both types when the probability of the high-talent type is $p_h = p^o$. It is computed as $\overline{q}(r, p^o) = p^o \frac{c}{c+\theta_h} r + (1 - p^o) \frac{c}{c+\theta_\ell} r$. The existence of an equilibrium requires $p_h \leq p^o$. If instead $p_h > p^o$, then the average output can lie to the northwest of the high-talent CEO's indifference curve, and it would be profitable for a firm to deviate from the separating equilibrium and instead offer a pooling contract inducing r in the vicinity of where the dashed line is tangent to the high-talent CEO's indifference curve. That would improve both types' payoffs while leaving a positive profit for the firm. However, if p_h is sufficiently low, such a deviation from the equilibrium separating contract is not profitable.

Naturally, $\tilde{r}_h$ decreases in θ_h and c, and it converges to the efficient level r_h^* as c grows large. In the limit, as $c \to \infty$, the gap between report and effort vanishes, so contracts based on reported performance and effort become equivalent.

Note that the CEO extracts the entire surplus, leaving the firms with a profit of zero. That is because several firms compete to hire one manager. The assumption can easily be relaxed. A more realistic model could include an "inside option" for the firms: They could promote an internal candidate whom they know well, so they can form an estimate of that candidate's talent as a CEO. Say, all firms have inside candidates with a fixed talent τ_0. For small but positive values of τ_0, the firms will not compete away all rents, and the equilibrium contract will generate a profit for the firm equal to what the firm would earn if it promoted the insider. Importantly, the structure of the contracts, i.e., the incentive power, does not change. As τ_0 increases, the firms eventually prefer the insider to the low-talent CEO, and they structure the contracts such that low-talent managers leave the market. As τ_0 grows further, the same will happen to the high-talent manager. Hence, our assumption that the firms earn zero profits can easily be relaxed, without changing the results.

The CEO's equilibrium compensation can be written as

$$\tilde{w}(r) = E_\theta[q(\tilde{r}\,(\theta), \theta)\,|\tilde{r}(\theta) = r].$$

In other words, the CEO's compensation equals the value of the firm, as assessed by investors who just received the CEO's performance report. The equilibrium contract thus has the flavor of being linked to the firm's share price. Alternatively, if the report r represents earnings, then compensation can also be thought of as a bonus dependent on reported earnings. The two are equivalent since there is a monotonic relation between the performance report and the firm's value. This leads to the question of how the contract may be implemented in practice.

Given that the support of θ is discrete, there are multiple ways to implement the equilibrium allocation via a contract $\tilde{w}(\cdot) : \mathbb{R} \to \mathbb{R}$ (or a menu of contracts). These contracts all share the feature that the CEO reports either $\tilde{r}_h$ or $\tilde{r}_\ell$ and then receives total compensation of either $\tilde{t}_h$ or $\tilde{t}_\ell$. No other report-compensation pairs should be observed in equilibrium. Thus, we focus on these report-compensation pairs, which we call *observable compensation*, when analyzing the properties of equilibrium contracts under competition, and the outcomes they generate.

Definition 5 *Given a contract $w(\cdot)$ inducing an allocation $\{r(\theta), t(\theta)\}$, the* ***incentive power*** *of* *observable compensation is defined as*

$$\varphi(r) \equiv \begin{cases} \frac{t_\ell}{r_\ell} & \text{if} \quad r = r_\ell, \\ \frac{t_h - t_\ell}{r_h - r_\ell} & \text{if} \quad r = r_h. \end{cases}$$

Incentive power captures the equilibrium sensitivity of observable compensation with respect to reported performance. This definition allows us to compare the strength of incentives across regimes. Using this metric we can also consider the convexity of observable compensation, by studying the relation between incentive power and reported performance. If incentive power increases in performance, then we say that observable compensation is convex.

Proposition 6 *(i) Observable compensation is convex in reported performance. (ii) Incentive power increases in the cost of misreporting c.*

The convexity of observable compensation means that in equilibrium, high-talent CEOs face greater incentive power than low-talent ones: The high-talent CEO reports a higher performance, and the incremental observable compensation has a higher slope (as a function of additionally reported performance) than that of a low-talent CEO. Compensation must be less sensitive for lower reported performance levels, since the low-talent CEO's incentive to misrepresent performance would otherwise be too strong (misreporting is relatively more attractive to her than to the high-talent CEO, since her cost of effort θ_ℓ is higher; that explains why the ratio $\frac{r(\theta)}{q(r(\theta),\theta)}$increases in θ). On the other hand, compensation should be more sensitive to reported performance for the high-talent CEO, who is more productive and thus more willing to use effort to generate performance. Given the convexity of the cost of misreporting, a sufficiently high performance level reported by the high-talent CEO is unattractive to the low-talent CEO, who will not mimick that report.[15]

The above convexity result does not imply that the *specific* compensation schedule written into the contract is convex throughout. The actual contract may specify the com-

[15] An earlier version of this paper analyzed a model with a continuum of types θ. The equilibrium contract in that setting includes a unique, continuous and convex compensation contract $w(r)$.

pensation paid to a CEO after performance reports that should not be observed in equilibrium, but as long as these promised payments do not violate the incentive constraints (for reporting $\tilde{r}_\ell$ or $\tilde{r}_h$ truthfully), they are inconsequential. While an econometrician may have access to some details of a CEO's theoretical compensation schedule, the important comparison is what compensation CEOs *realized*, given the performance they reported (performance that is reflected in the econometrician's data set).

That incentive power increases in c is intuitive: If the costs of misreporting increase, this makes reported performance a more useful measure to reward performance, so an optimal contract should make heavier use of it. A direct implication is that generally low incentive power (for both types) may be an optimal response to a low misreporting cost (Goldman and Slezak (2006) established a similar result in a single-firm setting).

We do not allow the cost of manipulation c to vary across firms. One could imagine that manipulation is easier at some firms and harder at others, maybe because some operations are opaque and others transparent, or because corporate governance is weaker in some firms than in others. If c varied (exogenously) across firms, then firms with higher values of c would be able to generate a larger surplus. That higher surplus would allow them to attract the more talented managers, leaving the less talented managers to the firms with lower values of c. Higher-c firms would exhibit higher incentive power and compensation levels, higher levels of manipulation, and (despite the compensation and manipulation) they would also be more valuable.[16] If the firms can increase the manipulation cost c at a cost, then competition for talent will drive up these investments in increasing c. As in Acharya and Volpin (2010), Dicks (2012), and Acharya et al. (2012), endogenizing c creates "governance externalities" between the firms, and a firm's equilibrium investment in increasing c creates a floor for other firms' choice of c (in those papers, firms compete for talent by reducing corporate governance somewhat, trading off expected cash diversion against reduced monetary compensation). However, unlike those earlier papers, competition creates excessively strong incentives in our model, unless c can be raised above $\bar{c}$ at a reasonable cost (see Proposition 4).

[16] This problem has a flavor similar to that in Laffont and Tirole (1987), suggesting that firms may choose which manager to hire stochastically, after offering a menu of contracts and observing managers' announced preferences over the various contracts.

4 The Effects of Competition

In this section, we analyze how competition for managerial talent affects the equilibrium contract and the outcome, compared with the single-firm setup.

Proposition 7 *Competition induces excessive reports and output, while lack of competition induces inefficiently low reports and output. Formally,*

$$\tilde{r}(\theta) \geq r^*(\theta) \geq \hat{r}(\theta),$$
$$q(\tilde{r},\theta) \geq q(r^*,\theta) \geq q(\hat{r},\theta).$$

It may seem odd that a CEO could exert "inefficiently high" effort. Note, first, that there is evidence of high pressure on executives, leading to bad decision-making, burn-out, and even suicide.[17] Excessive pressure may also have contributed to the shortening of the average CEO's tenure over the past few decades. Second, recall that the firms choose what effort level to induce in equilibrium. To an outsider, it may seem that a CEO could be induced to add more value, by offering more compensation — for most executives, the marginal compensation is less than the value they can add or destroy at the margin, in particular at large companies. However, inducing extra effort alone is not feasible; all the firm can induce is increased reported performance; and that may be created by manipulating more, instead of exerting more effort. Manipulation creates a deadweight cost that reduces the surplus, making it too expensive at the margin to induce higher effort levels than those chosen in equilibrium by high-talent CEOs. (An alternative model could include a capacity constraint for CEO effort; see, e.g., Edmans et al. (2012).)

Competition induces strictly higher effort from both types, compared with the single-firm setup. But the strengthened incentives also increase the incentives to manipulate the performance measure:

[17] See "Another Torrent BP Works to Stem: Its C.E.O.," *New York Times*, June 3, 2010; "When the CEO Burns Out," *Wall Street Journal*, May 7, 2013; or "C-suite suicides: When exec life becomes a nightmare," *Fortune.cnn.com*, September 10, 2013.

Proposition 8 *Competition induces excessive misreporting. Formally,*

$$\tilde{b}(\theta) \geq b^*(\theta) \geq \hat{b}(\theta).$$

The misreporting escalation that occurs under competition is wasteful but unavoidable in equilibrium. A high-talent CEO can credibly reveal her type only by reporting a sufficiently high performance, which low-talent CEOs prefer not to mimick because of the convex costs of both effort and misreporting. The report thus reveals information about the CEO's type, and investors can then reverse-engineer the reported performance to infer the true value of the firm, $q(r, \theta)$. The investors are not deceived in equilibrium, but the misreporting is necessary to prevent investors from identifying a high-talent CEO as low-talent, and treating her accordingly (as in a signal jamming model). The high-talent CEO benefits from being able to separate from the low-talent CEO, even at the cost of wasteful misreporting and inefficiently high effort.

In the single-firm setup, in contrast, the firm focuses on *both* maximizing surplus and extracting rents from the CEO. By reducing the effort and reporting levels, compared with the competitive outcome, it reduces surplus when dealing with a low-talent CEO while it increases surplus when dealing with a high-talent CEO. It can extract much of the high-talent CEO's information rents by distorting the low-talent CEO's outcome, and it can extract all rents from the low-talent CEO.

Competition for talent changes the structure of the equilibrium contract:

Proposition 9 *Competition induces excessive incentive power. Formally, for all $i \in \{L, H\}$ we have*

$$\tilde{\varphi}(\tilde{r}_i) \geq \varphi^*(r_i^*) \geq \hat{\varphi}(r_i)$$

Competition boosts the incentive power of contracts beyond efficient levels. To understand this, suppose that under competition the firms offered the efficient contract. From Lemma 2, this contract must yield strictly positive profits to the firm hiring the high-talent manager. The rival firms would then have an incentive offer a contract that is more attractive to the high-talent manager, to poach her away and earn (most of) that profit. Raising the fixed part of the offered compensation would not be the best way to do that, since the low-talent manager would then also receive higher compensation, causing a loss to the firm if hired. As long as the firm makes a positive profit when hiring the high-talent manager, rival firms will try to offer a more attractive contract to that type, leaving the firm to make a loss if it hires a low-talent manager. A better way to compete is to strengthen the incentives for the high-talent manager beyond the efficient level, such that a low-talent manager will not mimick a high-talent manager. The low-talent manager's incentive compatibility condition and the firm's zero-profit condition (when hiring the high-talent manager) jointly determine how strong the incentives for the high-talent manager have to be in equilibrium.

In essence, an inefficient outcome is unavoidable under competition: The firms compete to attract the high-talent manager, and in order to do that without incurring losses if they hire a low-talent manager, they must drive the incentive power beyond efficient levels (and beyond what they would offer in the single-firm setup).

The ability to misreport performance affects the structure of the equilibrium contract: if misreporting is more costly, the sensitivity of compensation to reported performance increases (intuitively, since reported performance is a better measure of true performance if misreporting is more costly). However, the effect on the *convexity* of observable compensation is not monotonic:

Proposition 10 *Under competition, the convexity of observable compensation is hill-shaped in c and vanishes as the cost of misreporting grows large ($c \to \infty$). In the single-firm setup, observable compensation remains convex in reported performance as c grows large.*

The convexity of observable compensation is thus driven by two features of the CEO labor market: The CEO's ability to misreport her performance, and (if this is difficult or costly) a lack of competition for talent. Convexity makes it possible to incentivize effort from high-talent CEOs, without worrying about low-talent CEOs just claiming to have been productive (by severely misreporting performance). In the single-firm setup, convexity is a tool to extract rents from high-talent CEOs: The high-talent CEO's effort level is efficient, while the low-talent CEO's is distorted downward for incentive compatibility reasons. It is possible to implement the efficient outcome in the single-firm setup (see Lemma 2), but doing so would not maximize the firm's expected payoff, since the surplus gained from increasing the low-talent CEO's effort does not make up for the high-talent CEO's increased information rent. Thus, even if the costs of misreporting are unbounded, making effort contractible, the single-firm contract remains convex for rent-extraction reasons. In contrast, the competitive equilibrium contract loses its convexity and becomes linear when misreporting is prohibitively costly:

What frictions are present in a model thus has a crucial effect on the equilibrium compensation contract. If the CEO has limited bargaining power, talent and effort are unobservable and misreporting is possible, we expect observable compensation to be convex; on the other hand, if misreporting is prohibitively costly and there is strong competition for talent, observable compensation should not be convex. Without any frictions, compensation should be convex in talent (see Rosen (1981)). This lack of robustness may explain the conflict between the calibration results and empirical findings in Dittmann and Maug (2007), whose calibrated principal-agent model (without misreporting) predicts less pay-performance convexity than they find in the data.

The two setups we analyzed lead to very different contracts and to different types of distortion: In the single-firm setup, the effort of a low-talent CEO is distorted, while in the competitive setup, the effort of a high-talent CEO is distorted; and the low-talent CEO's effort is distorted *downward* in the single-firm setup, while the high-talent CEO's effort is distorted *upward* in the competitive setup. We now analyze to what degree "market forces" generate smaller efficiency losses than setups in which there is limited competition for talent.

Proposition 11 *(i) When the cost of misreporting c is relatively low, the competitive equilibrium is less efficient than the single-firm equilibrium:*

$$\mathbb{E}_\theta S(\tilde{r}(\theta), \theta) < \mathbb{E}_\theta S(\hat{r}(\theta), \theta).$$

ii) When $c \geq \bar{c}$, the competitive equilibrium is efficient:

$$\mathbb{E}_\theta S(\tilde{r}(\theta), \theta) - \mathbb{E}_\theta S(r^*(\theta), \theta) = 0.$$

If the cost of misreporting is sufficiently high, it is easy to separate the two types of manager in the competitive setup: there is no need to distort the induced effort levels for incentive compatibility reasons. Competition for talent then leads to an efficient outcome. That is not true for the single-firm setup: There, it remains optimal to distort the low-talent CEO's effort even if misreporting becomes very costly. The difference is that the competitive setup creates distortions out of necessity, while in the single-firm setup the inefficiency serves to extract rents from the CEO. Recall that the efficient outcome is feasible in the single-firm setup (see Lemma 2), but it would not maximize the firm's expected payoff, since the surplus gained from increasing the low-talent CEO's effort does not make up for the high-talent CEO's increased information rent. Thus, even if the costs of misreporting are unbounded, making effort contractible, the single-firm contract remains convex for rent-extraction reasons. In contrast, the competitive equilibrium contract loses its convexity and becomes linear when misreporting is prohibitively costly: A simple linear contract ensures that both types exert the efficient effort levels, i.e., it maximizes the surplus for both types and allocates it to the CEO.

With lower costs of misreporting, however, both setups create inefficiencies. As Proposition 11 shows, the distortion needed to preserve incentive compatibility in the competitive setup can be so significant that the efficiency loss exceeds that of the single-firm setup. Competition can thus be beneficial or value-destroying, depending on the circumstances.

The relative inefficiency of competition is particularly acute when the misreporting cost is low. The reason is that, as just explained, a lower cost of misrepresentation requires a stronger distortion of the more productive CEO's effort in the competitive setup, while the distortion in the single-firm setup targets the less productive low-talent CEO, who produces a smaller surplus, so distortions are relatively less important (which also explains why a distortion is optimal for any level of c). The single-firm distortion is driven by the firm's ability to offer a contract, allowing it to extract all of the CEO's information rents.

The relative inefficiency of competition also depends on the distribution of talent. If $c < \bar{c}$ and the probability of high-talent CEOs is high, then an increase in that probability makes competition more inefficient, relative to the single-firm setting. The reason is that competition strongly distorts the behavior of high-talent CEOs, who are able to produce larger surpluses, whereas the single-firm setting merely distorts the behavior of low-talent CEOs.

In Proposition 9, we show that the incentive power of the equilibrium contract is increased by competition. CEOs exert more effort and require compensation for that. Given the convexity of observed compensation, this can change the relative size of the compensation the CEOs receive. Specifically, if high-talent CEOs face much stronger incentives under competition, their observable compensation may increase by more than that of low-talent CEOs. In other words, inequality in pay may increase. The idea that competitive labor markets can lead to inequalities among workers of different talent can be found in, e.g., Lucas (1978), Rosen (1981). "Superstars" earn incomes that are much larger than those of their mere-mortal peers, whether it refers to scientists, sportsmen, or CEOs. The conventional view is that when talent is heterogenous, the winner takes all in competitive markets. But is this true when performance can be manipulated?

Proposition 12 *(i) Competition increases the dispersion of CEO rents. Formally,*

$$\tilde{u}_h - \tilde{u}_\ell > u_h^* - u_\ell^* > \hat{u}_h - \hat{u}_\ell.$$

(ii) Competition may decrease the dispersion of CEO's total compensation.
(iii) Competition increases CEO compensation.

The increase in rent dispersion caused by competition does not per se imply that competition increases the dispersion of compensation because compensation can be decomposed as the sum of the CEO's rent $\tilde{u}(\theta)$ and her personal costs $C(r(\theta), \theta)$, or:

$$\tilde{t}(\theta) = \tilde{u}(\theta) + C(\tilde{r}(\theta), \theta).$$

While competition increases the dispersion of rents, it may reduce the dispersion of the CEOs' cost, making the overall effect ambiguous. Figure 2 illustrates this possibility, by plotting the difference in the dispersion of compensation, between the competitive and single-firm setups (for different values of p_h and c).

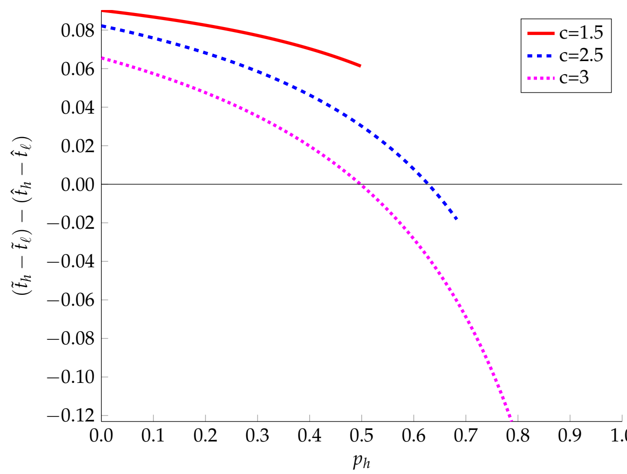

Figure 2: *Competition and the dispersion of compensation. Competition may decrease the dispersion of compensation, particularly when the cost of misreporting c is large (plotted using the parameters* $\theta_h = 1.0$ *and* $\theta_\ell = 1.2$*; the right ends of the graphs are not identical, since the values for* p^o *are different).*

The examples reveal that when the cost of misreporting is high, and the probability of facing a high-talent CEO is high, competition reduces the dispersion of compensation, compared with the single-firm setup. If c rises, it becomes generally less costly to separate types, resulting in a reduced distortion in both setups. However, in the single-firm case, the distortion arises partly for rent-extraction reasons: Even if c is prohibitively high, it remains optimal to distort the low-talent CEO's decisions downwards. In contrast, under competition for talent, the distortions are eliminated if $c \geq \bar{c}$. Thus, the effort gaps should decrease more in the competitive setup, and so should the compensation gaps. (These effects are stronger if p_h is high, since then it becomes less costly, in expected terms, to distort the effort of the low-talent CEO in the single-firm setup, allowing the firm to extract more rents from the high-talent CEO; while in the competitive setup, the distribution of talent does not affect the equilibrium contract.)

5 Empirical Implications

There have been major changes in the area of executive compensation in the past few decades (see Hall and Liebman (1998); Frydman and Saks (2010); Frydman and Jenter (2010); Murphy (2013)). Since the mid-to-late 1970s, executive compensation has increased dramatically; it has become more strongly linked to firm value, with an increasing use of stock options; and income dispersion among executives has increased. However, since the early 2000s, these changes seem to have come to a halt.

The contracting environment in which firms and CEOs negotiate also changed. First, competition for talent strengthened (see Murphy (2013); Murphy and Zabojnik (2004); Murphy and Zabojnik (2007); Faulkender and Yang (2013); Frydman and Jenter (2010)), with more firms trying to appoint a CEO from a limited pool of promising candidates. Consistent with this, firms increasingly appointed outsiders as CEOs, while until the late 1980s that was uncommon (insiders were normally promoted into the position; see Murphy and Zabojnik (2004); Murphy and Zabojnik (2007); Frydman (2005); Murphy (2013)). One factor in this increase in competition was that "general" managerial skills that are transferable across firms gained in appreciation, while firm-specific or even industry-specific knowledge became relatively less important (see Frydman (2005); Murphy and Zabojnik (2007); Fee and Hadlock (2003); Kaplan et al. (2012); Custódio et al. (2013); Falato et al. (2012)). CEOs increasingly had experience in a variety of industries and increasingly had MBAs, giving them general managerial skills. The pool of acceptable candidates was also limited because firms increasingly looked to appoint CEOs that had experience running other firms as CEOs (Frydman (2005); Murphy and Zabojnik (2007)). And some candidates were regarded as "stars," particularly sought after by firms looking to appoint a "charismatic leader" as their CEO (see Khurana (2002)).

Adding to the increased competition for talent, it became easier to poach other firms' CEOs. Compensation consultants were increasingly used by boards of directors, making it easier and more acceptable to obtain information about compensation at other firms (in particular after disclosure requirements were enacted in 2006; see Bizjak et al. (2011); Faulkender and Yang (2013); Albuquerque et al. (2013)) and to contact a firm's CEO about a possible switch to another firm. At the same time, CEOs could form more precise forecasts about their possible compensation packages at other firms and use that information when negotiating a compensation package with their board.

Other important changes to the contracting environment happened around the turn of the century. A long stock market bull run ended, making stock and stock option compensation less rewarding; and it became harder to manipulate performance measures, in part due to the passing of the Sarbanes-Oxley Act (SOX) in 2002 (see Bergstresser and Philippon (2006), Cohen et al. (2008)).

This evidence is consistent with our results. Proposition 9 predicts that competition for talent generates excessive incentive power, stronger than in the absence of such competition. In other words, the model predicts that an increase in competition for talent strengthens the link between reported performance and compensation. Further, Proposition 12.(iii) predicts that compensation will generally be higher under competition for talent. Proposition 12 also predicts that competition increases the dispersion of CEO rents, and similarly for compensation, unless the proportion of high-talent CEOs is high and the cost of manipulation c is high. (Given how hard the problem of finding the "right" CEO seems to be, it seems reasonable to assume that the proportion of "high talent" types is low for most firms.)

An explanation for the flattening of compensation since 2000 and the decreased use of options (and increased use of restricted stock) may be a general backlash after abuses of option compensation became known, coupled with many executives finding themselves with under-water options and decreasing or stagnating share prices. Given the soft economic conditions, it also became harder for executives to produce great performance.

Improved disclosure regulation also has important effects, according to our model's predictions. As discussed in, say, Cohen et al. (2008), the Sarbanes-Oxley Act (SOX) passed in 2002 improved the quality of disclosure, even if executives adapted other decisions, for example by changing the real investments or pricing decisions made by their firms. In our model, the CEO chooses both the effort level and the extent of manipulation, and if manipulation becomes more costly, the optimal response is to adapt both the report and the effort decision. But changes in c also affect the structure of the optimal contract. Importantly, Proposition 10 predicts that the convexity of the competitive contract is hill-shaped in c. Thus, if SOX (and general improvements in investor control) made manipulation *significantly* more costly after 2001, the model predicts that observable compensation should become less convex in reported performance (in the limit, compensation becomes linear). If, simultaneously, performance decreased generally since 2001, then we should expect less convex contracts producing lower levels of observable compensation.

The years leading up to 2000 also saw a surge in the intensity of earnings manipulation (see Bergstresser and Philippon (2006), Burns and Kedia (2006), or Peng and Röell (2008*a*)), particularly at firms whose CEOs had significant stock option holdings, and some of the largest accounting frauds ever witnessed in the U.S. (e.g., Enron, Tyco International, Adelphia, Peregrine Systems and WorldCom). That is consistent with a significant increase in competition for talent: Proposition 8 predicts excessive performance manipulation, and Proposition 9 predicts excessive incentive power for that setup. The two effects go hand in hand (incentives to perform make incentives to manipulate unavoidable), and both are caused by competition for talent, even if the incentives that the optimal contract generates in that setting seem to "cause" the manipulation.

Our model also makes predictions that have not been tested. For example, Proposition 7 predicts that as competition for talent becomes significant, CEOs exert strictly higher effort. CEOs thus become more effective or productive, both in terms of reported performance (r) and true performance (q). In particular, low-talent CEOs increase effort from an inefficiently low level to a higher, efficient level; and high-talent CEOs increase effort from their efficient level to an excessively high level. Effort provision increases across the board, but the *efficiency* of effort provision is asymmetric: low-talent CEOs improve their efficiency, while high-talent CEOs reduce theirs, by investing too much effort.

We could expand the model by assuming that a manager's outside option yields a strictly positive payoff. If the outside option had a sufficiently large value, then less talented managers would decline any contracts (if their productivity is sufficiently low, such that the extracted surplus is low). Under these assumptions, the competitive and the single-firm regime would lead to very different outcomes. The single-firm regime distorts the low-talent CEO's effort downwards, and thus also the surplus generated. Consequently, a low-talent manager may choose not to accept any contracts, even if she would be able to generate a positive surplus. In contrast, the competitive setup does not distort the low-talent CEO's effort or surplus. The high-talent CEO's effort is distorted upwards, and the surplus she produces is thereby reduced (see Proposition 11), but the surplus is larger in equilibrium than that produced by a low-talent CEO.[18] So in the competitive setup, the participation decision is efficient. Importantly, if competition for talent becomes significant, the pool of managers who get hired can worsen: Some firms hire low-talent managers that would have stayed out of the market if there was no competition for talent. Thus, even though CEOs face stronger incentives and work harder, the average CEO is less talented, and the realized productivity may be reduced.

6 Regulation

Given the inefficiency of competitive contracts, it is natural to study the scope for regulation in this model. An immediate implication is that regulators should make misreporting as costly as possible:

Proposition 13 *The surplus generated by the CEOs increases in c, both in the single-firm setup and in the competitive setup.*

That making manipulation of reported performance more costly is beneficial is hardly surprising, and both legislators and regulators have long focused on making it as difficult and costly as possible (for example, with disclosure requirements, the standardization of accounting rules, required auditing, etc.).

More recently, attention has shifted to executive compensation: Besides the claim that many CEOs earn too much, legislators and regulators are looking at the incentive power created by contracts that reward performance (as perceived by investors), using bonuses, stock awards, options, etc. For example, in early 2009, certain financial institutions that required financial assistance from the U.S. Treasury had their CEOs' compensation (excluding restricted stock) capped at \$500,000.[19] Soon afterwards, a "pay czar" was appointed to oversee executive compensation at those firms.[20] In March 2013, Swiss voters approved a law restricting executive compensation, limiting golden handshakes and

[18] That follows from the incentive constraint (13), recalling that $C(r, \theta)$ is increasing in θ and that $\theta_\ell > \theta_h$.
[19] See "Obama Lays Out Limits on Executive Pay," *Wall Street Journal*, Feb. 5, 2009.
[20] See "Treasury to Set Executives' Pay at 7 Ailing Firms," *New York Times*, June 11, 2009.

golden parachutes and requiring binding shareholder "say on pay" votes.[21] A few weeks earlier, European regulators passed laws restricting bonuses paid to executives at certain financial firms, limiting them to no more than the executive's base salary (or twice that amount, with shareholder consent).[22]

Given the current interest in this type of regulation, we now ask whether regulation can restore efficiency, and if so, how. Regulation can indeed reduce or even eliminate the inefficiencies created in the competitive setup.

Proposition 14 *Under competition, if* $c \in \left[\frac{\theta_h(2p_h\theta_\ell - \Delta)}{\Delta}, \bar{c}\right)$*, then efficiency can be restored by setting a compensation cap*

$$\overline{w} = \frac{1}{2}\frac{\theta_h^2 + \theta_\ell^2}{\theta_\ell\,(c+\theta_\ell)\,\theta_h^2}c.$$

If $c < \frac{\theta_h(2p_h\theta_\ell - \Delta)}{\Delta}$*, then efficiency can be partly restored with a restriction on total compensation.*

A regulator can induce efficiency in the competitive setup, by restricting total compensation to be no greater than the compensation that the efficient contract would award to a high-talent CEO. The compensation cap must limit total compensation, not just its variable component. One obvious problem with restrictions on the variable component is that a firm could bypass regulatory limits on variable compensation by changing the fixed component.[23] Additionally, if the regulation was defined as a cap on variable compensation (thus restricting the magnitude of $t_h - t_\ell$), then the existence of a competitive equilibrium would be compromised. To see this, suppose that the cap prevents firms from paying the high-talent CEO her competitive compensation. Then the firms would earn profits on the high-talent CEO and would thus face competitive pressure to increase the levels of compensation, to compete away those profits. Raising the level of compensation would in fact allow a firm to significantly increase its chances of hiring the manager. But

[21] See "Swiss Voters Approve a Plan to Severely Limit Executive Compensation," *New York Times*, March 4, 2013.

[22] See "Cap and Flayed," *The Economist*, February 23, 2013; "Europe Caps Bank Bonuses," *New York Times*, March 24, 2013; and "Europe's Bonus Clampdown Hits Two-Thirds of Fund Managers," *Bloomberg Businessweek*, March 22, 2013. Banks seem to be busy raising base salaries, already: see "Salaries Lifted to Beat Bonus Cap," *Financial Times*, August 20, 2013.

[23] This is one important criticism of the European Union's recent legislation; see the articles cited in footnote 22. Variable compensation can be relabeled as fixed compensation by adding "clawback" provisions.

such an increase would not be sustainable, because low-talent CEOs would be overpaid, so that an alternative contract, attracting only the high-talent manager, would become available to competing firms.

In our model, the optimal cap is independent of performance. However, with more than two types, the optimal cap would be contingent on reported performance r. In particular, the compensation cap would increase in performance. This means that in general one size does not fit all, when efficiency is the regulator's main concern.

Notice that the cap entails a wealth transfer between the CEO and the firms. In fact, when the cap is imposed, the firms earn abnormal profits. To avoid this wealth transfer, the regulation could be implemented as a progressive (payroll) tax, whose goal is to curb misreporting. The low performer would pay no tax, but the high performer would pay an amount equal to

$$\text{tax} = q(r_h^*, \theta_h) - \overline{w}.$$

Proposition 14 should not be interpreted, literally , as a policy recommendation. Given its complexity, and given the lack of information that regulators typically face, a compensation cap that is contingent on performance is beyond the set of tools a regulator could consider in the real world. The regulation results may be hard to implement, and the specific results are not robust to changes in assumptions. For example, in the absence of competition for talent (in the single-firm setup), a beneficial dictator should induce higher effort from the low-talent CEO, by *subsidizing* performance at low performance levels. Furthermore, our analysis ignores general equilibrium effects. If a cap is applied to a single industry (e.g., banking) then this might lead to a talent drain in the banking industry, because the most talented managers would obtain higher compensation in the unregulated sectors of the economy. Regulation must also consider the interrelation of labor markets across countries. If a country sets the cap unilaterally then the effectiveness of the cap may depend on whether talent is mobile across countries (see e.g., Borjas (1987)). If in this model there were two countries, say the regulated country and the unregulated one, and if managers could freely move across countries at no cost, then the talented managers of the regulated country would migrate to the unregulated country, simply because compensation levels would be higher in the unregulated country. The regulated country would thus suffer a talent drain.[24]

7 Extension: When c Is Unknown

In this section, we sketch the outcome of a model in which the unobservable characteristic of a CEO is her cost of manipulation instead of her talent. Assume that the CEO's talent θ is known but the misreporting cost c is the CEO's private information, where $c \in \{c_\ell, c_h\}$ with probability p_ℓ and p_h. In this context, c represents the CEO's hidden type as opposed to a characteristic of the firm. We refer c as the CEO's integrity and we say that a CEO with cost c_ℓ has low integrity, and a CEO with cost c_h has high integrity.

The significance of this extension is that it reverses the implications of the previous analysis. In particular, the incentive power of competitive contracts is excessively low. As before we define functions

$$q(r,c) \equiv \frac{c}{c+\theta} r$$
$$C(r,c) \equiv \frac{1}{2} \frac{\theta c}{c+\theta} r^2$$

and

$$\Delta_c \equiv c_h - c_\ell.$$

Consider now the competitive equilibrium. The competitive equilibrium solves

$$\tilde{\mathcal{P}} : \max_{\mathbf{r},\mathbf{u}} u_h$$

[24] See "Salaries Lifted to Beat Bonus Cap," *Financial Times*, August 20, 2013.

subject to

$$u_\ell \geq S(\theta^{-1}, c_\ell) = \frac{c_\ell}{2\theta\,(c_\ell + \theta)} \tag{21}$$

$$u_h - u_\ell \geq C(r_\ell, c_\ell) - C(r_\ell, c_h) \tag{22}$$

$$u_\ell - u_h \geq C(r_h, c_h) - C(r_h, c_\ell) \tag{23}$$

$$u_\ell \leq S(r_\ell, c_\ell) \tag{24}$$

$$u_h \leq S(r_h, c_h). \tag{25}$$

Proposition 15 *The competitive reporting schedule $\tilde{r}(c)$ is given by*

$$\tilde{r}_\ell = \theta^{-1}$$
$$\tilde{r}_h = \frac{c_h\,(c_\ell + \theta) - \sqrt{\theta\Delta_c\,(2c_\ell c_h + \theta c_\ell + \theta c_h)}}{c_\ell\,(c_h + \theta)}\theta^{-1}.$$

So unlike the case were θ is unknown, here the competitive solution leads to under reporting as opposed to over reporting. The high integrity CEO issues a report that is lower than the efficient report θ^{-1} but also ends up exerting less effort.[25] This suggests that competitive contracts suffer from too little power, particularly at low levels of reported performance. Unlike the case when θ is unknown, here the competitive contract is always inefficient regardless of Δ_c, the gap between CEOs' integrities. The CEO with low integrity get the most rents.

We now consider the single-firm setting.

Proposition 16 *The reporting schedule with a single firm $\hat{r}(\theta)$ is given by*

$$\hat{r}_\ell = \theta^{-1} \tag{26}$$

$$\hat{r}_h = \frac{c_h}{c_h + \frac{\pi\Delta_c}{c_\ell + \theta}}\theta^{-1} \tag{27}$$

Unlike the competitive solution, the single-firm solution distorts the report of the high-integrity CEO. But much like competition, it distorts the report of the high-integrity CEO

[25] This is the outcome one would intuitively expect if the CEO had to signal credibility to the market by means of his report.

c_h downwards. In other words, the single-firm solution generates weak incentives, particularly for CEOs with high integrity. Unlike competition, the sign of the distortion in the provision of incentives is independent of the nature of the asymmetry of information, and whether it refers to talent or integrity.

8 Concluding Remarks

We have analyzed a model in which firms compete to appoint a CEO, by offering compensation contracts that the CEO may find attractive, and the equilibrium contract must give the CEO an incentive to make decisions that maximize the value of the firm. The CEO in our model is thus in a position to extract rents from firms, because firms compete to appoint one CEO candidate, but compensation also reflects the productivity of the CEO, once appointed.

We have analyzed the equilibrium contract if there are realistic obstacles to writing "complete" contracts: The CEO's decisions are not observable, creating a moral hazard problem; the CEO's cost of making value-increasing decisions is unobservable, creating an adverse selection problem; and the CEO can manipulate (at a cost) the firm's performance as measured by the shareholders or directors (creating another moral hazard problem). By comparing the equilibrium contracts and outcomes for two setups, a single-firm setup and a setup with many firms, we can analyze the role of competition for CEO talent.

Competition for CEO talent has a significant effect on the equilibrium contract. It is excessively high-powered, with compensation that is excessively strongly linked to reported performance. Competition for CEOs has increased strongly in the U.S. during the second half of the 20th century: CEOs have become transferable across industries, directors have moved towards appointing outsiders instead of insiders, and information about compensation packages offered by competing firms has become more readily available. The increasing slope of equilibrium compensation can thus explain changes in compensation contracts and CEO decisions over the past few decades: the model predicts large rent extraction by the most talented CEOs, but also extreme productivity paired with excessive manipulation of performance measures (also consistent with recent stylized facts).

The incentives provided under competition are not merely stronger than those in the single-firm setup. Instead of distorting low-CEO talent downwards, as happens in the single-firm setup, the competitive equilibrium contract distorts the high-talent CEO's effort, and it distorts it upwards. Incentives are *excessively* strong, which both the firms and the high-talent CEOs would prefer to change, but incentive compatibility makes it a necessary feature of competitive contracts. "Excessive compensation" as described in the media and in the academic literature thus goes along with excessive effort and excessive productivity, but that is not widely recognized.

Politicians and shareholder rights advocates have proposed limits on CEO compensation. We have analyzed how regulation can improve efficiency in the market for CEO labor. Efficiency can be restored, using limits to pay-performance sensitivity. The model shows that simple limits to this sensitivity may be beneficial, even if they seem suboptimal from a firm's perspective.

A possible extension of our model would be to consider competition among firms which differ in their governance quality. Such an extension would allow us to endogenize governance quality and consider whether the most talented CEOs are attracted by firms with lower misreporting costs.

A Proofs

A.1 Proof of Proposition 4

First note that the firms cannot earn a positive profit with either type. If they did, it would be possible to offer a contract that gives away some of that profit to attract the CEO. So (15) and (16) must be binding. Next, (12) and (16) together imply that

$$\tilde{u}_\ell = S(r_\ell^*, \theta_\ell),$$

which in turn implies that $\tilde{r}_\ell = r_\ell^*$, otherwise the firms would either make a loss on type θ_ℓ, or they could offer a strictly profitable contract to type θ_ℓ.

The two incentive constraints (13) and cannot bind simultaneously: If they did, then adding them would imply that $\tilde{r}_\ell = \tilde{r}_h$, which would violate one of the incentive constraints. So at most one IC can be binding. It cannot be (13), the IC for type θ_h. If (13) was binding, then

$$u_h - S(r_\ell^*, \theta_\ell) = C(r_\ell^*, \theta_\ell) - C(r_\ell^*, \theta_h).$$

This implies that

$$u_h = q(r_\ell^*, \theta_\ell) - C(r_\ell^*, \theta_h).$$

But since

$$q(r_\ell^*, \theta_\ell) - C(r_\ell^*, \theta_h) < S(r_\ell^*, \theta_h),$$

this means that the firms are making strictly positive profits on θ_h, which violates the zero-profit condition (15).

It is not difficult to verify that (14) evaluated at $\{r_h^*, r_\ell^*\}$ binds if and only if $c \leq \bar{c}$. When (14) binds, the value of $\tilde{r}_h$ must be given by

$$u_h - u_\ell > C(r_\ell, \theta_\ell) - C(r_\ell, \theta_h)$$
$$u_\ell - u_h = C(r_h, \theta_h) - C(r_h, \theta_\ell)$$

$$S(r_\ell^*, \theta_\ell) - u_h = C(r_h, \theta_h) - C(r_h, \theta_\ell),$$

which, by the zero-profit condition (15) implies

$$S(r_\ell^*, \theta_\ell) - [q(r_h, \theta_h) - C(r_h, \theta_h)] = C(r_h, \theta_h) - C(r_h, \theta_\ell).$$

The solution to this equation is

$$\tilde{r}_h = \frac{\theta_\ell + c + \sqrt{\theta_\ell^2 + 2c\Delta - \theta_h^2}}{c + \theta_h}\theta_\ell^{-1}.$$

By contrast, when (14) evaluated at $\{r_h^*, r_\ell^*\}$ does not bind, the optimal $\tilde{r}_h$ is the efficient one, namely $\tilde{r}_h = r_h^*$. Finally, it is not difficult to verify that

$$S\,(r_\ell^*, \theta_\ell) - S\,(r_h^*, \theta_h) - [C(r_h^*, \theta_h) - C(r_h^*, \theta_\ell)] \geq 0$$

if and only if $c \geq \bar{c}$. This establishes that the constraint (14) will bind iff $c < \bar{c}$. ■

A.2 Existence of Equilibrium

To prove the existence of the competitive equilibrium we need to rule out the existence of a pooling contract $\{t^d, r^d\}$ generating positive profits to the principal who deviates from the equilibrium separating contract. First, note that a pooling contract inducing a report r generates expected output

$$\overline{q}(r, p_h) = \left[\frac{p_h}{c + \theta_h} + \frac{p_\ell}{c + \theta_\ell}\right] cr.$$

A deviation to this contract is profitable if $t^d \leq \overline{q}(r^d, p_h)$. Below we look for the value of p_h such that the indifference curve of θ_h in equilibrium is exactly tangent to $\overline{q}(r, p_h)$. If p_h is below that value, then no contract can attract θ_h.

Figure 1 in the text shows how this cut-off value for p_h is derived. The solid red and blue lines represent the outcome produced by high and low-talent CEOs. The dashed line, in between, is the average output from pooling both types when the probability of $p_h = p^o$. It is computed as $\overline{q}(r, p^o) = [p^o \frac{c}{c+\theta_h} + (1 - p^o)\,\frac{c}{c+\theta_\ell}]r$. The existence of an equilibrium requires $p_h < p^o$, since in that case $\overline{q}(r, p_h)$ would lie strictly below the indifference curve of θ_h, hence a pooling contract could never be profitable, given the equilibrium contract.

Consider the indifference curve of θ_h (in the t, r space) evaluated at the equilibrium payoff $\tilde{u}_h$ (see equation (19)):

$$t = \tilde{u}_h + C(r, \theta_h).$$

This indifference curve is tangent to $\overline{q}(r, p_h)$ at $r = r^o$ defined by

$$\frac{\theta_h r^o}{c + \theta_h} = \frac{p_h}{c + \theta_h} + \frac{p_\ell}{c + \theta_\ell}$$

or

$$r^o = \frac{p_h \Delta + c + \theta_h}{(\theta_\ell + c)\, \theta_h}$$

At that point, the average outcome is

$$\overline{q}(r^o, p_h) = \frac{c\,(p_h \Delta + c + \theta_h)^2}{(c + \theta_h)\,(\theta_\ell + c)^2\, \theta_h}$$

Hence for any $p < p^o$ there is no profitable pooling equilibrium, where p^o is defined by

$$\overline{q}(r^o, p^o) = \tilde{u}_h + C(r^o, \theta_h).$$

or

$$p^o = \frac{(\theta_\ell + c)\sqrt{\frac{2\tilde{u}_h}{c}\,(c + \theta_h)\,\theta_h} - (c + \theta_h)}{\Delta}, \tag{28}$$

where $\tilde{u}_h = S(\tilde{r}_h, \theta_h)$, and

$$\tilde{r}_h = \begin{cases} \frac{\theta_\ell + c + \sqrt{\theta_\ell^2 + 2c\Delta - \theta_h^2}}{c + \theta_h}\theta_\ell^{-1} & \text{if} \quad c < \overline{c} = \theta_h \frac{\theta_h + \theta_\ell}{\Delta} \\ r_h^* & \text{if} \quad c \geq \overline{c} \end{cases}$$

(see Proposition 4).

A.3 Proof of Proposition 6

Consider first incentive power under competition. When $c \geq \bar{c}$, the incentive power of competitive contracts is given by

$$\tilde{\varphi}(r) \equiv \begin{cases} \frac{c}{c+\theta_\ell} & \text{if} \quad r = \tilde{r}_\ell \\ \frac{c}{c+\theta_h}\left[\frac{\theta_h}{c+\theta_\ell}+1\right] & \text{if} \quad r = \tilde{r}_h \end{cases} \tag{29}$$

which is clearly increasing in r and convex, so we focus on the case $c < \bar{c}$.

When $c < \bar{c}$, the incentive power of competitive contracts is given by

$$\tilde{\varphi}(r) \equiv \begin{cases} \frac{c}{c+\theta_\ell} & \text{if} \quad r = \tilde{r}_\ell \\ \frac{c}{c+\theta_h}\left(1+\frac{\frac{c+\theta_h}{c+\theta_\ell}\Delta}{\Delta+\sqrt{\theta_\ell^2+2c\Delta-\theta_h^2}}\right) & \text{if} \quad r = \tilde{r}_h \end{cases} \tag{30}$$

It is easy to verify that $\tilde{\varphi}\left(\tilde{r}_h\right) > \tilde{\varphi}\left(\tilde{r}_\ell\right)$. We next show that incentive power increases in c. This is immediate for $\tilde{\varphi}\left(r_\ell\right)$. Consider $\tilde{\varphi}\left(\tilde{r}_h\right)$. First note that

$$\left.\tilde{\varphi}\left(\tilde{r}_h\right)\right|_{c=0} = 0$$

and

$$\left.\tilde{\varphi}\left(\tilde{r}_h\right)\right|_{c=\bar{c}} = \frac{1}{2}\frac{\left(\theta_h+\theta_\ell\right)^2}{\theta_h^2+\theta_\ell^2}$$

Also note that

$$\begin{aligned} \left.\frac{\partial}{\partial c}\tilde{\varphi}\left(r_h\right)\right|_{c=\bar{c}} &= \frac{1}{4\theta_h}\frac{\left(\theta_\ell^2+2\theta_\ell\theta_h-\theta_h^2\right)\left(\theta_\ell-\theta_h\right)^2}{\left(\theta_h^2+\theta_\ell^2\right)^2} > 0 \\ \left.\frac{\partial}{\partial c}\tilde{\varphi}\left(r_h\right)\right|_{c=0} &> 0. \end{aligned}$$

We now show that $\frac{\partial}{\partial c}\tilde{\varphi}\left(\tilde{r}_h\right) > 0\ \forall c \in [0,\bar{c}]$. The proof is by contradiction. Suppose there exists a a subset of $[0,\bar{c}]$ such that $\tilde{\varphi}\left(\tilde{r}_h\right)$ is decreasing in c over that subset. Then the equation

$$\frac{\partial}{\partial c}\tilde{\varphi}\left(\tilde{r}_h\right) = 0 \tag{31}$$

must have an even number of roots in $(0,\bar{c})$ (because $\tilde{\varphi}(\tilde{r}_h)$ increases in c at both ends of the interval $[0,\bar{c}]$. We will show that (31) can have at most one solution for c in $[0,\bar{c}]$.

The solution to (31) is given by

$$c=\frac{1}{2}\frac{y^2-\theta_\ell^2+\theta_h^2}{\Delta},$$

where y solves the equation $\Gamma(y)=0$ and

$$\Gamma(y)\equiv y^4-4\theta_\ell y^3+2(2\theta_\ell-\theta_h)\Delta y^2-(\theta_\ell+\theta_h)\Delta^3. \tag{32}$$

This follows from

$$\begin{aligned}\left.\frac{\partial}{\partial c}\tilde{\varphi}(\tilde{r}_h)\right|_{c=\frac{1}{2}\frac{y^2-\theta_\ell^2+\theta_h^2}{\Delta}} &= \left.\frac{\partial}{\partial c}\left(\frac{c}{c+\theta_h}\left(1+\frac{\frac{c+\theta_h}{c+\theta_\ell}\Delta}{\Delta+\sqrt{\theta_\ell^2+2c\Delta-\theta_h^2}}\right)\right)\right|_{c=\frac{1}{2}\frac{y^2-\theta_\ell^2+\theta_h^2}{\Delta}}\\ &=\frac{-\Delta^2\Gamma(y)}{y\left(y^2+\Delta^2\right)^2(\Delta-y)^2},\end{aligned}$$

which equals zero (as required for (31)) if $\Gamma(y)=0$.

We now show that the equation $\Gamma(y)=0$ has only one admissible solution in y, namely a y such that $c=\frac{1}{2}\frac{y^2-\theta_\ell^2+\theta_h^2}{\Delta}$ belongs to $[0,\bar{c}]$. If so, then we must have $\frac{\partial}{\partial c}\tilde{\varphi}(\tilde{r}_h)>0$ $\forall c\in[0,\bar{c}]$.

By Descartes' rule of signs, the equation $\Gamma(y)=0$ has only one negative solution, which we denote by y_1. Evaluate $\Gamma(y)$ at $y=-\sqrt{\theta_\ell^2-\theta_h^2}$ (such that $c=\frac{1}{2}\frac{y^2-\theta_\ell^2+\theta_h^2}{\Delta}=0$):

$$\left.\Gamma(y)\right|_{y=-\sqrt{\theta_\ell^2-\theta_h^2}}\propto\Delta^2(\theta_\ell+\theta_h)+\Delta^{\frac{3}{2}}(\theta_\ell+\theta_h)^{\frac{3}{2}},$$

which is positive. Thus,

$$-\sqrt{\theta_\ell^2-\theta_h^2}<y_1<0,$$

and y_1 is not admissible, since $c=\frac{1}{2}\frac{y_1^2-\theta_\ell^2+\theta_h^2}{\Delta}<0$.

Now we show that the equation $\Gamma(y)=0$ has only one positive solution for y. Consider the critical points of $\Gamma(y)$. The equation

$$\frac{\partial \Gamma(y)}{\partial y} = 0$$

has three solutions in y, all of which are non-negative and can be ordered as follows:

$$\begin{aligned} y &= 0 \\ y &= \frac{3}{2}\theta_\ell - \frac{1}{2}\sqrt{\theta_\ell^2 + 12\theta_\ell\theta_h - 4\theta_h^2} \\ y &= \frac{3}{2}\theta_\ell + \frac{1}{2}\sqrt{\theta_\ell^2 + 12\theta_\ell\theta_h - 4\theta_h^2} \end{aligned}$$

(Note that $\frac{3}{2}\theta_\ell - \frac{1}{2}\sqrt{\theta_\ell^2 + 12\theta_\ell\theta_h - 4\theta_h^2} > \frac{3}{2}\theta_\ell - \frac{1}{2}\sqrt{\theta_\ell^2 + 8\theta_h^2} > \frac{3}{2}\theta_\ell - \frac{1}{2}\sqrt{\theta_\ell^2} > \theta_\ell > 0$.)

Furthermore,

$$\begin{aligned} \Gamma''(y)\big|_{y=0} &= 8\theta_\ell^2 + 4\theta_h^2 - 12\theta_\ell\theta_h \\ &> 12\theta_\ell^2 - 12\theta_\ell\theta_h \\ &> 0 \end{aligned}$$

Hence, at $y = 0$ we have a local minimum, therefore at

$$y = \frac{3}{2}\theta_\ell - \frac{1}{2}\sqrt{\theta_\ell^2 + 12\theta_\ell\theta_h - 4\theta_h^2}$$

we must either have a local maximum, or an inflexion point. But it cannot be an inflexion point, or else at

$$y = \frac{3}{2}\theta_\ell + \frac{1}{2}\sqrt{\theta_\ell^2 + 12\theta_\ell\theta_h - 4\theta_h^2}$$

we should have a maximum, but we know that $\Gamma(y)$ explodes as $y \to \infty$.

Next, we show that

$$\Gamma(y)\big|_{y=\frac{3}{2}\theta_\ell - \frac{1}{2}\sqrt{\theta_\ell^2 + 12\theta_\ell\theta_h - 4\theta_h^2}} < 0.$$

To see this, notice that

$$\Gamma(y)\big|_{y=\frac{3}{2}\theta_\ell - \frac{1}{2}\sqrt{\theta_\ell^2 + 12\theta_\ell\theta_h - 4\theta_h^2}} = \frac{8\theta_h^3 - \theta_\ell^3 - 26\theta_\ell^2\theta_h - 8\theta_\ell\theta_h^2 - \sqrt{\theta_\ell^2 + 12\theta_\ell\theta_h - 4\theta_h^2}\left(4\theta_h^2 - \theta_\ell^2 - 12\theta_\ell\theta_h\right)}{2\theta_\ell^{-1}}.$$

We want to show that the right-hand side of the above equation is negative. So consider the equation

$$8\theta_h^3 - \theta_\ell^3 - 26\theta_\ell^2\theta_h - 8\theta_\ell\theta_h^2 - \sqrt{\theta_\ell^2 + 12\theta_\ell\theta_h - 4\theta_h^2}\left(4\theta_h^2 - \theta_\ell^2 - 12\theta_\ell\theta_h\right) = 0$$

This equation has the following solutions in θ_h:

$$\begin{aligned}
\theta_h &= \frac{1}{2}\left(\frac{5}{2} - \frac{3}{2}\sqrt{3}\right)\theta_\ell \\
\theta_h &= 0 \\
\theta_h &= \theta_\ell \\
\theta_h &= \frac{1}{2}\left(\frac{5}{2} + \frac{3}{2}\sqrt{3}\right)\theta_\ell
\end{aligned}$$

We are interested in the sign of

$$8\theta_h^3 - \theta_\ell^3 - 26\theta_\ell^2\theta_h - 8\theta_\ell\theta_h^2 - \sqrt{\theta_\ell^2 + 12\theta_\ell\theta_h - 4\theta_h^2}\left(4\theta_h^2 - \theta_\ell^2 - 12\theta_\ell\theta_h\right)$$

when $\theta_h \in [0, \theta_\ell]$. So consider

$$\left.\frac{\partial\left[8\theta_h^3 - \theta_\ell^3 - 26\theta_\ell^2\theta_h - 8\theta_\ell\theta_h^2 - \sqrt{\theta_\ell^2 + 12\theta_\ell\theta_h - 4\theta_h^2}\left(4\theta_h^2 - \theta_\ell^2 - 12\theta_\ell\theta_h\right)\right]}{\partial\theta_h}\right|_{\theta_h=0} = -8\theta_\ell^2 < 0.$$

This demostrates that

$$\Gamma\left(y\right)\big|_{y=\frac{3}{2}\theta_\ell - \frac{1}{2}\sqrt{\theta_\ell^2 + 12\theta_\ell\theta_h - 4\theta_h^2}} < 0$$

for $\theta_h \in [0, \theta_\ell]$. In turn, this implies that equation $\Gamma\left(y\right) = 0$ has only one positive solution for y. ■

A.4 Proof of Proposition 7

It is easy to verify that $\hat{r}_\ell < r_\ell^* = \tilde{r}_\ell$, and that if $c < \bar{c}$, then $\hat{r}_h = r_h^* < \tilde{r}_h$, while if $c \geq \bar{c}$, then $\hat{r}_h = r_h^* = \tilde{r}_h$. Using the definition of $q(r, \theta)$ in (1), these inequalities readily imply that $q\left(\tilde{r}, \theta\right) \geq q\left(r^*, \theta\right) \geq q\left(\hat{r}, \theta\right)$ for all $\theta \in \{\theta_h, \theta_\ell\}$. ■

A.5 Proof of Proposition 8

From the definition of $b(r,\theta)$ (see (3)),

$$b(r,\theta) = \frac{\theta}{c+\theta} r.$$

So the ranking of misreporting across regimes is determined by the ranking of reports $r(\theta)$. From Prop. (7), this implies that $\tilde{b}(\theta) \geq b^*(\theta) \geq \hat{b}(\theta)$. ■

A.6 Proof of Proposition 9

Incentive power at $r = r_h$ can be written as

$$\frac{t_h - t_\ell}{r_h - r_\ell} = \frac{u_h - u_\ell + C(r_h, \theta_h) - C(r_\ell, \theta_\ell)}{r_h - r_\ell}$$

When the incentive compatibility constraint of θ_ℓ is binding (as under competition and efficiency) incentive power boils down to

$$\begin{aligned} \frac{t_h - t_\ell}{r_h - r_\ell} &= \frac{C(r_h, \theta_\ell) - C(r_h, \theta_h) + C(r_h, \theta_h) - C(r_\ell, \theta_\ell)}{r_h - r_\ell} \\ &= \frac{C(r_h, \theta_\ell) - C(r_\ell, \theta_\ell)}{r_h - r_\ell} \\ &= \frac{1}{2}(r_\ell + r_h)\frac{\theta_\ell c}{\theta_\ell + c} \end{aligned}$$

This is increasing in r_h and r_ℓ. Since $\tilde{r}_h \geq r_h^*$ we get that $\tilde{\varphi}(\tilde{r}_h) \geq \varphi^*(r_h^*)$.

In the single-firm setting, the incentive compatibility constraint of θ_h binds, hence

$$\begin{aligned} \hat{\varphi}(\hat{r}_h) &= \frac{C(\hat{r}_\ell, \theta_\ell) - C(\hat{r}_\ell, \theta_h) + C(\hat{r}_h, \theta_h) - C(\hat{r}_\ell, \theta_\ell)}{\hat{r}_h - \hat{r}_\ell} \\ &= \frac{C(\hat{r}_h, \theta_h) - C(\hat{r}_\ell, \theta_h)}{\hat{r}_h - \hat{r}_\ell} \\ &= \frac{1}{2}(\hat{r}_\ell + \hat{r}_h)\frac{\theta_h c}{c + \theta_h} \\ &< \frac{1}{2}(\tilde{r}_\ell + \tilde{r}_h)\frac{\theta_\ell c}{c + \theta_\ell} \end{aligned}$$

(the inequality follows because $\tilde{r}_\ell > \hat{r}_\ell$, $\tilde{r}_h > \hat{r}_h$, and $\frac{\theta c}{c+\theta}$ is increasing in θ). ■

A.7 Proof of Proposition 10

Using (29) and (30), $\lim_{c\to 0} \tilde{\varphi}(\tilde{r}_\ell) = \lim_{c\to 0} \tilde{\varphi}(\tilde{r}_h) = 0$ and $\lim_{c\to\infty} \tilde{\varphi}(\tilde{r}_\ell) = \lim_{c\to\infty} \tilde{\varphi}(\tilde{r}_h) = 1$. For intermediate values of c, $\tilde{\varphi}(\tilde{r}_\ell) < \tilde{\varphi}(\tilde{r}_h)$.

Incentive power in the single-firm case is given by

$$\widehat{\varphi}(r) \equiv \begin{cases} \frac{1}{2}\frac{\theta_\ell c}{\theta_\ell + c}\frac{1}{\theta_\ell + \frac{c\pi(\theta_\ell - \theta_h)}{c+\theta_h}} & \text{if} \quad r = \widehat{r}_\ell \\ \frac{1}{2}\frac{\theta_h c}{\theta_h + c}\left(\frac{1}{\theta_h} + \frac{1}{\theta_\ell + \frac{c\pi(\theta_\ell - \theta_h)}{c+\theta_h}}\right) & \text{if} \quad r = \widehat{r}_h, \end{cases} \tag{33}$$

and it is easily verified that $\lim_{c\to 0} \widehat{\varphi}(\widehat{r}_\ell) = \lim_{c\to 0} \widehat{\varphi}(\widehat{r}_h) = 0$ and that $\widehat{\varphi}(r)$ is increasing and convex, for any $c > 0$. ■

A.8 Proof of Proposition 11

We show that competition is less efficient than the single-firm setup if $c \in [0, c^\dagger)$ for some $c^\dagger < \bar{c}$. Compare the efficiency loss in the two setups, as a function of c:

$$\Phi(c) \triangleq \underbrace{p_\ell\left(S(\theta_\ell^{-1}, \theta_\ell) - S(\hat{r}_\ell, \theta_\ell)\right)}_{\text{efficiency loss, single-firm setup}} - \underbrace{p_h\left(S(\theta_h^{-1}, \theta_h) - S(\tilde{r}_h, \theta_h)\right)}_{\text{efficiency loss, competition}}$$

One can easily verify that

$$\left.\frac{\partial \Phi(c)}{\partial c}\right|_{c=0} < 0.$$

Also, since $\Phi(0) = 0$, we know that $\Phi(c)$ is negative when c is in the vicinity of 0. Furthermore since $\Phi(\bar{c}) > 0$, then there must be a $c^\dagger$, with $c^\dagger < \bar{c}$, such that for all $c \in [0, c^\dagger]$ competition is less efficient than the single-firm setup. Similarly, assume that $c < \bar{c}$. Define the relative efficiency of competition by

$$\Psi(p) \triangleq (1-p)\left(S(\theta_\ell^{-1}, \theta_\ell) - S(\hat{r}_\ell, \theta_\ell)\right) - p\left(S(\theta_h^{-1}, \theta_h) - S(\tilde{r}_h, \theta_h)\right).$$

One can easily verify that $\Psi(p)$ is negative when p is close to 1 and that $\Psi(0) = 0$. Also $\lim_{p\to 0}\Psi'(p) < 0$. In fact,

$$\lim_{p\to 0}\Psi'(p) \propto -\left[\theta_h^2\theta_\ell + \theta_\ell c^2 + 2\theta_h^2 c - c^2\theta_h + \theta_h^3 - 2\theta_h\sqrt{\Delta(\theta_\ell + 2c + \theta_h)c}\right],$$

which is negative for $c \in (-\theta_H, \bar{c})$. Hence $\Psi(p)$ must be negative when p is close to zero. Also, notice that $\Psi''(p) = 0$ only at

$$p = \frac{\theta_\ell}{2^{\frac{c(\theta_\ell - \theta_h)}{c+\theta_h}} + \theta_\ell} \in (0,1).$$

This means that the function $\Psi(p)$ can cross zero at most twice in $(0,1)$. This in turn implies that $\Psi(p)$ can be positive only in an interval in the interior of $[0,1]$. One could also show that $\Psi(p)$ is negative all over $[0,1]$ when c is sufficiently low. Naturally, when $c \geq 0$, it must be the case that $\Psi(p) \geq 0$. ■

A.9 Proof of Proposition 12

For part (i) it suffices to note that

$$\begin{aligned}\tilde{u}_h - \tilde{u}_\ell &= C(\tilde{r}_h, \theta_\ell) - C(\tilde{r}_h, \theta_h)\\ u_h^* - u_\ell^* &= C(r_h^*, \theta_\ell) - C(r_h^*, \theta_h),\end{aligned}$$

hence, since $\tilde{r}_h > r_h^*$ and since $C(r, \theta_\ell) - C(r, \theta_h)$ increases in r, it follows that $\tilde{u}_h - \tilde{u}_\ell > u_h^* - u_\ell^*$. Similarly, from the solution to the single-firm problem we know that

$$\hat{u}_h - \hat{u}_\ell = C(r_\ell^*, \theta_\ell) - C(r_\ell^*, \theta_h).$$

Since $r_H^* < r_h^*$, this implies that

$$u_h^* - u_\ell^* > \hat{u}_h - \hat{u}_\ell.$$

Part (ii) can be illustrated with two examples. Assume $c = 1$, and $\theta_h = 1$ and $\theta_\ell = 1.5$.

Then $(\tilde{t}_h - \tilde{t}_l) - (\hat{t}_h - \hat{t}_l)$ is equal to 0.0193 when $p_h = .25$ and -0.00413 when $p_h = 0.7$ (for these parameters $p_h^o = 0.714$).

For part (iii), recall that the low-talent CEO earns a positive rent under competition, higher than the zero rent in the single-firm case; and under competition, she reports a higher performance r_ℓ (see Proposition 7), so her disutility $C(r,\theta)$ from choosing r and q is higher. This implies that the compensation $t_\ell = U_\ell + C_\ell$ is higher under competition. Next, from part (i) of this Proposition, the rent dispersion is higher under competition, i.e., $U_h - U_\ell$ is higher; since U_ℓ is higher, so must be U_h. And since r_h is higher under competition, it follows that $t_h = U_h + C_h$ is higher under competition. ■

A.10 Proof of Proposition 13

In the single-firm setup, the result follows from analyzing how changes in c affect $S(\hat{r}_h, \theta_h)$ and $S(\hat{r}_\ell, \theta_\ell)$,

$$\begin{aligned} S(\hat{r}_h, \theta_h) &= \frac{c}{2\theta_h\left(\theta_h + c\right)} \\ S(\hat{r}_\ell, \theta_\ell) &= \frac{c}{(c+\theta_\ell)\left(\theta_\ell + \frac{ch(\theta_\ell - \theta_h)}{c+\theta_h}\right)} - \frac{\theta_\ell c}{2\left(\theta_\ell + c\left(\theta_\ell + \frac{ch(\theta_\ell-\theta_h)}{c+\theta_h}\right)^2\right)}. \end{aligned}$$

In the competitive setup, a similar analysis of $S(\tilde{r}_\ell, \theta_\ell)$ and $S(\tilde{r}_h, \theta_h)$ (for the case $c \geq \bar{c}$) quickly yields the result; when $c < \bar{c}$, the result for $S(\tilde{r}_h, \theta_h)$ follows from analyzing the channels through which changes in c affect the surplus,

$$S(q(r(c)), r(c), c) = q(r(c), c) - C(r(c), c).$$

The total derivative with respect to c is

$$\frac{dS}{dc} = \left(\frac{\partial q(r(c), c)}{\partial r(c)} - \frac{\partial C(r(c), c)}{\partial r(c)}\right)\frac{\partial r(c)}{\partial c} + \frac{\partial q(r(c), c)}{\partial c} - \frac{\partial C(r(c), c)}{\partial c} \tag{34}$$

Using (1) and (2), the first term in parentheses can be rewritten as

$$\frac{\partial q(r(c),c)}{\partial r(c)} - \frac{\partial C(r(c),c)}{\partial r(c)} = \frac{\partial}{\partial r}\left(\frac{c}{c+\theta_h}r - \frac{1}{2}\frac{\theta_h c}{\theta_h + c}r^2\right) = \frac{c\,(1-r\theta_h)}{c+\theta_h}.$$

Since $\tilde{r}_h > \frac{1}{\theta_h}$, that term is negative. Using (17),

$$\begin{aligned}
\frac{\partial r(c)}{\partial c} &= \frac{\partial}{\partial c}\frac{\theta_\ell + c + \sqrt{\theta_\ell^2 + 2c\,(\theta_\ell - \theta_h) - \theta_h^2}}{\theta_h + c}\frac{1}{\theta_\ell} \\
&= -\frac{(\theta_\ell - \theta_h)\left((\theta_\ell + c) + \sqrt{\theta_\ell^2 + 2c\,(\theta_\ell - \theta_h) - \theta_h^2}\right)}{(c+\theta_h)^2\sqrt{\theta_\ell^2 + 2c\,(\theta_\ell - \theta_h) - \theta_h^2}}\frac{1}{\theta_\ell},
\end{aligned}$$

which is also negative. So the first summand in (34) is positive.

The second and third summands in (34) can be rewritten (again using (1) and (2)) as

$$\begin{aligned}
\frac{\partial q(r(c),c)}{\partial c} - \frac{\partial C(r(c),c)}{\partial c} &= \frac{\partial}{\partial c}\frac{c}{c+\theta_h}r - \frac{\partial}{\partial c}\left(\frac{1}{2}\frac{\theta_h c}{\theta_h + c}r^2\right) \\
&= \frac{1}{2}r\frac{\theta_h}{(c+\theta_h)^2}\left(2 - r\theta_h\right).
\end{aligned}$$

That term has the same sign as $2 - r\theta_h$, which is positive if, replacing $r = \tilde{r}_h$ using (17),

$$\begin{aligned}
\frac{\theta_\ell + c + \sqrt{\theta_\ell^2 + 2c\Delta - \theta_h^2}}{c+\theta_h}\frac{1}{\theta_\ell}\theta_h &< 2 \\
\frac{\sqrt{\theta_\ell^2 + 2c\Delta - \theta_h^2}}{c+\theta_h} - \frac{\theta_\ell}{\theta_h} &< c\frac{\theta_\ell - \theta_h}{\theta_h\,(c+\theta_h)}.
\end{aligned}$$

The right-hand side is positive, so it is sufficient to show that the left-hand side is negative, or

$$\frac{\sqrt{\theta_\ell^2 + 2c\,(\theta_\ell - \theta_h) - \theta_h^2}}{\theta_h + c} < \frac{\theta_\ell}{\theta_h}.$$

The left-hand side is decreasing in c, so the condition is satisfied if it is satisfied for the smallest value of c in $[0, \bar{c}]$, i.e., $c = 0$. That is the case, so we have $2 - r\theta_h > 0$, and thus the sum of the second and third summands in (34) is positive. Consequently, (34) is positive, i.e., $S(\tilde{r}_h, \theta_h)$ is increasing in c if $c < \bar{c}$. ■

A.11 Proof of Proposition 14

Given the compensation cap $\overline{w}$, a competitive contract must satisfy

$$\max_{\{r_h, r_\ell\}} u_h$$

subject to:

$$u_\ell = S(r_\ell^*, \theta_\ell) = \frac{1}{2\theta_\ell(c + \theta_\ell)}. \tag{35}$$

$$u_\ell - u_h \geq C(r_h, \theta_h) - C(r_h, \theta_\ell) \tag{36}$$

$$u_\ell \leq q(r_\ell, \theta_h) - C(r_\ell, \theta_\ell) \tag{37}$$

$$u_h \leq \overline{w} - C(r_h, \theta_h) \tag{38}$$

The restricted contract maximizes the utility of the high-talent CEO subject to four constraints. Equation (35) requires that the low-talent CEO must obtain the whole surplus produced by her symmetric information contract, otherwise a firm could make strictly positive profits from offering such a contract. Equation (36) requires that the contract be incentive compatible for the low-talent CEO. Obviously, the incentive compatibility constraint of θ_h will not bind when the cap is set appropriately, so we have removed it for simplicity. Equation (37) requires that the firm does not make a loss on θ_ℓ.

As before, if the firm made a loss when hiring type θ_ℓ, it could profitably deviate by dropping the (portion of the) contract aimed at θ_ℓ. Finally, equation (38) requires that the compensation of θ_h be no higher than the cap $\overline{w}$. First note that (35) and (37) taken together imply that $\tilde{r}_\ell = \theta_\ell^{-1}$. Second, the compensation constraint (38) must bind for the high-talent CEO. Now, the incentive compatibility constraint (36) must also bind. Since $\tilde{r}_h < r_h^*$ violates the incentive compatibility constraint, we must therefore only consider whether $\tilde{r}_h > r_h^*$ can be optimal. But if $\tilde{r}_h > r_h^*$, then a firm could increase u_h by reducing r_h without violating incentive compatibility, hence $\tilde{r}_h > r_h^*$ cannot be optimal. The value of $\tilde{r}_h$ must thus be determined by the constraints (35), (36) and (38). Solving this system leads to $\tilde{r}_h = \theta_h^{-1}$.

The equilibrium induced by this cap is both incentive compatibly for θ_ℓ at $\tilde{r}_h = r_h^*$ if

$$\begin{aligned}\tilde{u}_\ell &= \frac{c}{2\theta_\ell(c+\theta_\ell)} \\ &= \overline{w} - C(r_h^*, \theta_\ell),\end{aligned}$$

which implies that

$$\overline{w} = \frac{1}{2}\frac{\theta_h^2 + \theta_\ell^2}{\theta_\ell\,(c+\theta_\ell)\,\theta_h^2}c$$

To verify the existence of such an equilibrium, we must rule out deviations. Under this compensation cap, the firms earn strictly positive profits on θ_h, so they might have an incentive to offer a pooling contract, $\left\{\overline{w}, r^d\right\}$, where $r^d < r_h^*$. Note that r^d must be lower than r_h^*, otherwise neither type would accept the contract, given the compensation is capped at $\overline{w}$.

This pooling deviation is not profitable, however, if the average (pooling) output of $\overline{q}(r) = \left[p_h \frac{c}{c+\theta_h} + p_\ell \frac{c}{c+\theta_\ell}\right] r$ is lower than the compensation cap for any $r \leq r_h^*$. Hence, to prevent the pooling deviation, the following condition must be met:

$$\overline{w} - \overline{q}(r_h^*) \geq 0 \qquad \Rightarrow c \geq \theta_h\left(\frac{2p_h\theta_\ell}{\Delta} - 1\right).$$

If this condition is met, efficiency can be attained through the compensation cap $\overline{w}$ (it is straightforward to check that $\frac{\theta_h(2p_h\theta_\ell - \Delta)}{\Delta} < \overline{c}$). If the condition is not met, an efficiency gain could be attained by setting a less restrictive compensation cap. ■

A.12 Proof of Proposition 15

First note that (21) and (24) imply that

$$\tilde{u}_\ell = \frac{c_\ell}{2\theta\,(c_\ell + \theta)}$$

and that $\tilde{r}_\ell = \theta^{-1}$. Second, (22) cannot bind. Suppose it binds. Then

$$u_h = q(r_\ell, c_\ell) - C(\theta^{-1}, c_h) > u_\ell,$$

but this would violate (23). Next, (23) must bind or else u_h could be increased without violating the incentive compatibility of c_ℓ. Naturally, (25) must bind. Hence $\tilde{r}_h$ is determined by

$$\frac{c_\ell}{2\theta\,(c_\ell+\theta)} = q(r_h, c_H) - C(r_h, c_\ell),$$

which yields

$$\tilde{r}_h = \left(\frac{c_h\,(c_\ell+\theta) - \sqrt{\theta\Delta_c\,(2c_\ell c_h + \theta c_\ell + \theta c_H)}}{c_\ell\,(c_h+\theta)}\right)\theta^{-1}$$

The term in parentheses is smaller than one. ■

A.13 Proof of Proposition 16

Consider the single-firm program

$$\begin{aligned}
\mathcal{P}:\ \max_{r_L, r_h}\ & p_\ell\,(S(r_\ell, c_\ell) - u_\ell) + p_h\,(S(r_h, c_h) - u_h) \\
& u_h \geq 0 \\
& u_\ell \geq 0 \\
u_h - u_\ell &\geq C(r_\ell, c_\ell) - C(r_\ell, c_h) && (39) \\
u_\ell - u_h &\geq C(r_h, c_h) - C(r_h, c_\ell) && (40)
\end{aligned}$$

First note that c_ℓ must get the information rents, so $u_h = 0$. Suppose (39) is binding, then

$$u_\ell = -(C(r_\ell, c_\ell) - C(r_\ell, c_H\ ))$$

Then the program becomes

$$\mathcal{P}:\max_{r_L, r_h} p_\ell\,(S(r_\ell, c_\ell) + C(r_\ell, c_\ell) - C(r_\ell, c_H\ )) + p_h\,(S(r_h, c_h))$$

This leads to $r_\ell = \frac{c_\ell(c_h+\theta)}{(c_\ell+\theta)c_h}\theta^{-1} < \theta^{-1}$ and $r_h = \theta^{-1}$. Since $r_\ell < r_h$ this would not be not incentive compatible. Hence, (40) must be the binding incentive compatibility constraint:

$$\begin{aligned} u_\ell - u_h &= C(r_h, c_h) - C(r_h, c_\ell) \\ u_\ell &= C(r_h, c_h) - C(r_h, c_\ell). \end{aligned}$$

Then the program becomes

$$\begin{aligned} \mathcal{P} : \max_{r_L, r_h} &\, p_\ell \left(S(r_\ell, c_\ell) - [C(r_H, c_h) - C(r_h, c_\ell)]\right) + p_h \left(S(r_h, c_H)\right) \\ = \max_{r_L, r_h} &\, p_\ell \left(S(r_\ell, c_\ell)\right) + p_h \left(S(r_h, c_h) - \pi \left(C(r_h, c_h) - C(r_h, c_\ell)\right)\right) \end{aligned}$$

This leads to $\hat{r}_\ell$ and $\hat{r}_h$ as described in (26) and (27). $\blacksquare$

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