Equilibrium Executive Compensation*

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Abstract

We examine a general equilibrium dynamic economy in which each firm i) hires a manager who can divert cash flows and ii) can fire him after poor performance, generating costs to both parties. The contract is terminated when the manager's continuation value reaches his compensation at another firm net of his termination cost. The unique competitive equilibrium features overcompensation, short-termism, and excessive executive tenure unless moral hazard is minimal. When a firm increases executive pay, it increases the cost to other firms to retain their managers, in turn forcing them to raise and front-load their compensation packages. The equilibrium contract can be implemented with inside equity relinquished upon termination. Inefficiencies decrease with the firm's discount rate and the manager's termination cost and increase with the manager's discount rate, the termination cost to the firm, and the moral hazard proxy. Optimal corporate and income tax schedules and transfer fees can generate the social planner's allocation. When moral hazard is minimal, undercompensation, excessive delay in pay, and excessive firing obtain while subsidies and firing fees restore first best.

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1 Introduction

Executive pay has long been the subject of considerable debate in economics, finance, and beyond. In recent decades, the proponents of the shareholder view argued that the fast growing executive compensation was an efficient response to market forces while others advocated that soaring executive pay was the outcome of rent extraction by powerful managers taking advantage of weak corporate governance and low top income tax rates.[1] Perhaps remarkable in that debate is that equilibrium and social welfare analyses taking the perspective of the shareholder view in the absence of taxation and weak corporate governance have been relatively overlooked.

In this paper, we study a continuous-time economy in which each firm hires a manager to create value. The manager is more impatient than the firm and he privately observes cash flows, which generates a moral hazard problem. The firm can fire the manager after poor performance, generating termination costs to both the firm and the manager. The contract is terminated when his continuation value reaches his outside option, which turns out to be the compensation he would obtain at a different firm net of the cost of finding a new job.

We show there exists a unique competitive equilibrium that is, in general, not socially optimal. Specifically, unless our moral hazard proxy is minimal, each firm fails to internalize the fact that by providing more generous compensation packages to provide the manager with appropriate incentives, it increases other firms' cost to retain their managers. This overcompensation mechanism in turn leads firms to offer excessively short-term compensation to managers, since firms want to avoid postponing large promised compensations to impatient managers. The cost of delaying compensation increases with the value promised to the manager. It is then optimal for the firm to pay the manager at a threshold closer to the initial value that he was promised. The equilibrium executive compensation contract can be implemented with inside equity that is relinquished upon termination.

Further, overcompensation and entrenchment come hand in hand. This is because the distance to termination at the onset is the same in the competitive equilibrium and in the social optimum. When the competitive equilibrium displays overcompensation, the continuation value is larger than in the social optimum. This effect reduces the likelihood of termination. On the other hand, since the competitive equilibrium features excessive front-loading, the continuation value is reflected

[1] Lower top income tax rates and more competitive markets for CEOs have been associated with a six-fold increase in real terms of CEO pay of S&P500 firms from 1980 to 2005 (Frydman and Saks (2010)) and has kept increasing since, in particular in relation to average incomes, fueling a vibrant academic literature (Edmans et al. (2017); Glode et al. (2012); Cahuc and Challe (2012)).

sooner in the competitive equilibrium than in the social optimum. This conflicting effect that makes termination more likely and turnover higher is dominated by the first effect unless moral hazard is minimal. Hence, overcompensation leads shareholders to keep managers too long. Overall, firms would be better off coordinating policies to offer less generous, less front loaded compensation contracts with greater turnover. However, this is not an equilibrium, as each firm will want to deviate and offer a more generous and shorter term compensation package with greater managerial tenure. In contrast, when the proxy for moral hazard is minimal, we obtain undercompensation, excessive delay in pay, and excessive firing from the firm.

In other words, excessively high and short-term compensation, excessive executive tenure as well as a welfare gap arise when the firm has all the bargaining power. That is, if one takes the "shareholder view" of executive compensation and rule out any corporate governance weakness, managerial pay and tenure are inefficiently high and pay is excessively short-termist. Further, these inefficiencies increase with the executive's bargaining power. The higher the firm's bargaining power, the higher the fraction of the surplus that goes to the firm and the lower managerial compensation. As a result, the manager's outside option is reduced, thereby leading to efficiency gains with more terminations and greater deferral in compensation. This is consistent with results that managerial compensation is lower in firms with high ownership concentration and in private firms than in publicly listed firms with dispersed ownership. Although an increase in the firm's bargaining power plays an important role in reducing the externality and the inefficiencies mentioned above, it is insufficient to align the competitive equilibrium with the social optimum.

Central to our analysis is the role played by termination costs. The termination cost to the manager, which may reflect the degree of firm specificity in the manager's skills or the magnitude of search costs, generates not only a deadweight loss every time a contract is terminated, but increasing it leads to less frequent terminations. This in turn leads compensation to be less tilted toward the short term. We show that, Unless the moral hazard proxy is minimal, the second effect dominates and social welfare is increasing in the termination cost to the manager. Furthermore, the increment in welfare induced by an increase in the termination cost to the manager is greater in the competitive equilibrium. The intuition for this is as follows: an increase in the manager's termination cost is akin to a reduction in managerial bargaining power, which reduces the initial managerial (over)compensation, and brings the competitive equilibrium closer to the social optimum.

We also explore the effect of the termination cost to the firm, which can be viewed as search costs or disruption costs associated with a change in management, on overcompensation, short-termism, excessive tenure, and the welfare gap. This cost generates a welfare loss because the firm bears it when replacing a manager every time a contract is terminated. However, the reduction in welfare due to an increase in that termination cost is more significant in the competitive equilibrium, leading to a larger welfare gap. The intuition is the following: an increase in the termination cost to the firm increases its cost to terminate the manager's contract, effectively reducing the firm's bargaining power and leading to more overcompensation. Hence, the competitive equilibrium will move further away from the social planner's optimum, inducing a larger welfare gap. Thus, the termination costs have asymmetric effects on the relative bargaining power of the parties involved. In particular, a higher termination cost to the manager (firm) makes termination more costly to the manager (firm), and reduces his (her) ex-ante bargaining power. Because overcompensation is exacerbated when the firm has little bargaining power, increasing the termination cost to the manager mitigates the effect of an increase in one manager's compensation on other firms' executive compensation whereas an increase in the termination cost to the firm compounds it.

The welfare gap between the social planner problem and the competitive equilibrium is increasing in our proxy for the degree of moral hazard unless moral hazard is minimal. Increasing that proxy leads the firm to expose the manager to more risk in order to prevent him from diverting cash flows, which in expectation leads to more inefficient terminations. Thus, an increase in the severity of moral hazard increases managerial compensation, short-termism and entrenchment. Intuitively, the information rents to a manager protected by limited liability increase in the severity of moral hazard because the firm has to give the manager more "skin on the game" (i.e., more upside, which is valuable). This increase in expected managerial rents leads the firm to increase its compensation and pay the manager sooner. As a consequence, an increase in overcompensation and short-termism imply that the equilibrium contract is further away from the socially optimal contract.

Further, the degree of overcompensation, excessive executive tenure, and short-termism are decreasing in the firm's discount rate and increasing in the manager's discount rate. Recall that one of the sources of inefficiency in our model comes from the fact that the manager is more impatient than the firm. Thus, delaying managerial compensation represents a deadweight loss. Since the competitive equilibrium fails to internalize the general equilibrium effect of the outside options on the sources of inefficiency, when the potential inefficiencies are larger, the magnitude of the externality is larger. Thus, as the firm discount rate decreases, overcompensation, excessive executive tenure, short-termism, and the welfare gap all increase. As a consequence, these inefficiencies are most severe during times of low interest rates. Moreover, as the manager's discount rate decreases, it is less costly to increase the promised value to the manager and to postpone compensation. Since the planner internalizes the reduction in efficiency from a larger compensation package, the manager's compensation grows more slowly in the planner's problem than in the competitive equilibrium, thereby rendering overcompensation a decreasing function of the manager's discount rate.

These results generate several other implications and empirical predictions: First, managerial overcompensation and short-termism are less prevalent in industries in which it is very costly for managers to match with a new firm and more prevalent in industries in which replacing the management is very costly for firms. Second, efforts to enhance corporate governance throughout the economy not only increase shareholder value for individual firms, but also mitigate overcompensation externalities and short termism, thereby leading to an increase in social welfare. Our paper therefore uncovers a novel mechanism through which corporate governance has positive spill-over effects for other firms in the economy. Third, comparative statics with respect to cash flow volatility are identical to those with respect to moral hazard. Higher volatility makes it more difficult for the firm to infer whether the manager truthfully reports cash flows or diverts them: In other words, the signal-to-noise ratio worsens as volatility increases, increasing the severity of moral hazard.

We then turn to policy implications. We show that taxing entire managerial compensation packages, as opposed to bonuses or stock option exercises, may be desirable. Alternatively, managerial compensation packages offered by firms that offer more generous packages than the median compensation in their industry (controlling for size) may be taxed.[2] In addition, our results suggest that schemes that increase the cost of paying the manager and the termination cost to the manager and that decrease the termination cost to the firm he leaves behind will increase social welfare. These include taxes on compensation and transfer fees such as those observed in professional sports leagues.

Our paper contributes to the growing equilibrium firm-manager models in finance.[3] The biggest strand of the literature focuses on a dynamic bilateral framework (see, among others, DeMarzo and Sannikov (2006), Edmans et al. (2017), Hartman-Glaser et al. (2019a), Frydman and Papanikolaou (2018), and Ai et al. (2021) who find that moral hazard induced incentive pay accounts for 52% of managerial compensation). Exceptions include Cooley et al. (2020) who emphasize the trade

[2]Mandated disclosure and say on pay so shareholders can decide on managerial compensation will not reduce overcompensation in our setting since the inefficiency comes from the externality generated by excessively high managerial pay. Lengthening vesting periods is constrained by the possibility of turnover while clawbacks may be hampered by limited liability.

[3]In entrepreneurial finance, see Gromb and Scharfstein (2002).

off between commitment and the reallocation of human resources. In contrast, we examine the implications of the threat of being fired, the prospect of being hired by another firm, matching frictions and firm specific skills on overcompensation. Our model also complements the frictionless assortment theories of executive compensation (see, e.g., Gabaix and Landier (2008)). We show that with search frictions, competitive markets generate externalities, which entail overcompensation, excessively short-term pay, and inefficiently high managerial tenure.

Our results add to those of Acharya and Volpin (2009) and Dicks (2012) that show that in static, partial equilibrium environments with weak corporate governance, excessive pay can spread to other firms.[4] Unlike these papers, our dynamic, general equilibrium model shows that overcompensation arises even in the absence of weak corporate governance. Further, we show that beyond overcompensation, these externalities generate excessively short-term pay and excessive executive tenure.

The forces at stake in our paper are also distinct from those in existing papers on short-termism in executive compensation.[5] The prevailing view in the existing literature is that short-termism is a consequence of a rent extraction motive by CEOs. See Edmans and Gabaix (2016) Section 4.1 for a discussion on this perspective. An exception is Bolton et al. (2006), where short-termism arises from speculative motives. In contrast, in our paper, short-termism arises as a consequence of general equilibrium and externalities in executive pay.

Finally, our paper contributes to the growing literature exploring the role of pecuniary externalities in economic outcomes (e.g., Alvarez and Jermann (2000)). Our paper contrasts with these in several respects. First, we show that firms ignore the effect of their compensation packages on other firms entails excessive tenure and short-termism in executive pay. Second, dynamic privately optimal contracts fail to deliver an efficient outcome because the firm and the manager optimally contract around a moral hazard friction while failing to internalize the effect of their contract on the general equilibrium outside options. The latter corresponds to the market price of labor, thereby constituting a pecuniary externality.[6]

The remainder of the paper is organized as follows. Section 2 presents the model, including the contracting problem in equilibrium. Section 3 characterizes the equilibrium compensation. Section

[4] Cahuc and Challe (2012) show that rational bubbles in the financial sector may lead too many workers to work for the financial sector rather than the productive sector. Glode et al. (2012) and Glode and Lowery (2016) show that financial firms may over-invest in hiring traders.

[5] Many papers examine short-termism in investment policy. See, among many others, Stein (1988), Stein (1989), and Hackbarth et al. (2021).

[6] Biais et al. (2016) study optimal contracts in general equilibrium, but their analysis is conducted within a static framework.

4 studies the social optimum and compares it with the equilibrium contract. Section 5 assesses the quantitative magnitudes of the theoretical insights and derives comparative statics. Section 6 discusses the implementation of the equilibrium compensation and the optimal policy response. Section 7 studies two main extensions of the baseline model. Section 8 concludes.

2 Model

2.1 Environment

Time is continuous and infinite, $t \in [0, \infty)$. The economy consists of a continuum of managers (agents) and firms (principals or shareholders), each of measure one. Firms and managers are risk-neutral. Firms discount the future at rate r while managers discount the future at a higher rate $\gamma > r$.

Each manager runs a firm that generates cumulative cash flows Y_t. Cash flow has mean μ and volatility σ:

$$dY_t = \mu dt + \sigma dB_t,$$

where B is a standard Brownian motion. The manager privately observes cash flows $Y = \{Y_t\}_{t \geq 0}$. The firm only observes the cash flows $\hat{Y} = \{\hat{Y}_t\}_{t \geq 0}$ reported by the manager, not the actual cash flows. This generates a *moral hazard* problem: the manager can divert cash flows for his private benefit. Specifically, the manager reports cash flows $\hat{Y}_t$ to the firm, diverting a cash amount equal to the difference between Y_t and $\hat{Y}_t$. He receives a fraction $\lambda \in (0, 1]$ of the diverted cash flows, where the fraction $(1 - \lambda)$ corresponds to a deadweight loss associated with diverting the funds.

There is *limited commitment* on the manager side: while firms can commit to the contract they sign, managers cannot. The managerial labor market is *competitive.* Managers can unilaterally move to a different firm and start afresh upon incurring a utility cost κ_A. We interpret κ_A as resulting from either a search cost or a loss in specific human capital associated with working for a particular firm.[7] Upon terminating its relationship with an existing manager, a firm can incur a cost κ_P to be immediately matched with a new but otherwise identical manager. We interpret κ_P as either a search cost of finding another suitable manager or the disruption costs associated with a change in management.

[7]With the search cost interpretation, this reduced-form specification captures the salaries forfeited during a stint of unemployment. To be consistent with our competitive labor market assumption, the cost can be micro-founded in a competitive search framework.

2.2 Bilateral Contracting Problem

Consider a firm-manager pair at time $t = 0$. A contract $\Gamma = (C, \tau)$ specifies a non-decreasing cumulative compensation process $C = \{C_t\}_{t\geq 0}$ for the manager, as well as a termination clause τ, both of which are based on the manager's reports $\hat{Y}$. Upon termination at time $t = \tau$, the firm obtains its liquidation value denoted by L, and the manager receives his outside option denoted by R, which we specify in detail later.

The firm's expected profit at time 0 if the manager reports $\hat{Y}$, with contract Γ, is given by

$$F_0(\hat{Y};\Gamma) \equiv \mathbb{E}\left[\int_0^\tau e^{-rt}(d\hat{Y}_t - dC_t) + e^{-r\tau}L\right],$$

where the firm receives flow profit according to the reported cash flow $d\hat{Y}$ net of compensation to the manager dC_t until termination. Correspondingly, the manager's flow payoff includes the compensation dC_t and the diverted cash $\lambda(dY_t - d\hat{Y}_t)$. Thus, the manager's total expected payoff at time 0 is given by

$$W_0(\hat{Y};\Gamma) \equiv \mathbb{E}\left[\int_0^\tau e^{-\gamma t}\left(dC_t + \lambda(dY_t - d\hat{Y}_t)\right) + e^{-\gamma\tau}R\right],$$

Given that the manager has limited commitment and can leave the contractual relation at any time, we keep track of the manager's continuation value at time t:

$$W_t(\hat{Y};\Gamma) \equiv \mathbb{E}\left[\int_t^\tau e^{-\gamma(s-t)}\left(dC_s + \lambda(dY_s - d\hat{Y}_s)\right) + e^{-\gamma(\tau-t)}R\right].$$

At the onset, the firm chooses a contract Γ while the manager chooses a feasible strategy $\hat{Y}$ to maximize his payoff. The manager's strategy $\hat{Y}$ is incentive compatible if it maximizes his total expected payoff W_0 given a contract Γ. Without loss of generality, we will focus on incentive-compatible contracts that implement truthful reporting $\hat{Y} = Y$. Any contract that results in the manager diverting cash is inefficient and can be improved upon. The optimal contracting problem boils down to obtaining an incentive-compatible contract that implements truth-telling and maximizes the firm's profit, subject to delivering the manager an initial promised value W_0. Formally, the optimal contract solves

$$\max_{W_0,\Gamma}\; F_0(Y;\Gamma) \tag{1}$$

subject to

$$W_0(Y;\Gamma) = W_0 \tag{PK}$$

$$W_t(Y;\Gamma) \geq W_t(\hat{Y};\Gamma), \forall t \in [0,\tau] \tag{IC}$$

$$W_t(Y;\Gamma) \geq R, \forall t \in [0,\tau]. \tag{PC}$$

Equation (PK) is the promise-keeping constraint that ensures the contract delivers the initial value W_0 to the manager. Equation (IC) corresponds to the incentive-compatibility constraint ensuring that it is optimal for the manager to always report truthfully. Equation (PC) ensures participation of the manager in the contractual relationship up to time τ.

When engaging in bilateral contracting, each firm-manager pair is a price-taker with regards to the manager's outside option R and the shareholder liquidation value L. Effectively, each firm-manager pair observes the equilibrium initial payoffs W_0 and F_0 in the economy, and computes the value that each party will receive upon termination, by subtracting their respective rematching costs κ_A and κ_P. We denote the solution to this problem by Γ^*. The respective payoffs for the firm and the manager under this contract are given by

$$F_0^* \equiv F_0(Y;\Gamma^*) \quad \text{and} \quad W_0^* \equiv W_0(Y;\Gamma^*).$$

In a multilateral contracting setting such as ours, the bilateral contracts can impose externalities on other parties not directly involved in the contract. Specifically, how much firms pay their managers affects their respective outside options and in turn the incentive design and dissolution of other contracts. It is crucial the extent to which the agents can coordinate among the contracts with different contracting parties (see, e.g., Segal (1999), Gomes (2005), and Bloch and Gomes (2006)). It gives rise to the possibility that the firm could coordinate among the contract with the current manager and the contracts with all future managers. As the firm optimally designs all contracts simultaneously, it would take into its endogenous liquidation value. We consider this alternative contracting process in Section 7.2.

2.3 Equilibrium

We now define our notion of equilibrium. In the competitive equilibrium, each firm-manager pair optimally contracts, taking as given the equilibrium outside options.

Definition 1 (Equilibrium). *A stationary competitive equilibrium consists of* Γ^*, W_0^*, F_0^*, R^*, *and* L^* *such that:*

i) Given (R^*, L^*), the contract Γ^* and W_0^* solves the firm-manager problem (1).

ii) The manager's outside option and the shareholder's liquidation value satisfy

$$R^* = W_0^* - \kappa_A \tag{2}$$

$$L^* = F_0^* - \kappa_P. \tag{3}$$

Equation (2) captures that the manager knows that he can always quit and immediately find another job at a different firm upon bearing cost κ_A. He takes the expected payoffs offered by other firms W_0^* as given and computes his outside option. Similarly, equation (3) states that upon termination the firm can find another (identical) manager and obtain F_0^* upon bearing the cost κ_P.

A competitive equilibrium requires consistency between the equilibrium payoffs for firms and managers and their respective termination payoffs. Since each firm-manager pair takes as given the contracts other firms and workers enter in the economy, they are price-takers of the equilibrium values determined by equations (2) and (3). These price-taking behaviors are part of the basis of our Walrasian equilibrium notion, *regardless of there being a finite or infinite number of agents.* We assume a continuum of agents in our economy to ensure that the law of large number holds when rematching firms and managers after terminations occurs. That is, there is a large number of vacant firms and an equal amount of available managers to be instantly matched to each other.[8]

We focus on stationary equilibrium in which equations (2) and (3) hold for positive values of outside options R and L. The equilibrium is stationary in the sense that, upon termination from their current match, managers and firms choose to stay in the competitive market rather than quit once and for all.

3 Equilibrium Characterization

In this section, we show that there exists a unique competitive equilibrium and characterize the equilibrium executive compensation.

[8]Alternatively, in an economy with a finite number of agents, we can think of the rematching process as a renegotiation process. That is, when a firm terminates with its manager, it rehires the manager by renegotiating a new contract. In this setup, the termination costs are interpreted as renegotiation costs.

3.1 Optimal Incentive Contract

The contracting problem in (1) consists of two separate parts: (1) the optimal incentive contract design Γ, and (2) the choice of compensation level W_0. We first study the optimal incentive contract, leaving out the compensation level for now. This will facilitate the analysis of both the equilibrium outcome and the social optimum. Following the analysis of DeMarzo and Sannikov (2006), the solution to this problem is fully characterized in the lemma below.

Lemma 1 (Optimal Incentive Contract)**.** *The optimal contract Γ has the following features:*

i) (Pay-for-Performance Sensitivity). It grants the manager an initial pay W_0 and outlines the dynamics of the manager's continuation value according to

$$dW_t = \gamma W_t dt - dC_t + \lambda(dY_t - \mu dt). \tag{4}$$

ii) (Deferral). It specifies a payout threshold $\bar{W}$. The payments dC_t reflect W_t at $\bar{W}$. If the initial promise $W_0 > \bar{W}$, an immediate payment $W_0 - \bar{W}$ is triggered:

$$dC_t = \begin{cases} 0, & \text{if } R \leq W_t < \bar{W} \\ W_t - \bar{W}, & \text{if } W_t \geq \bar{W}. \end{cases} \tag{5}$$

iii) (Termination). It is terminated when the manager's continuation value hits the outside option for the first time:

$$\tau = \min \{t | W_t = R\}. \tag{6}$$

The optimal contract has three important features. First, the manager is motivated through promises about his future compensation. In order to prevent cash diversion, the sensitivity of the manager's promised value to the reported output is proportional to the moral hazard parameter, λ. Second, the manager receives payments only when his continuation value reaches the threshold $\bar{W}$. Finally, termination occurs when the manager's promised continuation value reaches R after a sequence of sufficiently low cash flows is reported.

Under the optimal incentive contract characterized in Lemma 1, the resulting firm value is denoted by $F(W; R, L)$. This function specifies explicitly that the firm's value depends on the promised continuation value to the manager, W, taking as given the manager's outside option R and the firm's liquidation value L. The following corollary characterizes the firm value.

Corollary 1 (Firm Value)**.** *The firm's value function $F(W;R,L)$ is concave with respect to W and satisfies the ordinary differential equation (ODE):*

$$rF(W;R,L) = \mu + \gamma W F'(W;R,L) + \frac{1}{2}\lambda^2\sigma^2 F''(W;R,L), \qquad \text{if } R \le W < \bar{W} \tag{7}$$

$$F'(W;R,L) = -1, \qquad \text{if } W \ge \bar{W}, \tag{8}$$

with boundary conditions

$$F(R;R,L) = L \quad \text{and} \quad rF(\bar{W};R,L) = \mu - \gamma\bar{W}. \tag{9}$$

The intuition for Corollary 1 follows naturally from Lemma 1. To understand ODE (7), recall that no payout is made to the manager until the promised value accumulates to $\bar{W}$. Hence, for W in the range from R to $\bar{W}$, the firm receives the entire cash flows, which is captured by the first term μ on the right-hand side. In addition, according to equation (4), the promised value W drifts upwards at rate γW that compensates for the delay in payment and has a standard deviation $\lambda\sigma$ that induces truth-telling. As such, we obtain the second and the third terms on the right-hand side. As soon as the payout threshold $\bar{W}$ is reached, any excess amount is paid out to the manager. Hence, we obtain the smooth-pasting condition (8) at the payout threshold. Finally, in (9), the first boundary condition states that, at termination, the firm obtains the liquidation value when the value promised to the manager hits the outside option. We also obtain the second boundary condition from (7) since $F''(\bar{W};R,L) = 0$.[9]

An implementation of the optimal contract in our executive compensation framework includes the offering of a compensation contract that is proportional to the continuation value to the manager. Perhaps more intuitively, the optimal contract can be implemented by a fraction λ of inside equity in the firm that pays a fraction λ of the dividends as long as the manager works for the firm and that is relinquished when the manager's contract is terminated. The payment of compensation/dividends occurs after cash flows exceed a performance threshold.

3.2 Equilibrium Compensation

Building on our previous characterization of the optimal incentive contract, we now characterize the competitive equilibrium outcome. In particular, the characterization of $F(W;R,L)$ in Corollary

[9] Taken together, we have a well-defined firm value function that satisfies a free-boundary second-order ODE with three degrees of freedom that exactly matches the three boundary conditions (8) and (9).

1 allows us to swiftly compute the payoffs to the firm and to the manager in the competitive equilibrium.

Assumption 1. *The termination costs satisfy*

$$0 < \kappa_A \leq W_0(0,0) \tag{10}$$

$$F(W_0(0,\bar{L});0,\bar{L}) - F(0;0,\bar{L}) \leq \kappa_P \leq F(W_0(0,0);0,0) - F(W_0(0,0)-\kappa_A;0,0), \tag{11}$$

where $\bar{L}$ *satisfies* $W_0(0,\bar{L}) = \kappa_A$.

Assumption 1 sets bounds to the termination costs for the firm and the manager. We impose this assumption for two purposes. First, this parameter restriction ensures that the equilibrium features positive outside options, which in turn ensure that the equilibrium is stationary. Second, strictly positive termination costs κ_A and κ_P help to ensure that the equilibrium is unique. Details are relegated to Appendix A.2.

Proposition 1 (Equilibrium Compensation)**.** *Under Assumption 1, there exists a unique equilibrium, in which the level of compensation* W_0^* *is characterized by*

$$F'(W_0^*;R^*,L^*) = 0. \tag{12}$$

The logic for this proposition is as follows. Recall that $F(W;R,L)$ represents the firm's payoff when it promises to deliver an initial promised value W to the manager, taking as given his outside option R and the firm's liquidation value L. In the competitive equilibrium, the firm is only constrained to delivering the manager a promised value above his outside option R. As a result, each firm-manager pair maximizes the firm value at W_0^* as characterized in equation (12).[10] Furthermore, the concavity of $F(W;R,L)$ ensures that (12) has a unique solution for the initial promised value.

4 Equilibrium (In)efficiency

The laissez-faire equilibrium is in general inefficient, since each firm-manager pair fails to internalize the impact of its compensation contract on other pairs' equilibrium outside options, and thereby the cost of their incentive contracts. Therefore, there is scope for the social planner to intervene and

[10] We note that the contract is renegotiation-proof as long as renegotiation costs are at least κ_A to the manager and κ_P to the firm.

increase social welfare. In this section, we characterize the socially optimal contract and compare it with the equilibrium one.

4.1 Social Optimum

To characterize the social optimum, we consider a planner who can jointly determine the contracts among all firm-manager pairs. Unlike contracts determined by private parties, the contracts chosen by the planner internalize their effect on managers' outside options when they quit their firms. That is, in addition to designing an optimal contract Γ and picking an initial payoff to the manager W_0, the planner also accounts for the levels of the outside option R and the liquidation value L to maximize social welfare. Formally, the social planner solves

$$\max_{\Gamma, W_0, R, L} \left\{ F_0(Y;\Gamma) + W_0 \right\}, \tag{13}$$

subject to (PK), (IC), and (PC), as well as conditions (2) and (3).

The interpretation of the social planner's problem (13) is as follows. When designing the optimal incentive contracts, the planner cannot mitigate the moral hazard problem associated with cash diversion, nor can he prevent the managers from quitting if their continuation value drops below their outside option. Thus, optimal incentive contracts are subject to the same incentive compatibility and participation constraints as before. However, unlike the bilateral contracting problem in (1), the planner takes into account that R and L are endogenously determined by the managers' initial compensation W_0. The social welfare is defined as the sum of the payoffs to all firms and to all managers. We denote the solution to the planner's problem by $(\Gamma^p, W_0^p, F_0^p, R^p, L^p)$.

We now proceed with characterizing the solution to the planner's problem. The planner provides the same incentives as the firms to resolve the moral hazard problem; therefore, the characterizations of the optimal incentive contract in Lemma 1 and of the firm value in Corollary 1 apply. However, as noted earlier, the planner takes into account the impact of each compensation, W_0 on other managers' outside option and other firms' liquidation value. The following proposition accounts for these considerations when deriving the social optimum.

Proposition 2 (Socially Optimal Compensation)**.** *The socially optimal level of compensation W_0^p is characterized by*

$$F'(W_0^p; R^p, L^p) = \frac{\partial}{\partial L} F(W_0^p; R^p, L^p) - \frac{\partial}{\partial R} F(W_0^p; R^p, L^p) - 1. \tag{14}$$

The social planner chooses the initial promised value to each manager to maximize the sum of the utilities to all firms and all managers. The planner is aware that the choice of each manager's initial promised value feeds back into the equilibrium outside options. To see this more clearly, let us study the first-order condition for the compensation level in the planner's problem (14). If the social planner were to increase the compensation level W_0 by \$1, the direct effect on social welfare would be captured by $F'(W_0; R, L) + 1$. The planner also takes into account the indirect effects induced by changes in equilibrium outside options in response to the change in compensation levels. The indirect effects include two parts. First, according to condition (2), a \$1 increase in compensation W_0 corresponds to a \$1 increase in the managers' outside option R. This then leads to changes of an amount $\frac{\partial}{\partial R}F(W_0; R, L)$ in firm value. Second, according to condition (3), a \$1 increase in compensation W_0 corresponds to changes in the firms' liquidation value by $(F'(W_0; R, L) + \frac{\partial}{\partial R}F(W_0; R, L))/(1 - \frac{\partial}{\partial L}F(W_0; R, L))$, which has a marginal effect of $\frac{\partial}{\partial L}F(W_0; R, L)$ on firm value. Adding the direct and indirect effects, at the socially optimal compensation W^p, the overall effect of a marginal change in compensation on social welfare is zero. Thus we obtain equation (14).

In general, the socially optimal compensation characterized in equation (14) differs from the one characterized by (12) in the laissez-faire equilibrium. The discrepancy reflects that the planner coordinates optimal contracts that internalize the effect of compensation packages on all equilibrium outside options in the economy. In contrast, in the competitive equilibrium, firms and managers are price-takers and do not account for the endogeneity of equilibrium prices. We show that such coordination can be valuable, rendering the competitive equilibrium suboptimal.

4.2 Equilibrium Over/Undercompensation

In this section, we compare the level of compensation implied by the optimal contract in the competitive equilibrium and the socially optimal contract. Suppose the economy starts at the competitive equilibrium (R^*, L^*). Consider perturbing this competitive equilibrium by reducing the outside option for the manager by an infinitesimal amount from R^* to $R^* - \Delta R$. Such reduction will need to be accompanied by a reduction in the liquidation value for the firm from L^* to $L^* - \Delta L$. According to the equilibrium conditions (2) and (3), these changes satisfy the relation:

$$\Delta L = F(W_0^*; R^*, L^*) - F(W_0^* - \Delta R; R^* - \Delta R, L^* - \Delta L).$$

Using the optimality condition (12), in the competitive equilibrium from Proposition 1, we further obtain

$$\frac{\Delta L}{\Delta R} = \frac{\frac{\partial}{\partial R}F(W_0^*; R^*, L^*)}{1 - \frac{\partial}{\partial L}F(W_0^*; R^*, L^*)},$$

Computing the local change in welfare from this perturbation, we obtain

$$-\frac{\Delta(F_0^* + W_0^*)}{\Delta R} = -\frac{\Delta L}{\Delta R} - 1 = -\frac{\frac{\partial}{\partial R}F(W_0^*; R^*, L^*)}{1 - \frac{\partial}{\partial L}F(W_0^*; R^*, L^*)} - 1. \tag{15}$$

The expression above connects to the insight in Proposition 2. Recall that the socially optimally level of compensation is characterized by equation (14). When the equilibrium compensation coincides with the social optimum, i.e., $W_0^* = W_0^p$, equation (14) illustrates that the perturbation leads to exactly zero change in social welfare.

The following Proposition provides an explicit expression for the welfare change associated with a reduction in outside option R. To that end, we recall that τ, defined in equation (6), represents the time at which the contract is terminated. Moreover, we define $T(W)$ as the price of an Arrow-Debreu security that pays \$1 upon termination of the manager's contract given his initial promised value W:

$$T(W) = \mathbb{E}\left[e^{-r\tau} | W_0 = W\right]. \tag{16}$$

Proposition 3 (Condition for Inefficient Compensation)**.** *The infinitesimal welfare change resulting from perturbing the competitive equilibrium by reducing the outside option, R, is given by:*

$$\frac{\mathbb{E}_0[e^{-r\tau}]}{1 - \mathbb{E}_0[e^{-r\tau}]} F'(R^*; R^*, L^*) - 1, \tag{17}$$

where $\mathbb{E}_0[e^{-r\tau}] = T(W_0^*)$. Moreover,

i) The competitive equilibrium is socially optimal if, and only if, expression (17) $= 0$.

ii) If expression (17)> 0, the equilibrium features overcompensation, i.e., $W_0^* > W_0^p$.

iii) Conversely, if expression (17) < 0, the equilibrium features undercompensation, i.e., $W_0^* < W_0^p$.

Expression (17) for the change in social welfare is intuitive. A reduction in the manager's outside option, R, will delay inefficient termination. The benefit for shareholders from this reduction is proportional to the slope of the value function at termination $F'(R^*; R^*, L^*)$, since this is the local gain for shareholders from moving away from the termination boundary. The net present value of this gain is therefore given by $\mathbb{E}_0[e^{-r\tau}]F'(R^*; R^*, L^*)$. Because the gains from reducing R will reduce termination costs for both the current manager and all future managers, we need to divide by $1 - \mathbb{E}_0[e^{-r\tau}]$ to appropriately account for the present value of all future gains.[11]

The case in which the competitive equilibrium coincides with the social optimum corresponds to the knife-edge case where the associated gain to the firm from a reduction in the equilibrium outside option is exactly offset by the loss to the manager, i.e., when expression (17) equals zero. Whenever this condition is not satisfied, the competitive equilibrium is not socially optimal.

As noted in Section 3.1, we can separate the optimal incentive contract design Γ from the choice of compensation level W_0. Given any level of compensation promised to the manager, the corresponding contract remains incentive compatible and the manager has no incentive to divert cash. Moreover, our "overcompensation" or "undercompensation" result does not rely on assumptions related to managerial entrenchment nor on managers extracting rents through contract offers. In fact, in our setting, the occurrence of overcompensation is consistent with shareholder value maximization.

We highlight the forces behind Proposition 3 that come from the interaction between moral hazard and limited commitment in general equilibrium. To illustrate the intuition, we discuss two important benchmark cases in which there is 1) no moral hazard and 2) full commitment, before departing from these cases. In the first case where there is no moral hazard, $\lambda = 0$, firms offer managers their outside option and contracts are never terminated. The equilibrium outside option is $R^* = 0$. Thus, moral hazard is needed to induce a deviation from the optimal compensation scheme. Intuitively, $\lambda > 0$ forces termination in equilibrium, inducing firms to offer $W_0 > R$ to mitigate costly termination. In other words, firms pay managers *more* than their outside option. To see this, the cost of termination increases with λ. Anticipating, Section 5.2 will illustrate numerically that for low values of λ, the planner would like to increase compensation above the equilibrium compensation level in order to increase the drift of the continuation value (which itself is proportional to W) and hence to reduce the rate of termination.

In the second benchmark where there is full commitment, $\kappa_A = \infty$, firms know the manager will not quit for any positive W, thereby offering a contract such that the equilibrium outside option $R^* = 0$. Hence, limited commitment is essential for a deviation from the optimal compensation

[11] To see this, note that $\frac{\mathbb{E}_0[e^{-r\tau}]}{1-\mathbb{E}_0[e^{-r\tau}]}F'(R^*; R^*, L^*) = \left(\mathbb{E}_0[e^{-r\tau}] + \mathbb{E}_0[e^{-r\tau}]^2 + \mathbb{E}_0[e^{-r\tau}]^3 + ...\right) F'(R^*; R^*, L^*)$, which corresponds to the net present value of the savings in termination costs associated with a reduction in R from all future contracts.

scheme to occur. Intuitively, a link between managerial compensation and outside options across different firms is needed to obtain overcompensation. Anticipating, in nearly all numerical simulations in Section 5.2, a higher compensation offered by a firm increases the manager's outside option at other firms, which will generate a compensation level that is higher than the one that would be chosen by the social planner who would take into account the effect of compensation on other firms. This link is severed with full commitment. Moreover, for large values of κ_A, undercompensation can arise: since the manager's cost of moving to another firm is very high, the firm can offer a low compensation, generating a low drift and hence a more likely termination. The cost of termination to the manager is captured in R, but the effect of a low compensation on other managers is not, therefore the social planner would like to offer a compensation that is higher than the equilibrium one.

It follows that when λ is sufficiently large and κ_A is sufficiently low, managers will receive an excessively high compensation in equilibrium. In contrast, undercompensation can arise in equilibrium with low values of λ and high values of κ_A for specific values of other parameters. Section 5.2 discusses this in greater depth.

4.3 Short-Termism and Turnover

We now compare the equilibrium contract Γ^* with the socially optimal one Γ^p and we examine whether (1) it excessively front-loads executive compensation, and (2) it leads to managerial entrenchment and inefficient turnover.

To study the dynamic structure of compensation, we define τ_C as the time in which the manager receives his first payment

$$\tau_C = \min\left\{t : W_t = \bar{W}\right\},$$

and $S(W)$ as the price of an Arrow-Debreu security that pays \$1 when the manager is paid for the first time given his initial promised value W:

$$S(W) = \mathbb{E}\left[e^{-r\tau_C} | W_0 = W\right].$$

We will use $S(W_0)$ as a measure of the timing of managerial pay. A higher (lower) value implies that the manager expects to receive his first compensation in the more immediate (more distant) future from the contract's onset $t = 0$.

Similarly, we use $T(W_0)$, defined in equation (16), as our measure for the turnover rate under a given contract. A larger (lower) value implies that the manager expects his contract to be terminated in the near (distant) future from the contract's onset $t = 0$.

Proposition 4 (Short-Termism and Turnover)**.** *If the competitive equilibrium displays overcompensation, i.e., $W_0^* > W_0^p$, the corresponding payout threshold is closer to the initial promised value:*

$$\bar{W}^* - W_0^* < \bar{W}^p - W_0^p. \tag{18}$$

Further, the equilibrium displays short-termism and an inefficiently low turnover relative to the social optimum:

$$S^*(W_0^*) > S^p(W_0^p) \quad \textit{and} \quad T^*(W_0^*) < T^p(W_0^p). \tag{19}$$

Proposition 4 first states that overcompensation and short-termism come hand in hand. To understand the intuition behind equation (18), we note that the cost of delaying compensation $(\gamma - r)W_t$ is proportional to the promised value to the manager W_t. When the competitive equilibrium displays overcompensation, i.e., $W_0^* > W_0^p$, it is more costly to delay payment to the manager than in the social optimum. It then follows naturally that it is optimal for the firm to pay the manager at a threshold closer to the initial promised value. In comparison to the social optimum, in the competitive equilibrium, the initial drift of the manager's continuation value is larger, $\gamma W^* dt > \gamma W^p dt$, and the relative distance of the payout threshold to the initial value is smaller. Combining the two forces, we can expect the manager's continuation value to hit the payout threshold sooner. As a result, as captured by the first inequality in (19), overcompensation induces short-termism.

Overcompensation and entrenchment also come hand in hand. To gain intuition, recall that the distance to termination at the onset is the same for the competitive equilibrium and the social optimum: $W_0^* - R^* = W_0^p - R^p = \kappa_A$. When the competitive equilibrium displays overcompensation, again the drift of the continuation value in the competitive equilibrium is larger than in the social optimum, i.e., $\gamma W^* dt > \gamma W^p dt$. This effect reduces the likelihood of termination and the turnover rate in the competitive equilibrium. On the other hand, since the competitive equilibrium features short-termism, the continuation value is reflected earlier in the competitive equilibrium than in the social optimum (equation (18)). This increases the likelihood of termination and the turnover rate. However, the latter effect is second-order and does not fully offset the former first-order effect.

Table 1 provides a numerical illustration for Propositions 3 and 4 by computing comparative statics for overcompensation, short-termism, excessive turnover, and expression (17) with respect to λ, κ_A, and κ_P, around a set of parameter values where the market equilibrium and the social

Table 1: Equilibrium over/under compensation

Parameter	$W_0^* - W_0^p$	$S^*(W_0^*) - S^p(W_0^p)$	$T^*(W_0^*) - T^p(W_0^p)$	$\frac{\mathbb{E}_0[e^{-r\tau}]}{1-\mathbb{E}_0[e^{-r\tau}]} F'(R^*; R^*, L^*) - 1$
$\lambda = 0.45$	-1.24	-.017	.004	-.049
$\lambda = 0.50$	0.03	.005	-.001	-.005
$\lambda = 0.55$	2.10	.023	-.008	.032
$\kappa_A = 5.5$	-1.48	-.020	.005	-.056
$\kappa_A = 5.0$	0.03	.005	-.001	-.005
$\kappa_A = 4.5$	2.69	.031	-.009	.039
$\kappa_P = 12$	1.074	.013	-.003	.020
$\kappa_P = 10$	0.03	.005	-.001	-.005
$\kappa_P = 8$	-.0794	-.008	.002	-.034

Notes: We compute compensation, timing of pay, turnover, and expression (17) for values of λ, κ_A, and κ_P nearby a set of parameter values where that the planner solution coincides with the market solution: $r = 0.05$, $\gamma = 0.065$, $\lambda = 0.5$, $\mu = 10$, $\sigma = 5$, $\kappa_A = 5$, and $\kappa_P = 10$.

optimum coincide. In line with our previous discussion, overcompensation, short-termism, and excessive turnover come hand in hand. Moreover, they are more prevalent in environments with higher moral hazard, more limited commitment, and a lower cost of replacing the manager whereas undercompensation, excessive delay in pay, and inefficiently high turnover arise in environments with lower degrees of moral hazard and higher costs of values of κ_A.

Hence, undercompensation, excessive delay in pay, and excessive turnover can arise when managerial incentives are unimportant and labor market frictions are very high. These cases appear to be more relevant to rank-and-file workers in less developed labor markets, in line with the literature on monopsony in labor markets (Dube et al. (2020); Manning (2013)). In all environments with parameter values used in DeMarzo and Sannikov (2006) in which moral hazard is quantitatively important, we obtain equilibrium overcompensation for all values of κ_A for which equilibrium exists.

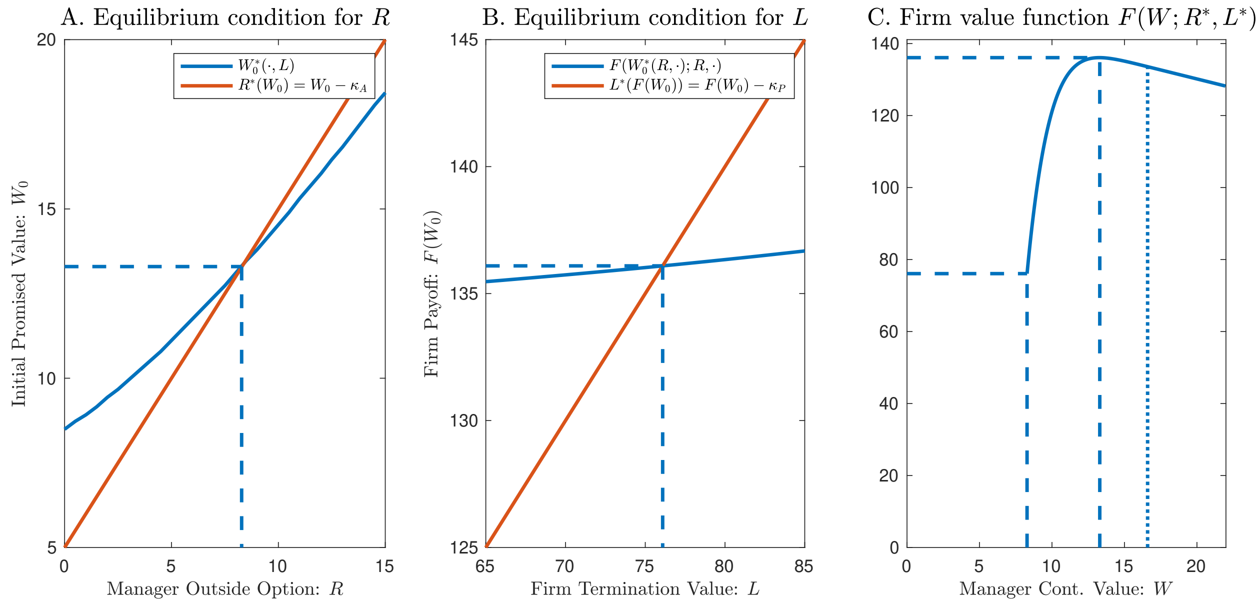
5 Quantitative Analysis

In this section, we assess the quantitative magnitude of the theoretical insights derived in Sections 3 and 4 and we examine comparative statics.

5.1 Equilibrium Overcompensation

For the benchmark economy, we set the parameter values to $r = 0.05$, $\gamma = 0.2$, $\mu = 10$, $\sigma = 5$, $\lambda = 0.5$, $\kappa_A = 5$, and $\kappa_P = 60$. We consider these parameter values to be empirically plausible. For

Figure 1: Equilibrium compensation



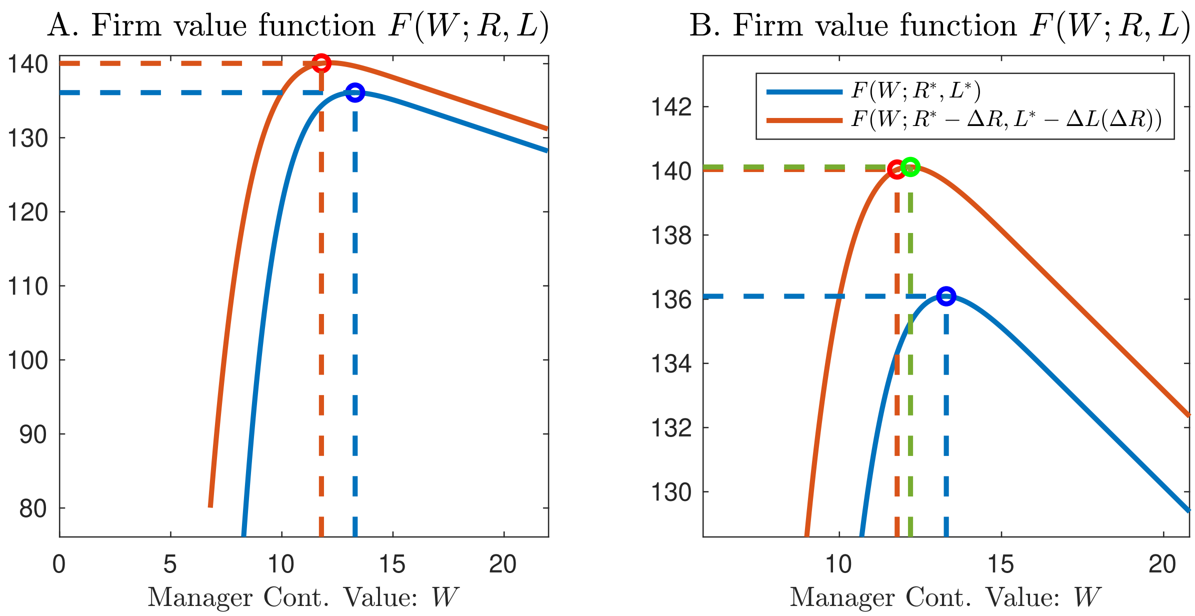
Notes: The parameter values are $r = 0.05$, $\gamma = 0.2$, $\mu = 10$, $\sigma = 5$, $\lambda = 0.5$, $\kappa_A = 5$, and $\kappa_P = 60$. In the competitive equilibrium, the manager's outside option is $R^* = 8.3$, and the firm liquidation value is $L^* = 76.1$. The initial promised value to the manager is $W_0^* = 13.3$, and the firm value at the onset is $F(W_0^*; R^*, L^*) = 136.1$.

instance, the literature has found large costs for shareholders associated with firing CEOs (see Taylor (2010)). Compared to the illustrative example in Table 1 where the equilibrium compensation is close to the social optimum, we focus on an economy in which the manager is more impatient, and the firm's termination cost is much larger. This large termination cost pushes expression (18) in Proposition 3 into the negative region, suggesting excessively high equilibrium compensation, which we elaborate below.

To begin with, we illustrate how the compensation level is determined in equilibrium in Figure 1. Panel A depicts $W_0^*(R, L)$ obtained from (12) and $R^*(W_0)$ obtained from (2). The equilibrium $\{W_0^*, R^*\}$ corresponds to the intersection of these curves. Panel B depicts $F(W_0^*(R, L); R, L)$ obtained from (12) and $L^*(F(W_0))$ obtained from (2), and shows the equilibrium $\{L^*, F(W_0^*)\}$.

In the competitive equilibrium, each firm-manager pair designs a contract taking the outside options as given. Panel C depicts the firm's value function $F(W; R^*, L^*)$ in the competitive equilibrium. The first dashed line corresponds to the equilibrium $\{R^*, L^*\}$. The second dashed line corresponds to the promised value to the manager W_0^* and the value for the firm $F(W_0^*; R^*)$. The dotted line depicts the reflecting boundary $\bar{W}$ for the optimal contract where payments to the

Figure 2: Equilibrium overcompensation



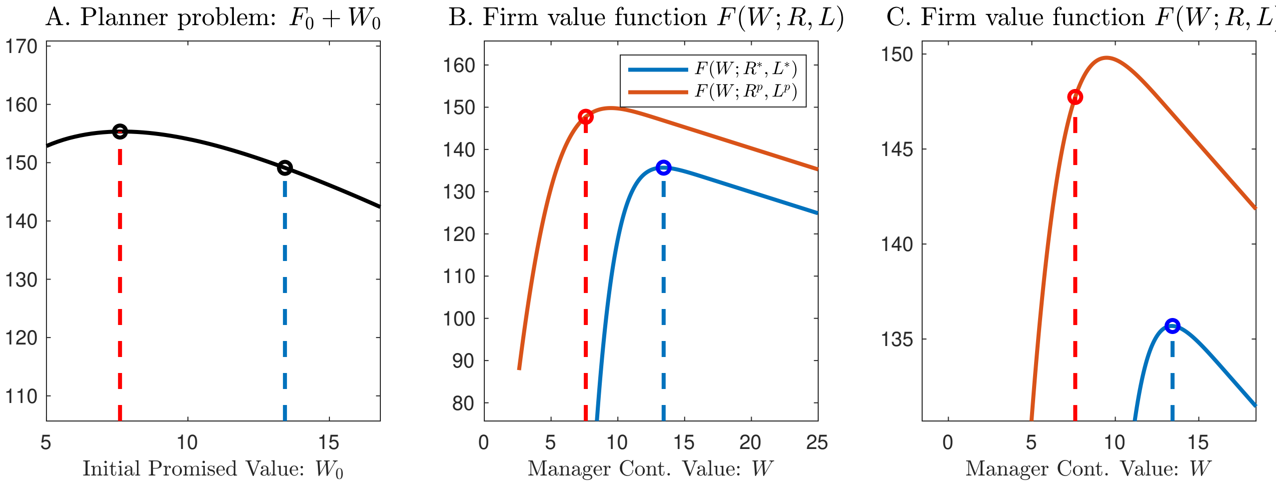
Notes: The parameter values are $r = 0.05$, $\gamma = 0.2$, $\mu = 10$, $\sigma = 5$, $\lambda = 0.5$, $\kappa_A = 5$, and $\kappa_P = 60$. The perturbation to the manager's outside option is $\Delta R = 1.5$. In the competitive equilibrium, the initial value promised to the manager is $W_0^* = 13.3$ (dashed blue line) and the firm value is $F(W_0^*;R^*,L^*) = 136.1$. After the perturbation, the initial value promised to the manager is $W_0^* - \Delta R = 11.8$ (dashed red line) and the firm value is $F(W_0^* - \Delta R; R^* - \Delta R, L^* - \Delta L(\Delta R)) = 140.0$.

manager take place.

The equilibrium features overcompensation, as shown in Figure 2. Panel A depicts the extent to which reducing the competitive equilibrium outside option from R^* to $R^* - \Delta R$ is welfare improving. When the outside option is reduced, the firm's value function $F(W;R^*-\Delta R, L^*-\Delta L)$ (red curve) is shifted upward from the original equilibrium one $F(W;R^*,L^*)$ (blue curve). This perturbation is achieved by reducing the initial promised value to the manager from W_0^* (dashed blue line) to $W_0^* - \Delta R$ (dashed red line). The resulting gain in firm value more than offsets the loss to the manager. That is, $F(W_0^* - \Delta R; R^* - \Delta R, L^* - \Delta L) - F(W_0^*; R^*, L^*) > \Delta R$. Panel B zooms into the plot in panel A to show more clearly that the above inequality holds in this case.

The compensation level under the reduced outside option depicted in Figure 2 is not optimal from the firms' perspective. Since each firm takes outside options as given, it will deviate from $W_0^* - \Delta R$ (dashed red line) and increase the promised value to $W_0^*(R^* - \Delta R, L^* - \Delta L)$ (dashed green line). It will do so in an attempt to generate an additional profit $F(W_0^*(R^* - \Delta R); R^* - \Delta R, L^* - \Delta L) - F(W_0^* - \Delta R; R^* - \Delta R, L^* - \Delta L) > 0$. However, such a gain will not materialize because

Figure 3: Numerical illustration: socially optimal compensation

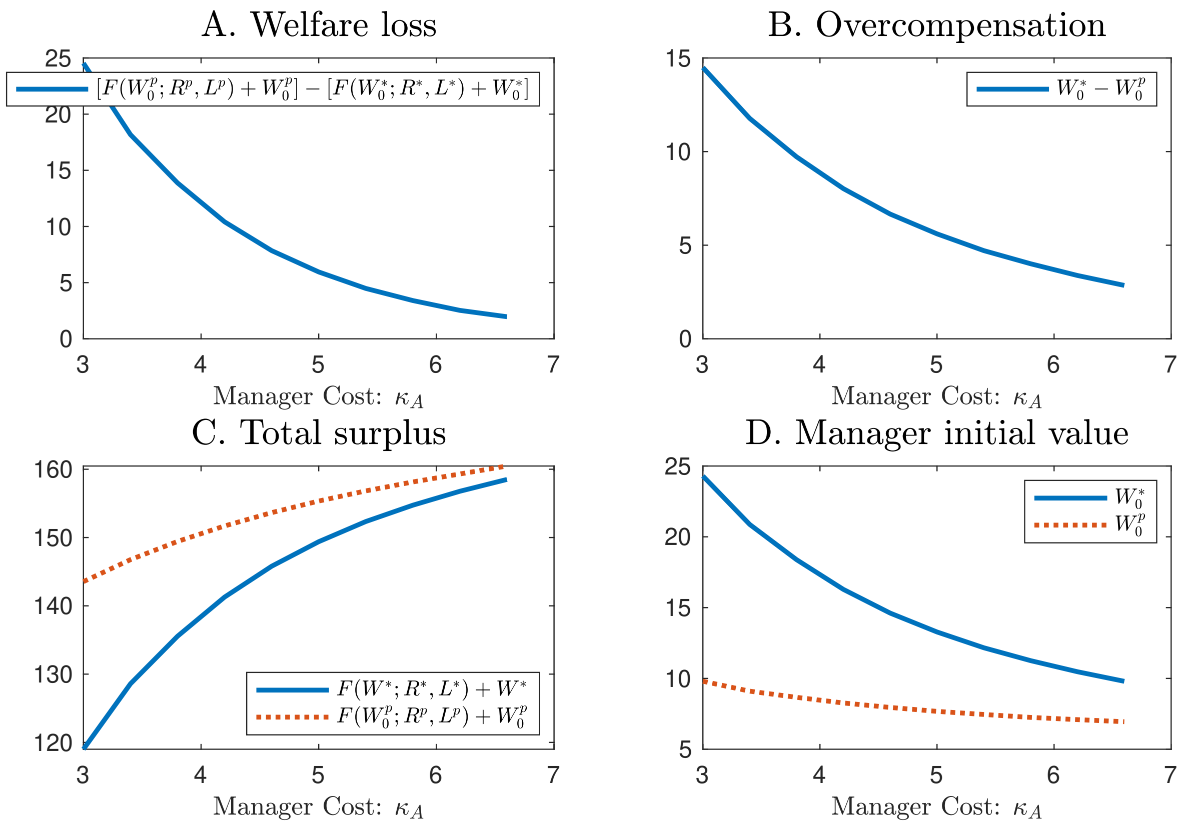


Notes: The parameter values are $r = 0.05$, $\gamma = 0.2$, $\mu = 10$, $\sigma = 5$, $\lambda = 0.5$, $\kappa_A = 5$, and $\kappa_P = 60$. In the competitive equilibrium, the initial value promised to the manager is $W_0^* = 13.3$ (dashed blue line) and the social welfare is $F(W_0^*; R^*, L^*) + W_0^* = 149.4$. In the social optimum, the initial value promised to the manager is $W_0^p = 9.5$ (dashed red line) and the social welfare is $F(W_0^p; R^p, L^p) + W_0^p = 155.3$.

increasing the manager's initial compensation feeds back into the equilibrium outside options R and L. Intuitively, each firm has an incentive to overcompensate its manager in order to improve incentives, because it fails to internalize the equilibrium reduction in welfare arising from a higher outside option R.

Building on this example, Figure 3 illustrates the socially optimal compensation level. Panel A depicts the social welfare as a function of the compensation level, W_0. The maximum is obtained at W_0^p (dashed red line) and yields a social value of $F(W_0^p; R^p, L^p) + W_0^p$. The competitive equilibrium corresponds to an initial value promised to the manager of W_0^* (dashed blue line) with an associated social welfare $F(W_0^*; R^*, L^*) + W_0^*$. The optimal intervention corresponds to a decrease of $W_0^* - W_0^p$ in the manager's initial compensation value. Such a reduction yields an increase in social welfare of $[F(W_0^p; R^p, L^p) + W_0^p] - [F(W_0^*; R^*, L^*) + W_0^*] > 0$. Panel B depicts the respective value functions for the firm in the competitive equilibrium, $F(W; R^*, L^*)$ (blue curve) and in the planner's solution, $F(W; R^p, L^p)$ (red curve). Panel C zooms into panel B for better viewing. These figures complement the analysis on the infinitesimal variation around the competitive equilibrium discussed earlier. Figure 2 shows that reducing the manager's outside option by an amount ΔR improves welfare "locally". Figure 3 illustrates that the "global" welfare optimum is achieved by reducing the manager's outside option by an amount $W_0^* - W_0^p$.

Figure 4: Comparative statics with respect to the termination cost to the manager, κ_A



Notes: The parameter values are $r = 0.05$, $\gamma = 0.2$, $\mu = 10$, $\sigma = 5$, $\lambda = 0.5$, and $\kappa_P = 60$.

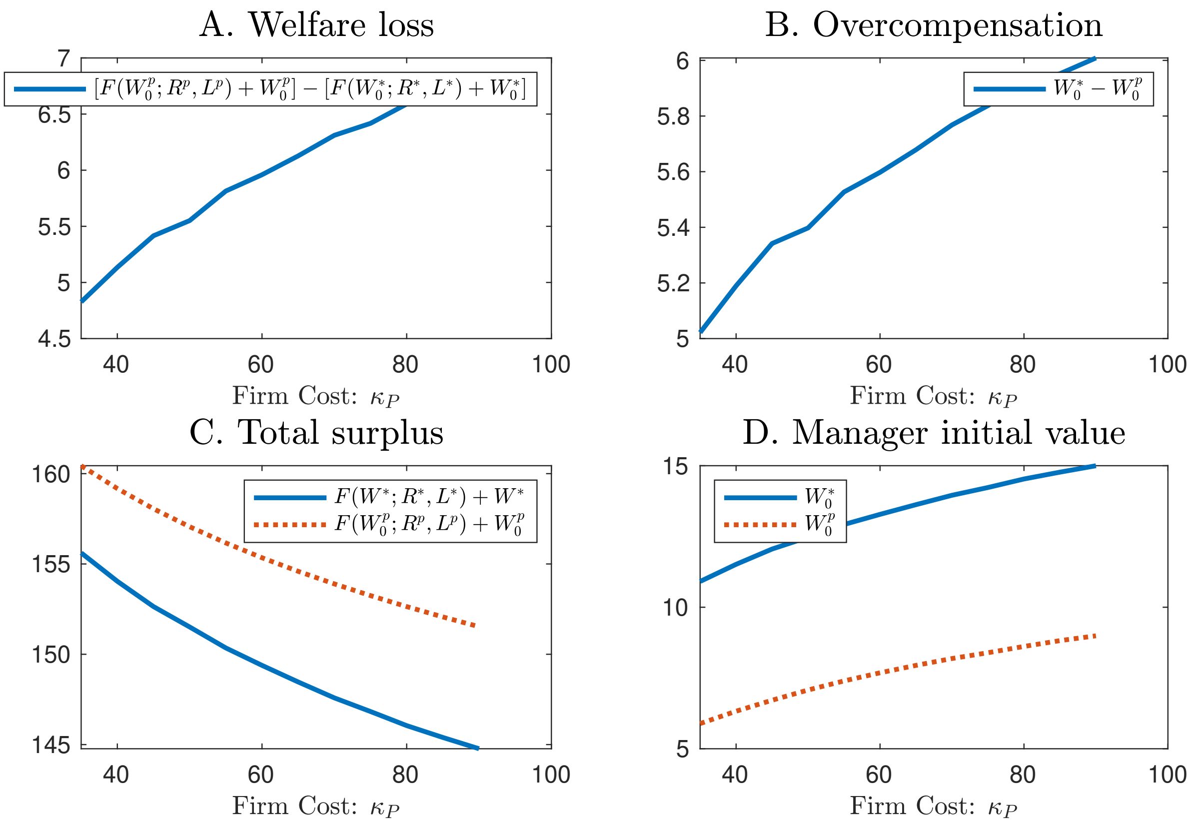
5.2 Comparative Statics on Overcompensation

Next, we explore the parameter space and show regions in which overcompensation is most severe.

Termination Costs κ_A and κ_P

We first explore the asymmetric effect of the termination costs, κ_A and κ_P, on the model's implications. In Figure 4, panel A depicts the welfare gap between the social optimum and the competitive equilibrium: $[F(W_0^p; R^p, L^p) + W_0^p] - [F(W_0^*; R^*, L^*) + W_0^*]$. Panel C shows that welfare in both the competitive equilibrium and the social optimum are increasing in the manager's search cost κ_A, but that the gap between these two is decreasing in κ_A. Increasing κ_A has two effects. On the one hand, it leads to a larger deadweight loss every time a contract is terminated. On the other hand, terminations occur less often because there is "more room" for bad shocks to occur without triggering costly termination (since $W_0 - R = \kappa_A$). In all our numerical simulations, the second

Figure 5: Comparative statics with respect to the firm replacement cost, κ_P



Notes: The parameter values are $r = 0.05$, $\gamma = 0.2$, $\mu = 10$, $\sigma = 5$, $\lambda = 0.5$, and $\kappa_A = 5$.

effect dominates, and social welfare is increasing in κ_A.

Importantly, in the competitive equilibrium, the increment in welfare induced by a larger κ_A is greater. To see why, we note that increasing κ_A reduces the manager's initial compensation but does so more significantly in the competitive equilibrium (panel C). Intuitively, a higher κ_A increases the manager's cost to have his contract terminated; it is "as if" the manager's bargaining power was reduced. Such reduction in bargaining power leads to less overcompensation (panel B) and brings the competitive equilibrium closer to the social optimum. As a result, the welfare gap depicted in panel A is decreasing in κ_A.

Figure 5 explores the role of κ_P on the degree of overcompensation. Panel C shows that increasing κ_P is welfare decreasing because every time a contract is terminated the firm has to pay a higher cost to replace the manager, i.e., termination becomes more inefficient. However, the reduction in welfare is more significant in the competitive equilibrium, leading to a larger welfare gap (panel A). The intuition is the following. A higher κ_P increases the firm's cost to terminate the contract, effectively reducing the firm's bargaining power and leading to more overcompensation (panel B). Hence, the competitive equilibrium will move further away from the social planner's optimum, inducing a larger welfare gap, as seen in panel A.

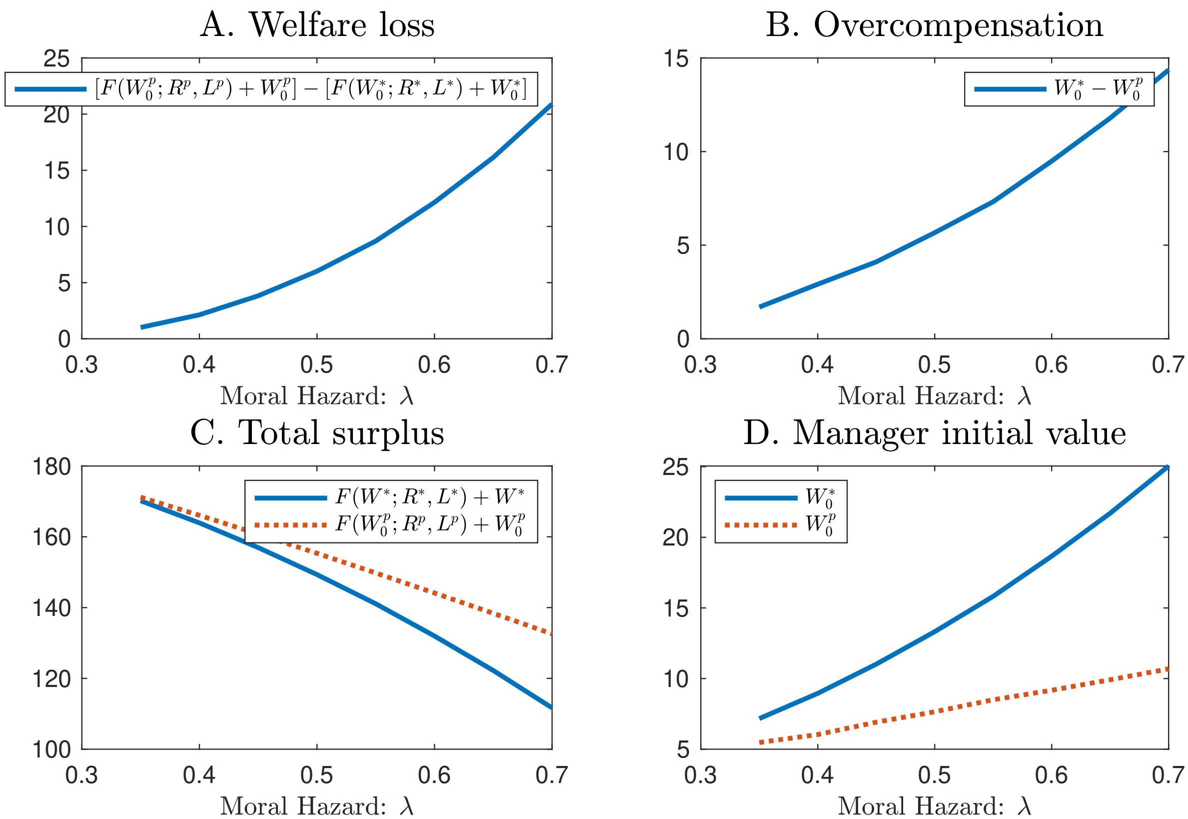
We conclude this section by highlighting the asymmetric roles played by κ_A and κ_P on the magnitude of overcompensation. Both κ_A and κ_P are deadweight losses that lead to costly terminations and are not borne in the first best (in which termination never occurs). However, they have asymmetric effects on the share of the surplus captures by the parties involved. In particular, an increase in κ_A (κ_P) increases the termination cost to the manager (firm) and reduces his (its) share of the surplus.

Our previous analysis generates at least two important empirical implications. First, managerial overcompensation is less prevalent in industries in which it is very costly for managers to match with a new firm. These costs can be search costs or retraining costs due to the specificity of human capital. Second, managerial overcompensation is more prevalent in industries in which replacing the management is very costly for the firms. The costs can be search costs or disruption costs associated with a change in management.

Severity of Moral Hazard λ

As we show, the magnitude of the impact of a manager's compensation on other compensations increases with the severity of the moral hazard problem. Panel A in Figure 6 shows that the welfare gap between the social optimum and the competitive equilibrium is increasing in our proxy for the degree of moral hazard λ. When moral hazard becomes more severe, the firm has to expose the manager to more risk to prevent him from diverting cash flows, which in expectation leads to more inefficient terminations. Thus, welfare is decreasing in the severity of moral hazard (panel B). However, managerial compensation is increasing in λ (panel D). Intuitively, as the severity of moral hazard increases, so does the informational rent to a manager protected by limited liability because the firm has to give the manager more "skin in the game" (i.e., more upside, which is valuable). Such an increase in expected managerial rents is akin to providing the manager with more bargaining power, leading to overcompensation being increasing in λ (panel C). Finally, more overcompensation means that the equilibrium contract is further away from the socially optimal contract, which entails a higher level of externalities as the degree of moral hazard increases (panel A). Our model implies that managerial overcompensation is most severe in industries in which moral hazard is pervasive.

Figure 6: Comparative statics with respect to the severity of moral hazard λ



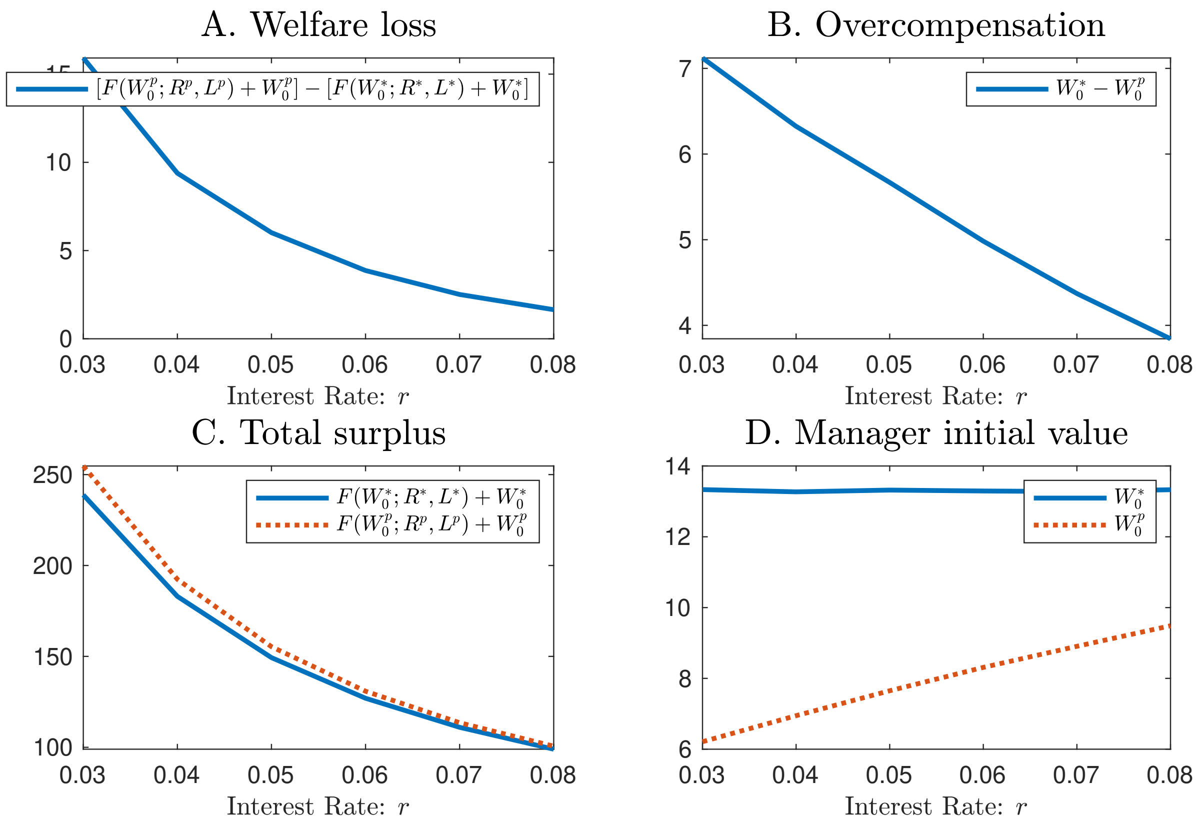
Notes: The parameter values are $r = 0.05$, $\gamma = 0.2$, $\mu = 10$, $\sigma = 5$, $\kappa_A = 5$, and $\kappa_P = 60$.

We conclude this section by mentioning that the comparative statics in our model with respect to the volatility of cash flows σ are identical to those with respect to λ. Higher volatility makes it more difficult for the firm to infer whether the manager is truthfully reporting cash flows or diverting them for his private benefit (i.e., the signal-to-noise ratio worsens as σ increases). Therefore, cash flow volatility is also a measure for the severity of moral hazard. Formally, the equivalence between σ and λ obtains because in our model only the product $\sigma\lambda$, but not the individual values of σ and λ, matters when deriving the optimal contract.

Discount Rates r and γ

We now show that the magnitude of the externality and the degree of overcompensation is decreasing in the firm's discount rate r and increasing in the manager's discount rate γ. Recall that one of the sources of inefficiency in our model comes from the fact that the manager is more impatient than the firm (i.e., $\gamma - r > 0$). Thus, delaying managerial compensation represents a deadweight loss:

Figure 7: Comparative statics with respect to firm discount rate r



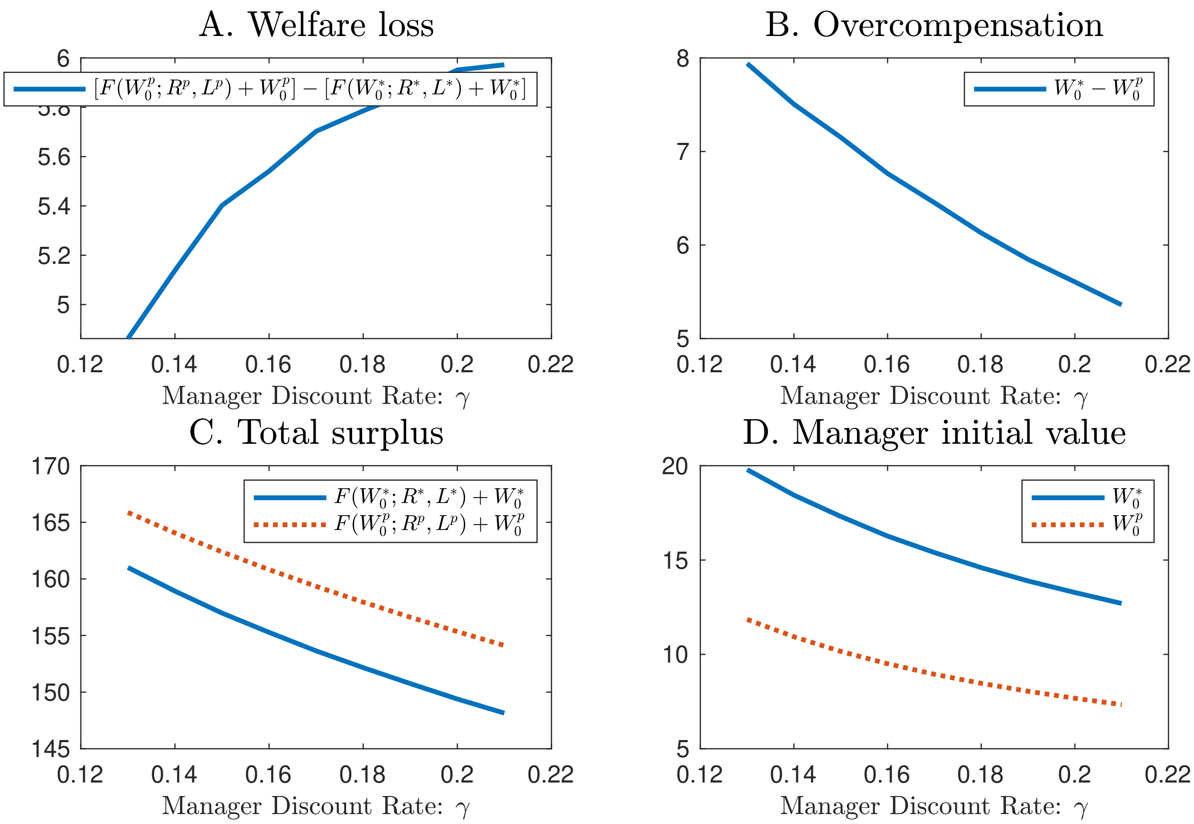
Notes: The parameter values are $\gamma = 0.2$, $\mu = 10$, $\sigma = 5$, $\lambda = 0.5$, $\kappa_A = 5$, and $\kappa_P = 60$.

note how panel C in Figure 7 shows that total welfare is decreasing in r for both the competitive equilibrium as well as the social optimum. Because in the competitive equilibrium the agents fail to internalize the general equilibrium effect of the outside options on the sources of inefficiency, it is intuitive that when the potential inefficiencies are larger (i.e., when r is small relative to γ), the magnitude of the externality will be larger (panel A).

Moreover, as r increases it is less costly to increase the promised value to the manager (and postpone compensation). Hence, the manager's initial value is increasing in r, as seen in panel C. Because the planner internalizes the reduction in inefficiency from a larger r, the manager's compensation grows faster in r than in the competitive equilibrium, thereby leading to overcompensation being decreasing in r (panel B). Our model implies that managerial overcompensation is most severe during periods in which interest rates are low.

Figure 8 depicts comparative statics with respect to the manager's discount rate γ. Greater managerial impatience leads to more inefficiency making total welfare decreasing in γ, as seen in

Figure 8: Comparative statics with respect to manager discount rate γ



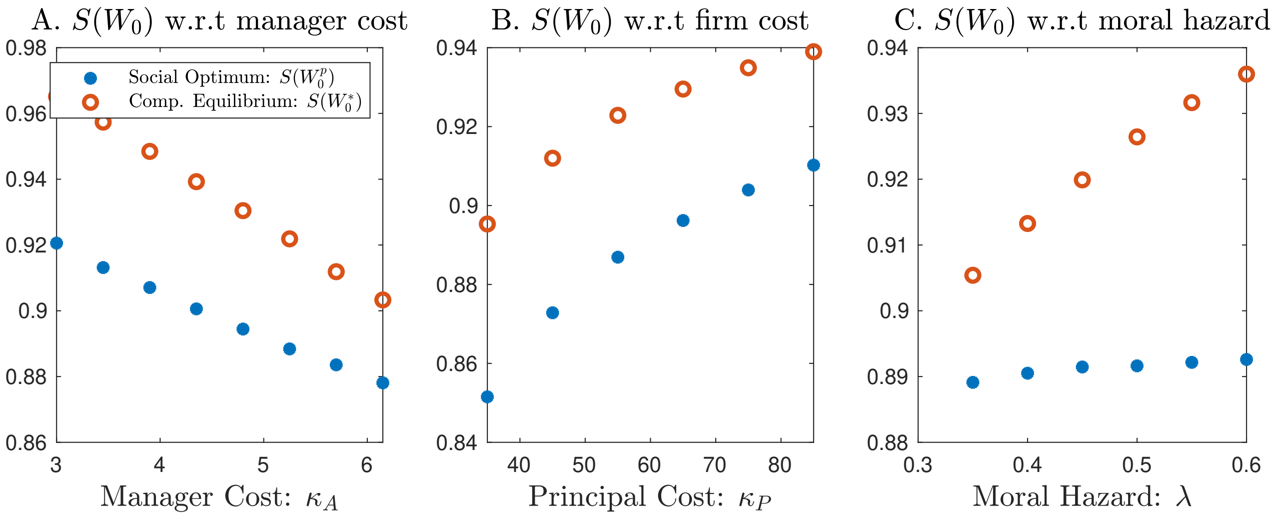
Notes: The parameter values are $r = 0.05$, $\mu = 10$, $\sigma = 5$, $\lambda = 0.5$, $\kappa_A = 5$, and $\kappa_P = 60$.

panel C. Such an increase in inefficiency is not fully internalized in the competitive equilibrium, thereby leading to a larger externality as γ increases (panel A). Moreover, a larger γ makes it more costly for the firm to delay managerial compensation, rendering it optimal to reduce the initial promised value to the manager, as seen in panel D. Finally, because the initial promised value tends towards zero as γ increases in both the competitive equilibrium and the social optimum, overcompensation is also decreasing in γ (panel B).

5.3 Equilibrium Short-Termism, Turnover, and Entrenchment

We now illustrate the insights in Proposition 4 that overcompensation and short-termism come hand in hand. Recall that we use $S(W_0)$ as a measure of timing of pay in the manager's incentive package. Figure 9 compares the degree of short-termism of the equilibrium contract (red circles) to the contract chosen by the social planner (blue dots). Unsurprisingly, given equilibrium over-

Figure 9: Comparative statics for short-termism



Notes: The baseline parameter values are $r = 0.05$, $\gamma = 0.2$, $\mu = 10$, $\sigma = 5$, $\lambda = 0.5$, $\kappa_A = 5$, and $\kappa_P = 60$.

compensation $W_0^* > W_0^p$, the competitive equilibrium also unambiguously displays short-termism, $S^*(W_0^*) > S^p(W_0^p)$. Moreover, we find that, when equilibrium overcompensation worsens, the equilibrium short-termism also tends to worsen relative to the social optimum.

Panel A shows that, as the manager's termination cost κ_A increases, pay occurs later in both the competitive equilibrium and the social optimum. Recall that in Figure 4, as κ_A increases, the initial value promised to the manager decreases. Since it is less costly to postpone a smaller value promised to an impatient manager, the firm and the planner both find it optimal to reduce the amount of front-loading on the manager's compensation package. Further, as the gap between the equilibrium compensation and the socially optimal compensation narrows, the discrepancy in timing of pay also narrows.

In contrast, panel B shows that, as the firm's termination cost κ_P increases, pay occurs sooner. Intuitively, when the firm finds it harder to replace the manager, it has to promise him a large initial value. Thus, it is optimal to pay the manager earlier, i.e., increase front-loading. In this case, it is unclear whether the gap between the equilibrium and the socially optimal timing of pay is narrowing or widening.

Finally, panel C shows that the degree of short-termism is increasing in the severity of moral hazard λ. As λ increases, the information rents for the manager increase, thereby increasing his promised value W_0, and rendering it optimal to increase front-loading. As we showed in Figure 6, with more severe moral hazard, the degree of equilibrium overcompensation worsens. Consistently, so does the extent of equilibrium short-termism.

We proceed to show that overcompensation and inefficiently low turnover also come hand in hand. To that end, we recall $T(W_0)$, our measure for the turnover rate. Consistent with Proposition 4, Figure 10 shows that, apart from overcompensation, the equilibrium also displays an inefficiently low turnover rate compared to the social optimum, i.e., $T^*(W_0^*) < T^p(W_0^p)$. Moreover, when the extent of overcompensation worsens, so does the excessively low turnover in equilibrium relative to the social optimum.

Panel A shows that turnover increases as the manager's search cost increases both in the competitive equilibrium and the social optimum. This is consistent with our analysis in Section 4.3: as the manager's search cost increases, the initial compensation level decreases, implying a lower upward drift and a higher likelihood of hitting termination. Panel B shows that turnover decreases with the firm's termination cost. Since higher κ_P increases the initial promised value for the manager, his continuation value has a higher upward drift, hence lowering turnover. Finally, panel C depicts comparative statics for turnover with respect to the degree of moral hazard. On the one hand, higher moral hazard increases compensation, which in turn reduces turnover. On the other hand, the volatility of the manager's promised value is increasing in λ, which increases the probability of hitting the termination boundary. The second effect dominates in our numerical results, making turnover increasing in λ.

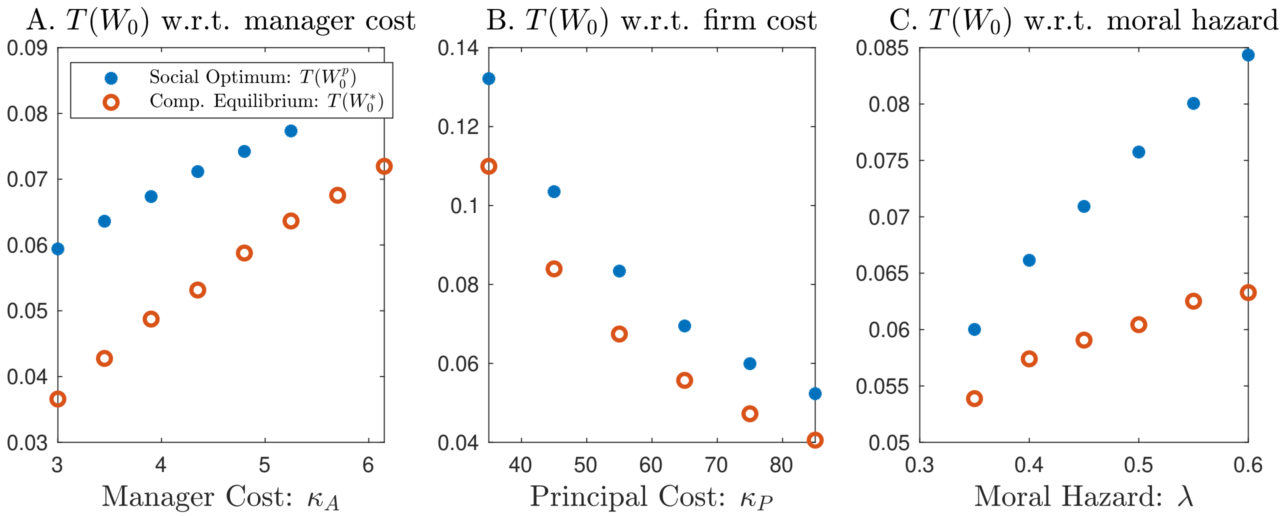
6 Policy Response

As discussed above, the equilibrium contract, which can be implemented with inside equity relinquished upon termination, features inefficiencies in pay levels, the timing of pay, and turnover. In this section, we study welfare-improving policy responses.

Specifically, taxing the managerial compensation package may be implemented by the social planner. Taxes apply beyond the exercise or vesting of options and bonuses. So one possible policy response is to have shareholders pay taxes on such compensation packages. Section 6.1 examines such taxation.[12] In contrast, compensation subsidies can be used as a policy response when there is undercompensation for workers with a low λ and a high κ_A.

[12] Setting an upper bound on the initial compensation package $W_0 \leq W_0^p$ can theoretically be used to implement first best, but such a policy response requires the policymaker to know all model parameters, which makes it hard to implement in practice.

Figure 10: Comparative statics for turnover



Notes: The baseline parameter values are $r = 0.05$, $\gamma = 0.2$, $\mu = 10$, $\sigma = 5$, $\lambda = 0.5$, $\kappa_A = 5$, and $\kappa_P = 60$.

We then move on to propose an alternative policy response in the form of transfer fees paid to the firm when a contract is terminated and the manager moves to another firm (Section 6.2). Again, this transfer fees can be negative and take the form of firing fees when undercompensation, excessive delay in pay, and excessive turnover arise. Both policy responses examined in this section implement the social optimum as a competitive equilibrium in which shareholder value is maximized.

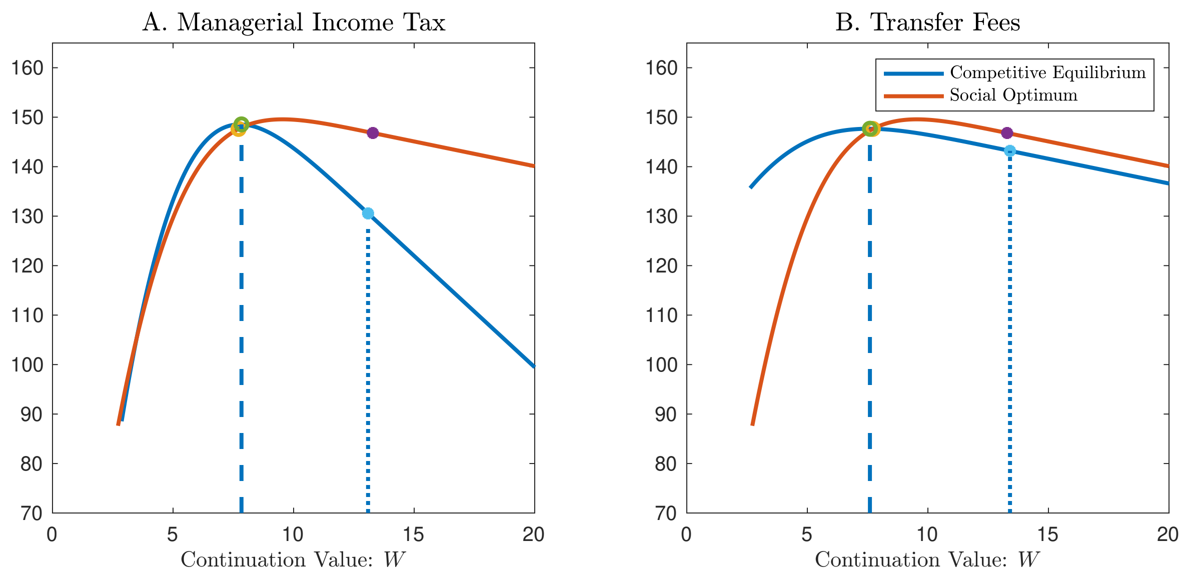
6.1 Taxing Managerial Compensation

In this subsection, we consider a tax-based policy response to tackle overcompensation and excessive managerial tenure that consists of two instruments: a state dependent corporate tax and a tax on managerial compensation. Specifically, the firms are taxed at a rate α_0 on their profits but receive a flow subsidy $\alpha_1 W$. In addition, the firm pays \$$\alpha_I$ to the government for every dollar the manager is paid. In the sequel, we only consider budget neutral interventions, i.e., taxes and subsidies exactly offset each other out. The firm's objective function under this alternative policy becomes:

$$\mathbb{E}\left[\int_0^\tau e^{-rt}((1-\alpha_0)dY_t + \alpha_1 W_t - (1+\alpha_I)dC_t) + e^{-r\tau}L\right].$$

Panel A in Figure 11 depicts the planner solution (red curve) and the competitive equilibrium attained under this policy response (blue curve). Intuitively, taxing the firm for every dollar paid to the manager $\alpha_I > 0$ reduces overcompensation as it increases the cost of offering a generous

Figure 11: Policy Responses



Notes: The parameter values are $r = 0.05$, $\gamma = 0.2$, $\mu = 10$, $\sigma = 5$, $\lambda = 0.5$, $\kappa_A = 5$, and $\kappa_P = 60$.

compensation package. Moreover, providing the firm with a subsidy when the value promised to the manager is large $\alpha_1 W > 0$ encourages the firm to delay managerial payout, thus addressing short-termism. Together, these instruments exactly implement the planner's compensation contract Γ^p as a competitive equilibrium.

Conversely, when λ is so low and κ_A is so high that undercompensation and excessive turnover obtain, appropriate income subsidies can implement the planner's compensation contract as a competitive equilibrium. In practice, these subsidies could be implemented as earned income tax credits (see e.g., Eissa and Liebman (1996); Dahl and Lochner (2012)).

6.2 Transfer Fees

Since the inefficiencies inherent to overcompensation, short-termism, and excessive tenure increase with the termination cost to the firm and decrease with the termination cost to the manager, one type of policy response includes schemes that make termination more costly to managers and/or less costly to firms while accommodating the intermittent payouts obtained in our model.

We now consider a policy response that consists of two instruments: a state dependent corporate tax and a transfer fee. Specifically, the firm is subject to a corporate tax rate α_0, but it receives a per period subsidy $\alpha_1 W$. The proceeds of these taxes are used to pay for a transfer fee ϕ paid to the firm upon termination of the manager's contract. Thus, this intervention is budget neutral. The firm's objective function under this policy becomes:

$$\mathbb{E}\left[\int_0^\tau e^{-rt}((1-\alpha_0)dY_t + \alpha_1 W_t - dC_t) + e^{-r\tau}(L+\phi)\right].$$

Panel B in Figure 11 depicts the planner's solution (red curve) and the competitive equilibrium attained under this policy response (blue curve). This intervention implements the social optimum by delivering the same utility for both firms and managers as in the planner's problem. The intuition for the rationale behind this intervention is as follows. Providing the firm with a transfer fee $\phi > 0$ reduces overcompensation as the firm is less concerned about termination and therefore offers less generous initial compensation packages to the manager. Granting the firm a subsidy $\alpha_1 W > 0$ when the value promised to the manager is large induces the firm to delay managerial payout, thus addressing short-termism. Together, these instruments implement the planner's compensation contract Γ^p as a competitive equilibrium. Finally, α_0 is chosen to ensure the total cost of the policy response is zero (i.e., budget neutral).

We note that our proposed fees resemble those observed in professional sports leagues. For example, European men soccer leagues have transfer fees. La Liga, in particular, features transfer fees given by the new club to the player which in turn pays the club he leaves, while in the Premier League, they are paid by the new club. Similarly, our state dependent corporate tax provides incentives to corporations for delaying managerial compensation until their inside equity is sufficiently large. In practice, that could be implemented via tax breaks for compensation packages with sufficiently long vesting periods, or tax breaks rewarding large inside ownership.

Conversely, when undercompensation arises and firms terminate contracts too soon in jobs with low values of λ and high values of κ_A, the planner would like to reduce the value of κ_A and possibly increase the value of κ_P. This can be achieved by taxing contract termination as well a corporate tax subsidy α_0 and a per period tax $\alpha_1 W$.

7 Extensions and Robustness

7.1 Bargaining Power

A distinctive feature of our analysis is that overcompensation, short-termism, and excessive tenure arise for nearly all parameter values as long as λ is not too small (and κ_A not too large) while firms make take-it-or-leave-it contract offers to managers. That is, managers can extract rents through their ability to divert cash, but not in negotiating compensation contracts with firms. One may expect our effects to be quantitatively larger when managers have bargaining power in designing their compensation contract.

We examine this issue by extending our baseline setting in allowing the surplus generated by the match between firms and managers to be split according to a simple bargaining rule. Specifically, we denote $\beta \in [0, 1]$ the firm's share of the surplus, or the firm's bargaining power, and $1 - \beta$ the manager's bargaining power. Such a split can be achieved with a simple asymmetric Nash bargaining game. Formally, the optimal contract solves

$$\max_{\Gamma, W_0} (F_0(Y; \Gamma) - L)^{\beta} (W_0 - R)^{1-\beta} \tag{20}$$

subject to (PK), (IC), and (PC). This extension embeds our baseline case when the firm has all the bargaining power, i.e., $\beta = 1$. The objective in problem (1) is a special case of the one in (20).

We now characterize the role played by bargaining powers on the equilibrium compensation, short-termism, and tenure. Formally,

Lemma 2 (Bargaining)**.** *Under Nash bargaining, the equilibrium level of compensation W_0^* is characterized by*

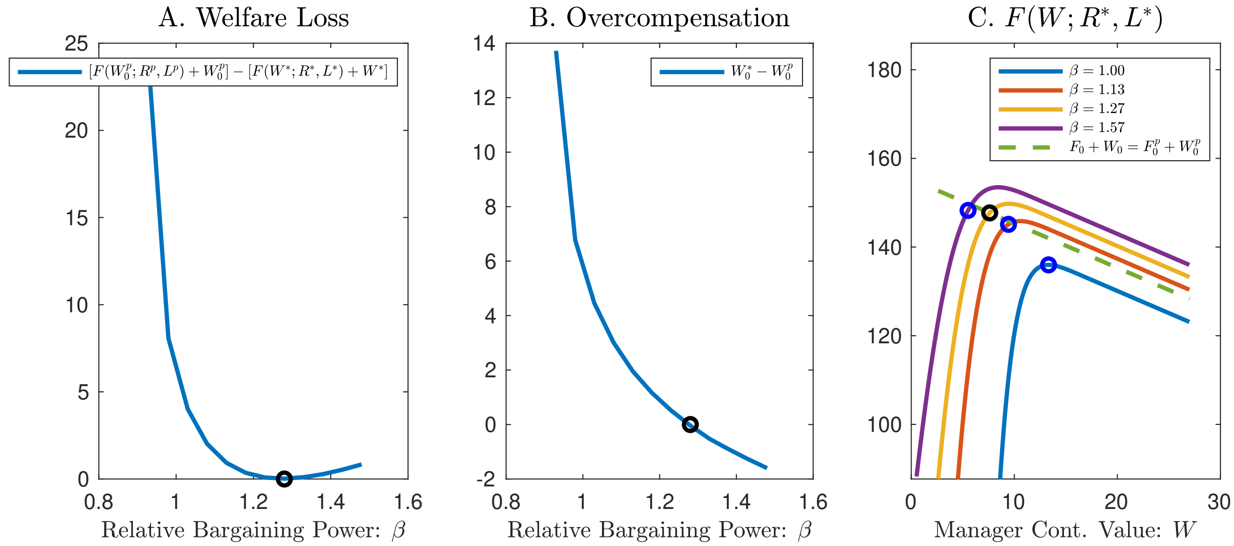
$$F'(W_0^*; R^*, L^*) = -\frac{1-\beta}{\beta} \frac{\kappa_P}{\kappa_A}. \tag{21}$$

Panel A of Figure 12 depicts comparative statics of the welfare gap between the social planner's problem and the competitive equilibrium $[F(W_0^p; R^p, L^p) + W_0^p] - [F(W^*; R^*, L^*) + W^*]$ for different values of β. Panel B depicts the respective gap in initial managerial compensation $[W^* - W_0^p]$ (i.e., the extent of overcompensation).

There are two key insights. First, overcompensation, short-termism, excessive tenure, and the welfare gap all decrease with β on the interval $[0, 1]$. This result is intuitive. Increasing the firm's bargaining power β allows firms to extract a larger fraction of the surplus and reduce managerial compensation W^*. As a result, the outside option R^* is reduced, thereby leading to efficiency gains: i) earlier termination and ii) higher deferral in compensation.

Second, increasing β beyond its natural upper bound 1 shows that overcompensation $[W^* - W_0^p]$ continues to decline and can even lead to under-compensation. Moreover, there is a value for β (circled dot in the graph) when the social planner's objective function coincides with the competitive equilibrium. Interestingly, this implies that the social optimal corresponds to a (fictional)

Figure 12: Comparative statics with respect to bargaining power β



Notes: The parameter values are $r = 0.05$, $\gamma = 0.2$, $\mu = 10$, $\sigma = 5$, $\lambda = 0.5$, $\kappa_A = 5$, and $\kappa_P = 60$.

competitive equilibrium in which firms have more than 100% bargaining power (i.e., $\beta > 1$). This is consistent with our main result that managers can be overcompensated even when they have zero bargaining power, and therefore the social optimum could only be obtained if managers had negative bargaining power.

Panel C complements this analysis by depicting comparative statics of the firm value function in the competitive equilibrium $F(W^*; R^*, L^*)$ for four different values of β. The dashed green line depicts the indifference curve that attains the planner's maximum, and which coincides with the allocation obtained in a competitive equilibrium featuring more than 100% bargaining power for the firm (solid yellow line).

Conversely, when low values of λ (and high values of κ_A) generate undercompensation, excessive delay in compensation, and excessive contract terminations, decreasing the firm's bargaining power reduce these three types of inefficiencies as well as the welfare gap.

7.2 Firms Internalizing Endogenous Liquidation Value

Of course, the inefficiencies that arise in the competitive equilibrium are due to firms' inability to cooperate. We now relax this assumption and consider an alternative contracting process in which firms can coordinate among their contracts. When contracting with its current manager at time zero, the firm can foresee that the liquidation value it can obtain at termination depends on its contract with the next replacing manager in the future. Given the firm has commitment power, it is natural that the firm internalizes the effect of its own contracts and optimally designs its current contract and future contracts simultaneously at time zero. Formally, in problem (1), in addition to the (PK), (IC), and (PC), the firm takes into account the endogenous liquidation value according to condition (3).

Despite the additional consideration that the firm accounts for, it turns out that the equilibrium characterized in Proposition 1 absent the consideration for the endogenous liquidation value is exactly unchanged, as the following proposition describes.

Lemma 3 (One-Sided Coordination)**.** *When the firm accounts for its endogenous liquidation value, the equilibrium level of compensation* W_0^* *is also characterized by equation* (12)*.*

The intuition for Proposition 3 is straightforward. In our baseline bilateral contracting problem, when the firm maximizes its value by considering the direct effect of the compensation level, i.e., $F'(W_0^*; R^*, L^*) = 0$, the equilibrium response of the liquidation value is zero: $\frac{\partial L}{\partial W} = \frac{F'(W^*;R^*,L^*)}{1-\frac{\partial}{\partial L}F(W^*;R^*,L^*)} = 0$. Thus, the indirect effect of endogenous liquidation value in response to changes in compensation level on firm value is zero. We conclude that, even when forward-looking firms can coordinate among its contracts, the same inefficiency as in the baseline economy arises in the competitive equilibrium. Crucially, the inefficiency remains because firms still fail to internalize the effect of their contracts on the manager's outside option, an insight also highlighted by Bloch and Gomes (2006).

8 Conclusion

Our analysis is motivated by the growing debate in academic and economic policy circles around the explosion of managerial compensation over the last three decades while average worker pay has remained essentially flat (Frydman and Saks (2010)) and whether overcompensation, short-termism and excessive tenure are inherent to managerial incentives, which have been argued to be due to managerial bargaining power (Bebchuk and Fried (2003); Edmans et al. (2017)). To that end, we develop a general equilibrium model featuring dynamic moral hazard and matching frictions in a model in which firms can make take-it-or-leave-it contract offers to managers. Our main result states that the laissez-faire equilibrium, i.e., the competitive equilibrium, displays excessively high and short-term managerial compensation and excessive managerial tenure compared to the socially optimal benchmark, i.e., the allocation chosen by a social planner. Because each firm-manager pair chooses an optimally private contract, it fails to internalize its effect on the outside option on other firm-manager pairs in the economy. In particular, each firm mitigates managerial moral hazard by aligning the manager's interest with its shareholders via a larger share of the surplus. This mechanism induces larger compensation packages and equilibrium outside options for managers in the economy, which in turn generates excessively short-term compensation, excessive managerial tenure, and, as a result, a deadweight loss.

Our paper shows that these inefficiencies due to the overcompensation externality hold even when firm's shareholders make a take-it-or-leave-it contract offer to the manager, i.e., our results do not rely on assuming weak corporate governance. Inefficiencies are most prominent when interest rates are low, shareholders have little bargaining power, and idiosyncratic volatility is high. All of these forces may have contributed to exacerbating overcompensation and short-termism over the past decades. In our model, the optimal contractual response features a form of inside equity that is returned to the firm when the manager leaves for another one. In addition, efforts to strengthen corporate governance that both increase shareholder bargaining power and mitigate the severity of moral hazard brought upon by higher idiosyncratic risk will result in a smaller welfare gap. However, the benefits of stronger corporate governance are not fully internalized by individual firms. Thus, policies designed to help firms coordinate on lower managerial pay are needed in order to increase social welfare. This can be achieved, for example, via taxes and transfer fees.

The current manuscript suggests a number of avenues for future research. Will the inefficiencies we highlight generate excessively high and short-term investment in both tangible and intangible assets? If managers can take actions whose consequence can only be observed in the distant future, will the competitive equilibrium feature excessive short-termism? If firms and managers could engage in risk-taking activities, e.g., in the financial industry, will the competitive equilibrium feature more risk-taking than is socially optimal? What are the general equilibrium effects of the equilibrium provision of incentives in asset pricing and asset allocation models with limited arbitrage (Gromb and Vayanos (2002, 2018))? Moreover, what are the appropriate policy interventions that are granted in these realistic scenarios?

A Proofs

A.1 Proof of Lemma 1 and Corollary 1

See Proposition 1 in DeMarzo and Sannikov (2006).

A.2 Proof of Proposition 1 and Corollary 2

We define the initial compensation for a given pair of outside options $(R, L) \in [0, \frac{\mu}{\gamma}] \times [0, \frac{\mu}{r}]$ in the partial equilibrium:

$$W_0(R, L) = \underset{W}{\operatorname{argmax}}\, F(W; R, L).$$

This function and the corresponding peak firm value feature the following comparative statics:

$$\frac{\partial}{\partial R} W_0(R, L) > 0 \quad \text{and} \quad \frac{\partial}{\partial L} W_0(R, L) < 0$$
$$\frac{\partial}{\partial R} F(W_0(R, L); R, L) < 0 \quad \text{and} \quad \frac{\partial}{\partial L} F(W_0(R, L); R, L) > 0.$$

Existence. We define a function $z(L) : [0, \frac{\mu}{r}] \to \mathbb{R}$:

$$z(L) = F(W_0(0, L); 0, L) - \kappa_P - F(W_0(0, L) - \kappa_A; 0, L),$$

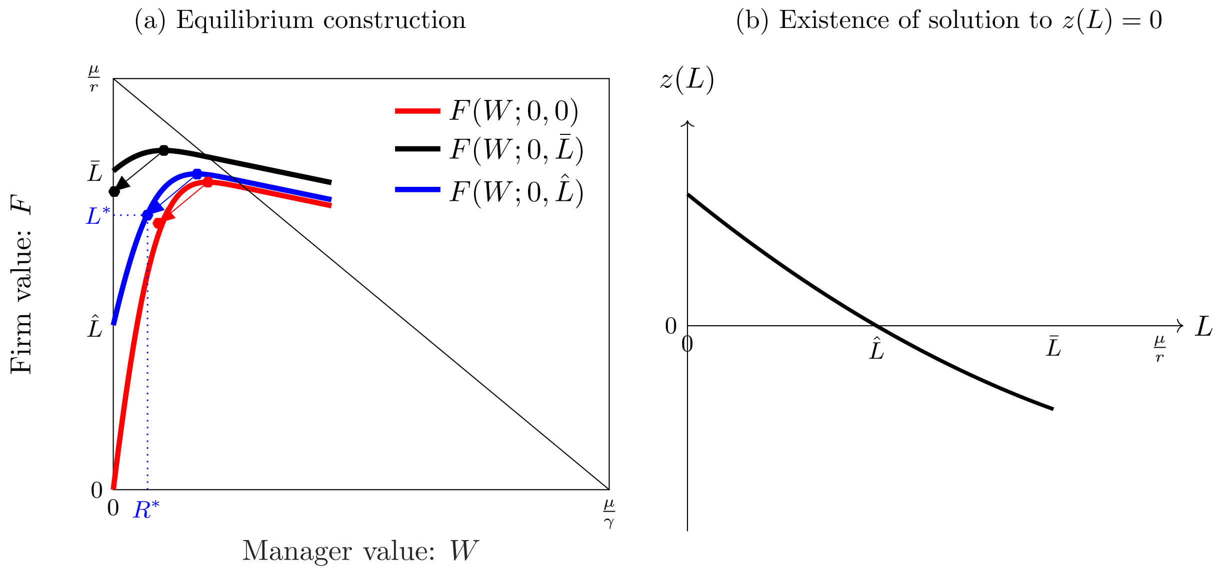
which computes the discrepancy between the firm's outside option $F(W_0(0, L); 0, L) - \kappa_P$ and its liquidation value $F(W_0(0, L) - \kappa_A; 0, L)$ for a given L. By continuity of $F(W_0(0, L); 0, L)$ and $F(W_0(0, L) - \kappa_A; 0, L)$, we obtain that $z(L)$ is also continuous in L.

Assumption 1 implies that $z(0) \geq 0$ and $z(\bar{L}) \leq 0$. Together, they ensure that there exists some $\hat{L} \in [0, \bar{L}]$ such that $z(\hat{L}) = 0$. It follows that

$$F(W_0(0, \hat{L}); 0, \hat{L}) - \kappa_P = F(W_0(0, \hat{L}) - \kappa_A; 0, \hat{L}).$$

Let $R^* \equiv W_0(0, \hat{L}) - \kappa_A$ and $L^* \equiv F(R^*; 0, \hat{L})$. We have $R^* \geq W_0(0, \bar{L}) - \kappa_A = 0$ and $L^* \geq \hat{L} \geq 0$. Note that the pair of outside options (R^*, L^*) delivers the same firm value function as $(0, \hat{L})$, i.e., $F(W; R^*, L^*) = F(W; 0, \hat{L})$. Specifically, they lead to the same peak point in firm value. That is, $W_0(R^*, L^*) = W_0(0, \hat{L})$ and $F(W_0(R^*, L^*); R^*, L^*) = F(W_0(0, \hat{L}); 0, \hat{L})$. In addition, the liquidation values also coincide: $F(R^*; R^*, L^*) = F(R^*; 0, \hat{L})$. Thus, the general equilibrium

Figure 13: Illustration of equilibrium existence



conditions (2) and (3) must hold at (R^*, L^*):

$$R^* = W_0(R^*, L^*) - \kappa_A$$
$$L^* = F(W_0(R^*, L^*); R^*, L^*) - \kappa_P.$$

We conclude that (R^*, L^*) forms the basis for a competitive equilibrium.

Uniqueness. To show that the equilibrium is unique, we first show the following result:

Lemma 4. *Let $F(W; R, L)$ and $G(W; R', L')$ be two solutions of (7) and (9) such that $F(W) > G(W)$, then $F'(\bar{W}_F + \Delta) \leq G'(\bar{W}_G + \Delta)$ for all $\Delta \leq 0$.*

Proof. We start by differentiating equation (7) twice to obtain that $F''''(\bar{W}) = -\gamma \bar{W}(\gamma - r)(\frac{2}{\sigma^2})^2 < 0$. Taking a Taylor expansion for F and G around $\bar{W}_F$ and $\bar{W}_G$ respectively, implies that $F'(\bar{W}_F - \epsilon) < G'(\bar{W}_G - \epsilon)$, since $\bar{W}_F < \bar{W}_G$. Now, suppose for a contradiction that there exists $\Delta < 0$ such that $F'(\bar{W}_F + \Delta) \geq G'(\bar{W}_G + \Delta)$. Pick the largest such Δ, which implies that $F''(\bar{W}_F + \Delta) < G''(\bar{W}_G + \Delta)$. We now recall equation (9) which implies that:

$$F(\bar{W}_F + \Delta) - G(\bar{W}_G + \Delta) > (\bar{W}_G - \bar{W}_F)\frac{\gamma}{r}. \tag{22}$$

On the other hand, evaluating (7) at $\bar{W}_F + \Delta$ and $\bar{W}_G + \Delta$ respectively for F and G yields:

$$
\begin{aligned}
F(\bar{W}_F + \Delta) - G(\bar{W}_G + \Delta) &= (\bar{W}_F - \bar{W}_G)\frac{\gamma}{r}F'(\bar{W}_F + \Delta) + \frac{\sigma^2}{2r}(F''(\bar{W}_F + \Delta) - G''(\bar{W}_G + \Delta)) \\
&\leq (\bar{W}_F - \bar{W}_G)\frac{\gamma}{r}F'(\bar{W}_F + \Delta) \leq (\bar{W}_G - \bar{W}_F)\frac{\gamma}{r},
\end{aligned}
$$

which is a contradiction to (22).

□

Suppose that there are two distinct competitive equilibria denoted by (R_F, L_F) and (R_G, L_G), in which the respective firm value functions are $F(W)$ and $G(W)$. Without loss of generality assume that $F(W_0^F) > G(W_0^G)$, where $F'(W_0^F) = G'(W_0^G) = 0$, which combined with the fact that F and G solve equation (7) implies that $0 > F''(W_0^F) > G''(W_0^G)$. Since $F(W_0^F) - F(R_F) = G(W_0^G) - G(R_G) = \kappa_P$, then there exists $-\kappa_A < \Delta < 0$ such that $F'(W_0^F + \Delta) = G'(W_0^G + \Delta)$. Picking the largest such Δ, implies that $F''(W_0^F + \Delta) < G''(W_0^G + \Delta)$. Moreover, we must have that:

$$
F(W_0^F + \Delta) - G(W_0^G + \Delta) > F(W_0^F) - G(W_0^G). \tag{23}
$$

Evaluating equation (7) at the respective W_0 and $W_0 + \Delta$ for F and G and substituting in (23) implies that:

$$
\frac{\gamma}{r}(W_0^F - W_0^G)F'(W_0^F + \Delta) + \frac{\sigma^2}{2r}(F''(W_0^F + \Delta) - G''(W_0^G + \Delta)) > \frac{\sigma^2}{2r}(F''(W_0^F) - G''(W_0^G)),
$$

which further implies that $W_0^F > W_0^G$.

Now recall that $F'(\bar{W}_F) = G'(\bar{W}_G) = -1$ and $F'(W_0^F) = G'(W_0^G) = 0$, which combined with Lemma 4 imply that:

$$
\bar{W}_F - W_0^F > \bar{W}_G - W_0^G \quad \Rightarrow \quad \bar{W}_F > \bar{W}_F - (W_0^F - W_0^G) > \bar{W}_G.
$$

However, recall that $F(W_0^F) > G(W_0^G)$, and since the payout thresholds must satisfy (9), and trajectories cannot cross, then we must have $\bar{W}_F < \bar{W}_G$, which is a contradiction.

Notice that in the argument above we need the termination costs κ_A and κ_P to be strictly positive for the uniqueness result to go through. Indeed, when termination is costless either on the firm side or on the manager side, equilibria exist but multiplicity may arise. While these cases are technically interesting, we leave them aside and focus on economies with unique equilibrium.

Equilibrium. Finally, we prove the equilibrium condition for the general case with bargaining power. The bargaining power only affects the level of equilibrium compensation, while the incentive contract is unchanged. We can rewrite problem (1) as

$$\max_{W_0} \left(F(W_0; R, L) - L\right)^{\beta} (W_0 - R)^{1-\beta}.$$

Taking first-order condition with respect to W_0 and replacing the equilibrium conditions (2) and (3), we obtain equation (21) for Corollary 2. Setting $\beta = 0$ yields equation (12) for Proposition 1.

A.3 Proof of Proposition 2

To obtain the planner's optimality condition, we differentiate the social welfare objective (13) with respect to W_0:

$$F'(W_0; R, L) + 1 + \frac{\partial F(W_0; R, L)}{\partial R} \frac{\partial R}{\partial W_0} + \frac{\partial F(W_0; R, L)}{\partial L} \frac{\partial L}{\partial W_0} = 0. \tag{24}$$

The first two terms in equation (24) capture the direct effect of changes in W_0 on social welfare; the next two terms capture the indirect effects induced by changes in equilibrium outside options in response to changes in W_0 on social welfare.

Differentiating equations (2) and (3) with respect to W_0 yields:

$$\frac{\partial R}{\partial W_0} = 1 \tag{25}$$

$$\frac{\partial L}{\partial W_0} = \frac{F'(W_0; R, L) + \frac{\partial F(W_0; R, L)}{\partial R}}{1 - \frac{\partial F(W_0; R, L)}{\partial L}}. \tag{26}$$

Substituting equations (25) and (26) in the first-order condition (24), reorganizing, and denoting the variables with superscript p for the planner's solution yields equation (14).

A.4 Proof of Proposition 3

We differentiate the boundary condition in equation (9) with respect to R:

$$\frac{\partial F(R; R, L)}{\partial R} = -F'(R; R, L).$$

Applying the Feynman-Kac formula, we can write the solution as an expectation

$$\frac{\partial F(W_0; R, L)}{\partial R} = \mathbb{E}\left[e^{-r\tau}\right] \frac{\partial F(R; R, L)}{\partial R} = -\mathbb{E}\left[e^{-r\tau}\right] F'(R; R, L), \tag{27}$$

which captures the additional profit gained on the path of W_t due to the change in the outside option R. A similar procedure shows that

$$\frac{\partial F(W_0; R, L)}{\partial L} = \mathbb{E}\left[e^{-r\tau}\right], \tag{28}$$

which says that increasing the liquidation value L by \$1 is equivalent to providing shareholders with an Arrow-Debreu security that pays \$1 at termination.

Substituting (27) and (28) in expression (15) for the welfare change and denoting the variables with superscript $*$ for the equilibrium solution, we obtain expression (17).

A.5 Proof of Proposition 4

Suppose the competitive equilibrium features overcompensation, namely $W_0^p < W_0^*$. We proceed in several steps.

Step 1: Because the social optimum features higher welfare than the competitive equilibrium it must be the case that for all W: $F(W; R^p, L^p) > F(W; R^*, L^*)$. Let $\hat{W}^p$ satisfy $F(\hat{W}^p; R^p, L^p) = 0$. Applying Lemma 4, we obtain that $\bar{W}^p - \hat{W}^p > \bar{W}^* - W^*$. Therefore,

$$\bar{W}^p - W_0^p > \bar{W}^p - \hat{W}^p > \bar{W}^* - W_0^*, \tag{29}$$

where the first inequality follows from the fact that overcompensation implies that $\hat{W}^p > W_0^p$. Thus, we obtain (18).

Step 2: Next, define $\tilde{S}(\Delta) = S(R + \Delta)$. It is the case that $\tilde{S}^*(\Delta)$ and $\tilde{S}^p(\Delta)$ solve:

$$r\tilde{S}(\Delta) = \gamma(\Delta + R)\tilde{S}'(\Delta) + \frac{1}{2}\lambda^2\sigma^2\tilde{S}''(\Delta), \tag{30}$$

with boundary conditions $\tilde{S}(0) = 0$ and $\tilde{S}(\bar{\Delta}) = 1$ where $\bar{\Delta} = \bar{W} - R$.

We now <u>claim</u> that $\tilde{S}^*(\Delta) > \tilde{S}^p(\Delta)$ for all $\Delta \in (0, \bar{W}^* - R^*]$. Suppose for a contradiction that it is not true. Let $\tilde{\Delta}$ be the largest such that $\tilde{S}^*(\tilde{\Delta}) = \tilde{S}^p(\tilde{\Delta})$. Since $\tilde{S}^*(\tilde{\Delta} + \epsilon) > \tilde{S}^p(\tilde{\Delta} + \epsilon)$ for $\epsilon > 0$, then by differentiability of $\tilde{S}$ it follows that $\tilde{S}'^*(\tilde{\Delta}) > \tilde{S}'^p(\tilde{\Delta})$. But now, we know that

$\tilde{S}^*(0) = \tilde{S}^p(0) = 0$, $\tilde{S}^*(\tilde{\Delta}) = \tilde{S}^p(\tilde{\Delta})$, and $\tilde{S}'^*(\tilde{\Delta}) > \tilde{S}'^p(\tilde{\Delta})$. Therefore, there must be a $\Delta < \tilde{\Delta}$ such that $\tilde{S}'^*(\Delta) = \tilde{S}'^p(\Delta)$. Let $\hat{\Delta}$ be the largest such Δ so that $\tilde{S}^*(\hat{\Delta}) < \tilde{S}^p(\hat{\Delta})$ and $\tilde{S}''^*(\hat{\Delta}) > \tilde{S}''^p(\hat{\Delta})$. But using (30) and the fact that $R^* > R^p$ yields that:

$$r\tilde{S}^*(\hat{\Delta}) = \gamma(\hat{\Delta} + R^*)\tilde{S}'^*(\hat{\Delta}) + \frac{1}{2}\lambda^2\sigma^2\tilde{S}''^*(\hat{\Delta}) > \gamma(\hat{\Delta} + R^p)\tilde{S}'^p(\hat{\Delta}) + \frac{1}{2}\lambda^2\sigma^2\tilde{S}''^p(\hat{\Delta}) = r\tilde{S}^p(\hat{\Delta}),$$

which is a contradiction, thereby proving the claim. Finally, setting $\Delta = \kappa_A$ in our claim implies that

$$S^*(W_0^*) = \tilde{S}^*(\kappa_A) \geq \tilde{S}^p(\kappa_A) = S^p(W_0^p)$$

Step 3: Using a similar procedure as the one in the previous step, one can show that:

$$T^*(W_0^*) \leq T^p(W_0^p),$$

which completes the proof of the lemma.

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