Too Much, Too Soon, for Too Long: The Dynamics of Competitive Executive Compensation*

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Abstract

We examine executive compensation in a general equilibrium model with dynamic moral hazard, where executives' outside options are endogenously determined by equilibrium market compensation. To provide incentives, firms structure compensation packages featuring deferred payments following good performance and termination following poor performance. Crucially, the effectiveness of termination threats as an incentive device is undermined by the outside options available to executives. As individual firms fail to internalize the effect of their compensation design on these endogenous outside options, the equilibrium is generally inefficient. In particular, compared to the shareholder-value maximizing compensation packages, executives are paid too much, too soon, and stay for too long.

Keywords: executive compensation, general equilibrium, contracting externalities, dynamic contracts.

JEL codes: D86, G34, G32, M12.

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1 Introduction

Executive pay has long been the subject of considerable debate in economics, finance, and beyond. The proponents of the shareholder view have argued that the considerable increase in executive pay over the past decades has been an efficient response to market forces. Others have advocated that soaring executive pay has been the outcome of rent extraction by powerful managers taking advantage of weak corporate governance and low top income tax rates.[1] It is perhaps remarkable that, while firms spend considerable resources to hire and retain CEOs and the shareholder view generally emphasizes that CEOs operate in a competitive market and need to be provided with high-powered incentives, there have been very few models examining the implications of competitive CEO pay with dynamic moral hazard.

In this paper, we study a dynamic *general equilibrium* economy in which each firm contracts with a manager, where the manager privately observes the cash flows and can potentially divert cash, generating a moral hazard problem. To provide appropriate incentives, the firm promises adequate compensation but exposes the manager to cash flow risk, delays paying him after good performance despite the manager's impatience, and fires him after poor performance. Upon termination, both parties return to the labor market and can be rematched by incurring the necessary costs. We first illustrate these equilibrium forces in a simple two-period model, following the canonical setup of Bolton and Scharfstein (1990), and then generalize them to a fully dynamic model, embedding the continuous-time principal-agent contracting à la DeMarzo and Sannikov (2006).

In equilibrium, one firm's compensation package generates spillovers to other firms. This *compensation externality* arises because how useful termination threats are depend on managers' equilibrium outside options, i.e., the compensation they would obtain at a different firm net of their termination cost. If the outside options are lucrative, the effectiveness of termination threats as an incentive device is undermined. Despite individual firms optimally designing the best possible incentive contracts, the resulting equilibrium is generally inefficient. As each firm fails to internalize that by offering a more generous compensation package to provide its manager with appropriate incentives, it inadvertently reduces the value of termination threats and increases the costs of incentive provision for other firms.

While correcting for this inefficiency can improve social surplus and potentially achieve Pareto improvements, we mainly focus our analysis on how coordinating all contracts to

[1] Lower top income tax rates and more competitive markets for CEOs have been associated with a six-fold increase in CEO pay at S&P500 firms from 1980 to 2005 (see Frydman and Saks (2010)) and a continuing increase in executive pay relative to average incomes, fueling a vibrant academic literature (e.g., Bebchuk and Fried, 2003; Edmans et al., 2017; Gabaix and Landier, 2008).

uniformly cut the ex-ante expected pay can substantially increase shareholders' values. In other words, the equilibrium compensation is excessively high compared to the pay that would maximize shareholder value. While it may seem obvious that shareholders would benefit from cutting executive pay, this is not the case from the perspective of individual firms in partial equilibrium. Taking the managers' outside options as given, each well-intending firm is inclined to increase its manager's compensation to maximize shareholder value. Yet, such efforts to improve shareholder value would end up lowering it.

In addition to being paid too much in equilibrium, executives are paid too soon and stay for too long. When structuring compensation, firms want to avoid postponing large promised compensations to impatient managers, and the cost of deferral increases with the compensation promised to them. As such, a smaller fraction of compensation is deferred. Moreover, given termination is not as cost-effective as an incentive device in equilibrium, managers are fired less frequently. In more technical terms of our full model, a larger promised compensation accumulates into even larger future promises, which reduces the likelihood of hitting the manager's outside option leading to termination. Insufficient turnover holds despite an offsetting force at play: since the equilibrium compensation is excessively frontloaded, the continuation value is reflected sooner, which can make termination more likely.

The compensation externality also has implications for equilibrium firm capital structure. The executive compensation contract can be implemented with inside equity, which is relinquished upon termination, combined with a credit line and a consol bond. We show that, in equilibrium, the limits on the credit line and the consol bonds are excessively low. This is because the compensation must be excessively high and frontloaded for the firm to retain its manager, requiring that debt instruments be sufficiently low to accommodate the executive compensation package.

Despite firms holding all the bargaining power when setting compensation, as we have implicitly assumed thus far, overcompensation still arises in equilibrium. Perhaps unsurprisingly, equilibrium compensation becomes even more excessive when managers hold more bargaining power. This change may seem like a mere redistribution, but it is not once we account for the equilibrium forces. As managers' bargaining power strengthens, they are able to bargain for higher pay, all else being equal. However, this also implies that the managers have better outside options. Consequently, it becomes even more expensive to incentivize them, further reinforcing the high equilibrium pay.

Central to our analysis is the role played by termination costs, which capture search costs for the two sides, and additionally, forgone salaries for the managers and disruption costs associated with management changes for the firms. While we maintain a simple reduced-form specification for these costs, we show that they can be micro-founded endogenously in a search framework. In environments where managers can quickly find a new job and their human capital is easily transferable across firms, the termination costs borne by the managers would be negligible. However, in environments where it takes a long time for firms to replace their managers and they incur high costs from disruption and searching to fill their vacancies, the termination costs borne by the firms would be sizable.

If the termination costs borne by managers are smaller, the equilibrium compensation increases, and the extend of overcompensation worsens. This outcome arises because, in the event of termination, managers can seek out their more lucrative outside option, making firms less inclined to use termination threats. In more technical terms of our continuous-time model, the distance of initial compensation to termination threshold is smaller, increasing the likelihood of reaching termination. Consequently, firms adjust by increasing the initial compensation to avoid early termination. However, they do not internalize that in doing so, they also improve the manager's equilibrium outside option. As a result, the equilibrium compensation level exceeds the optimal level even further. Similarly, if the termination costs borne by firms are larger, the equilibrium results in higher compensation and more in excess of the optimal level.

While we quantitatively assess the equilibrium forces by calibrating our full model, the comparative statics outlined above yield several empirical predictions for industry equilibrium. First, managerial overcompensation tends to be more pronounced in industries where managers are more mobile, either because more outside opportunities are available or because their human capital is more easily transferable. Similarly, overcompensation is also more acute in industries where replacing management is particularly costly for firms. Second, although the severity of moral hazard plays a subtle role, we find that in our calibrated model it tends to drive up equilibrium pay and widen the gap from optimal pay. Finally, notice that higher cash flow volatility has an effect isomorphic to more severe moral hazard. Indeed, more volatile cash flows make it more difficult for the firms to tell whether their managers are reporting the performance truthfully. In other words, the signal-to-noise ratio worsens as volatility increases, effectively increasing the severity of moral hazard. Consequently, industries characterized by more volatile cash flows are more susceptible to overpaying their managers. These sectors are also more likely to experience the associated symptoms: insufficient deferral, excessively long CEO tenures, and excessively low credit line limits and long term debt levels.

We then turn to policy implications. We first consider noncompete clauses, which are prevalent in executive contracts and restrict their outside employment. By limiting managers' outside options, noncompetes can potentially restore the effectiveness of termination as an incentive device and curtail equilibrium overcompensation. However, despite the appeal of mitigating dynamic compensation externality, we caution that an intricate trade-off must be weighed: noncompetes also introduce negative externalities on other firms by limiting their ability to employ managers. Second, 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]

Related literature. Our paper is most closely related to the literature on equilibrium compensation externalities (e.g., Acharya and Volpin, 2010; Dicks, 2012; Levit and Malenko, 2016). These analyses focus on static settings in which the principal toolkit is enriched by adding a corporate governance or monitoring margin. In Acharya and Volpin (2010) and Dicks (2012), for instance, one firm's governance effort benefits other firms by reducing the cost of hiring their agents, by diminishing the agents' outside options. By contrast, in our setting, outside options affect the effectiveness of termination threats as a means to provide dynamic incentives. Thus, our contribution complements this literature by uncovering externalities via the equilibrium outside option on the cost of dynamic incentive provisions. Closely related to our mechanism, Axelson and Bond (2015) study the cyclicality in financial sector compensation packages within a dynamic moral hazard framework. Their mechanism emphasizes the fact that during good economic conditions, financial sector workers expect to "land on their feet"; increasing the cost of incentives in good times when workers' equilibrium outside options are attractive.

Our paper also contributes to the growing equilibrium firm-manager models in corporate finance. The biggest strand of the literature focuses on a dynamic bilateral framework (see, among others, Biais et al. (2007, 2010); DeMarzo and Sannikov (2006, 2016); Edmans et al. (2017); Frydman and Papanikolaou (2018); Gromb (1994); Hartman-Glaser et al. (2019), and Ai et al. (2021) who find that moral hazard induced incentive pay accounts for 52% of managerial compensation).

In contrast, we examine how the threat of being fired and the prospect of being hired by another firm shapes compensation contracts. Our paper also complements the frictionless assortment theories of executive compensation (see, e.g., Gabaix and Landier (2008)). We show that with competitive markets generate externalities, which entail overcompensation, insufficient deferral, and excessively long tenure.

Importantly, papers obtaining overcompensation as a result of corporate governance

[2]Mandated disclosure and say on pay so that 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.

weaknesses and rent extraction predict that CEO pay increases with executive tenure. In contrast, a distinguishing feature of our setting is that executives obtain a significant pay rise when they move to another job, as documented, for example, by Custódio et al. (2013); Falato et al. (2015) and McCann (2020).

The forces at stake in our paper are also distinct from those in existing papers on short-termism in executive compensation.[3] 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). An exception is Bolton et al. (2006), where short-termism arises from speculative motives. By contrast, in our paper, short-termism arises as a consequence of general equilibrium and externalities in executive pay.

Despite the extant literature on the effects of leverage choice on managerial incentives that argues, for example, that leverage can provide managers with appropriate incentives by reducing free cash flows (Jensen (1986)) and distorting their investment policy (Berk et al. (2010); Hart and Moore (1994); He (2011); Zwiebel (1996)), there is a scarcity of dynamic models that have followed DeMarzo and Sannikov (2006) in examining equilibrium capital structure from the point of view of incentives within the firm.[4] In our setting, leverage emerges as an implementation of optimal incentive contracts inside the firm. The capital structure that emerges as part of our equilibrium managerial compensation contract implies that overcompensation, short-termism, and excessive tenure come hand in hand with excessively low credit line limits and long term debt levels.

Finally, while introducing search frictions into an dynamic model of executive compensation, our paper contributes to the growing literature exploring the role of externalities and search frictions in economic outcomes (Moen and Rosén, 2011; Wright et al., 2017, e.g.,). Specifically, we show that firms ignore the effect of the dynamic incentive compensation packages on other firms, which entails excessively high equilibrium pay levels, excessive tenure and short-termism. In other words, dynamic privately optimal incentive contracts generally fail to deliver an efficient outcome because firms and managers optimally contract around a dynamic 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.

The remainder of the paper is organized as follows. Section 2 presents an illustrative two-period model. Section 3 describes the full dynamic model. Section 4 studies the social

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

[4]Maksimovic and Zechner (1991) analyse leverage and incentives for risk taking in industry equilibrium. Berk et al. (2010) examine an equilibrium model where debt comes with tax benefits, but large human costs of bankruptcy.

optimum and compares it with the equilibrium outcome. Section 5 assesses the quantitative magnitudes of the theoretical insights. Section 6 discusses the implementation of the social optimum and the optimal policy response. Section 7 studies three extensions to the baseline model. Section 8 concludes.

2 Illustrative Two-Period Model

We first present an illustrative model featuring dynamic moral hazard in the spirit of Bolton and Scharfstein (1990). The model is embedded into a general equilibrium setting, aiming to demonstrate the role of outside options in generating a compensation externality and to emphasize the critical role that dynamic moral hazard plays in generating this externality.

The economy lasts for two periods. There is a continuum of firms (principals or shareholders) and managers (agents), each of measure one. Both firms and managers are risk-neutral. We assume that firms are patient, whereas managers are impatient. Managers discount the future by a factor $\delta \in (0, 1]$ per period, thereby making the agency rent socially costly.

A firm hires a manager to run a project. In each period, the project generates a random cash flow of binary outcomes: the cash flow is high, $y > 0$, with probability $p \in (0, 1)$; or low, $y = 0$, with probability $1 - p$. The expected cash flow is denoted by $\mu = py$. The manager privately observes the cash flows, while the firm relies on the cash flows reported by the manager. This friction leads to a *moral hazard* problem: the manager can divert cash flows for his private benefit. Specifically, the manager can under-report cash flows, diverting an amount equivalent to the difference between the realized and reported cash flows. The manager receives a fraction $\lambda \in (0, 1]$ of the diverted funds, while the remaining $1-\lambda$ portion constitutes a deadweight loss. Agents have *limited liability*: all compensation payments to the managers must be non-negative, precluding the possibility of the agents buying out the project ex-ante or imposing monetary punishments on the agents ex-post.

At the outset, all managers are already matched with a firm. In each period, the manager can either continue with the firm or gets terminated. To form new matches, managers incur a cost of κ_A, while firms incur a cost κ_p. We assume that $\kappa_A \in [0, \delta\lambda\mu)$ and $\kappa_p \in [0, (1 - \lambda)\,\mu)$. In addition, we assume that the principals have all the bargaining power, i.e., they make a take-it-or-leave-it offer to their agents.

2.1 Static Moral Hazard

We first consider a special case where all projects last for only one period, making the agency friction inherently *static*. A firm-manager pair enters into a one-period static contract $\Gamma^S =$

$\{\tilde{x}, c_H, c_L\}$, which specifies a probability $\tilde{x} \in [0,1]$ of undertaking the project, a compensation payment c_H if the reported cash flow is high and c_L if it is low. This contract structure is sufficient, as the firm refrains from providing any upfront payment. Since the contract is static and concludes with certainty at the end of the period, the incentive-compatibility constraint to induce truthful reporting of high cash flow is unaffected by the agent's outside option after the contract ends: $c_H - c_L \geq \lambda y$. The firm chooses the contract to maximize its expected profit every period:

$$\max_{\Gamma^S} \; \tilde{x}\left[p\left(y - c_H\right) - (1-p)\, c_L\right] \quad \text{subject to} \quad c_H - c_L \geq \lambda y.$$

It immediately follows that the principal pays the agent $c_H = \lambda y$ if the realized cash flow is high and $c_L = 0$ otherwise. Within the period, the agent extracts a rent $\lambda\mu$, while the firm obtains a profit $(1-\lambda)\mu$.

The compensation scheme above is optimal for all principal-agent pairs in each period. After the projects end, the agents obtain their outside option, denoted by R, and the principal obtains a liquidation value, denoted by L. If $\tilde{x} \geq \min\left\{\frac{\kappa_A}{\delta\lambda\mu}, \frac{\kappa_P}{(1-\lambda)\mu}\right\}$, the outside values satisfy

$$R = \tilde{x}\delta\lambda\mu - \kappa_A \quad \text{and} \quad L = \tilde{x}\left(1-\lambda\right)\mu - \kappa_P; \tag{1}$$

Otherwise, there is no matching for the second period: $R = L = 0$. While we allow for the initial contractual provision for the potential shutdown of projects, the principals always wish to undertake them, i.e., $\tilde{x} = 1$.

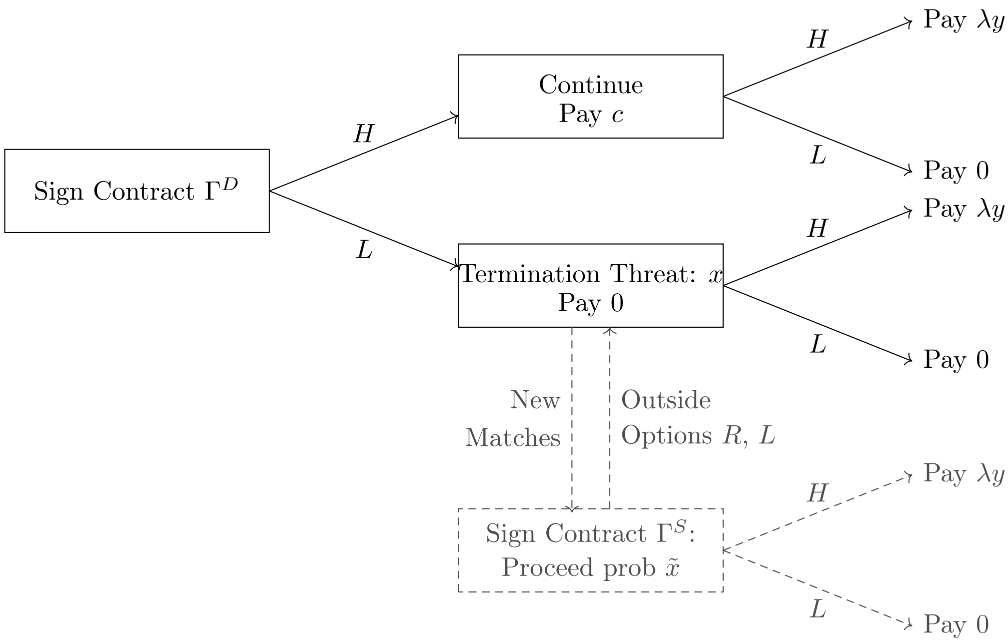
Despite the moral hazard friction, the equilibrium described above is efficient. The static nature of the contract eliminates any spillovers across contracts: the agency rent, $\lambda\mu$, does not depend on the outside options available to the agents. Intuitively, the compensation schemes of other principal-agent pairs have no impact on the contract a principal offers his agent. By contrast, in the next section, we show that agency rent increases with outside options when the moral hazard problem becomes dynamic, giving rise to compensation externalities.

2.2 Dynamic Moral Hazard

The projects last for two periods. If a firm terminates its incumbent manager, it replaces him with a new manager, and the outgoing manager finds a new match. The events and the contracts are depicted in Figure 1.

Equilibrium. In period 2, new matches formed choose the contract Γ^S described in the previous static case, yielding an outside option for the agents $R = \delta\lambda\mu - \kappa_A$, and a liquidation

Figure 1: Event tree and contracts



value for the principals $L = (1-\lambda)\mu - \kappa_P$.

In period 1, the principal designs a two-period dynamic contract. Several considerations simplify the design of the optimal contract. First, termination following poor performance can reduce the cost of incentive provision. Therefore, in period 1, the agent continues with certainty if the realized cash flow is high, but termination might be considered if the cash flow is low. We denote the continuation probability in the low state by $x \in [0,1]$. Second, the cheapest incentive-compatible contract involves paying the agent nothing if the realized cash flow is low in any period. However, for high cash flow, a reward of at least λy is required, either in immediate or deferred payment. Considering the agent's impatience, it is then optimal to set the payment for high cash flow to λy in period 2, while the payment for high cash flow in period 1, denoted by c, depends on whether a termination threat is deployed. In summary, the contract can be reduced to $\Gamma^D = \{x, c\}$.[5]

Given the outside option R and the liquidation value L, the principal maximizes the shareholder value:

$$\max_{\Gamma^D} \; p\left[y - c + (1-\lambda)\,\mu\right] + (1-p)\left[x\,(1-\lambda)\,\mu + (1-x)\,L\right]$$

[5]These observations allow us to reduce the dimensionality of the fully specified dynamic contract $\Gamma = \{x_0, x_H, x_L, c_0, c_H, c_L, c_{HH}, c_{HL}, c_{LH}, c_{LL}\}$ to simply optimizing over $\{x, c\}$.

subject to the incentive-compatibility constraint in period 1,

$$c + \delta\lambda\mu \geq x\delta\lambda\mu + (1-x)R + \lambda y. \tag{IC-1}$$

Condition (IC-1) states that the agent needs to be rewarded in the high state his continuation value in the low state, $x\delta\lambda\mu + (1-x)R$, plus the extra rent he can extract, λy. This condition shows that termination threats in the low state can reduce the cost of providing incentives in the high state. This potential cost reduction $\delta\lambda\mu - R$ depends crucially on the value of the agent's outside option, becoming less valuable if the agent's outside option is high. However, termination can also be costly for the principal, reducing the principal payoff by amount $(1-\lambda)\,\mu - L$ if the low state were to occur. The principal thus finds termination desirable, setting $x = 0$, if the cost reduction in the high state outweighs the loss in the low state, i.e., $p(\delta\lambda\mu - R) > (1-p)\,[(1-\lambda)\,\mu - L]$. While individual principals and agents take their outside values as given, in equilibrium their values lead to termination taking place when $p\kappa_A > (1-p)\kappa_p$. With these insights in hand, we summarize the equilibrium outcomes below.

Lemma 1 (Equilibrium)**.** *The equilibrium contract features termination when termination is relatively costly for the agents. Specifically,*

(i) If $\kappa_A \leq \frac{1-p}{p}\kappa_P$, the agents continue regardless of performance and obtain an expected compensation $(\delta + \delta^2)\lambda\mu$. Consequently, the shareholder value is $2\,(1-\lambda)\,\mu$.

(ii) If $\kappa_A > \frac{1-p}{p}\kappa_P$, the agents are terminated for bad performance and obtain an expected compensation $(\delta + \delta^2)\lambda\mu - \delta\kappa_A$. Shareholder value is $2\,(1-\lambda)\,\mu + p\kappa_A - (1-p)\,\kappa_P$.

The characterization in Lemma 1 shows that when the agent's termination cost is high and hence their equilibrium outside option is low, the principals find termination to be effective in reducing the cost of the incentive contracts.

Social Optimum. In the equilibrium described above, each individual principal fails to internalize that the contracts Γ^s they sign with their newly replaced agents will affect the outside option for these agents and in turn the cost of incentive provision for other principals. Specifically, principals always proceed with the new matches, i.e., $\tilde{x} = 1$, implying a high outside option for the agents. In contrast, a planner who internalizes the externality may find it desirable to shut down some projects for new matches, i.e., set $\tilde{x} < 1$. Formally, we consider a planner who aims to maximize shareholder value, adopting the same criteria as

Dicks (2012). The planner coordinates across contracts and solves:

$$\max_{\Gamma^S,\Gamma^D} \; p\left[y - c + (1-\lambda)\,\mu\right] + (1-p)\left[x\,(1-\lambda)\,\mu + (1-x)\,L\right]$$

subject to (IC-1), as well as condition (1).

As the planner takes into account the endogenous agent outside option, the cost-benefit analysis is adjusted. Suppose a small ε fraction of the new matches were to be shut down. In the low state, the agent outside option would decrease by $\delta\lambda\mu\varepsilon$, and simultaneously, the principal liquidation value would decrease by $(1-\lambda)\,\mu\varepsilon$. In the high state, the principal payoff would improve by an amount equal to the reduction in the agent's outside option, $\delta\lambda\mu\varepsilon$. The principals are better off if and only if $p \cdot \delta\lambda\mu > (1-p)\cdot(1-\lambda)\,\mu$. In other words, if the moral hazard is sufficiently severe, i.e., $p\delta\lambda > (1-p)(1-\lambda)$, it becomes desirable to undertake fewer outside projects until the agent's outside option R reaches zero. The extent to which this strategy should be pursued and the gains in shareholder value depend on the relative costs of termination.

Indeed, when moral hazard is sufficiently severe, the agents are able to extract large rents. Thus, the threat of termination can be valuable to incentivize the agents since such rents would be foregone following low output. Compared to the socially optimal contract characterized in the lemma below, the equilibrium contracts feature excessively high compensation. Intuitively, principals fail to internalize the fact that a more generous compensation scheme will increase the agent's equilibrium outside option R, thereby undermining the effectiveness of the termination threat as an incentive device for other principal-agent pairs. As a result, termination is less likely to be deployed, leading to higher compensation and earlier payments.

Lemma 2 (Social Optimum)**.** *If the severity of moral hazard, i.e., $p\delta\lambda > (1-p)(1-\lambda)$, the equilibrium features overcompensation. The planner designs a different contract for new matches such that the agent outside option R reduces to zero. As a result, the agents are always terminated for bad performance and obtain an expected compensation $\delta\lambda\mu$. Let $\Delta \equiv p\delta\lambda - (1-p)(1-\lambda)$,*

(i) If $\kappa_A < \delta\frac{\lambda}{1-\lambda}\kappa_P$, all outside matches are shut down, i.e., $\tilde{x} = 0$.

  (i-a) If $\kappa_A \leq \frac{1-p}{p}\kappa_P$, the shareholders gain $\Delta\mu$.

  (i-b) Otherwise, the shareholders gain $\Delta\mu - p\kappa_A + (1-p)\,\kappa_P$.

(ii) If $\kappa_A \geq \delta\frac{\lambda}{1-\lambda}\kappa_P$, outside matches proceed with probability $\tilde{x} = \frac{\kappa_A}{\delta\lambda\mu} < 1$. The shareholder value improves by $\left(1 - \frac{\kappa_A}{\delta\lambda\mu}\right)\Delta\mu$.

The characterization in Lemma 2 also helps to reveal sources of inefficiency in the economy. To illustrate this, consider a case with extreme moral hazard $\lambda \to 1$ and $p \to 1$ and negligible termination costs. In such a scenario, agents can extract almost all of the output as rent, leaving almost zero profit to shareholders, yet this enormous agency rent induces significant social losses due to agent impatience. Similar interventions to those described here can lead to substantial gains in social surplus and achieve Pareto improvements. We relegate a formal discussion to Appendix B.1.

While the illustrative model delineates the compensation externality clearly, it has several limitations. First, its predictions are unnecessarily stark and extreme given the two-period binary cash flow setup. It misses finer gradients, making it unsuitable for mapping the model to the data in a meaningful way and conducting quantitative and policy analysis. Moreover, the only contractual instrument available to alter the agent's outside option is to shut down outside projects upfront. Our fully dynamic model, which we turn to next, overcomes these limitations and provides a more complete analysis of compensation externalities under dynamic moral hazard.

3 The Full Dynamic Model

We now set up a continuous-time model that embeds the dynamic moral hazard problem by DeMarzo and Sannikov (2006) in a general equilibrium setting. Despite its richer structure, the underlying forces in this model mirror those in our previous illustrative model. Building on the insights by Biais et al. (2007), one can obtain the following model as the continuous-time limit of our previous two-period binary cash flow setup extended into infinite periods.

3.1 Environment

Time is continuous and infinite, $t \in [0, \infty)$. As in Section 2, the economy consists of a continuum of firms and managers, each of measure one. While both firms and managers are risk-neutral, they differ in their patience: firms discount the future at rate r, while managers discount the future at a higher rate $\gamma > r$. [6]

Each firm hires a manager to run a long-term project. At any instant, the project generates a cash flow drawn from a normal distribution with a mean μ and volatility σ. Thus, the cumulative cash follow at time t of the project Y_t follows

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

[6] The relative patience here maps to the one in our two-period model: $\delta = e^{r-\gamma}$.

where B is a standard Brownian motion. The manager privately observes cumulative cash flows $Y = \{Y_t\}_{t \geq 0}$, while the firm relies on the cash flows reported by the manager $\hat{Y} = \{\hat{Y}_t\}_{t \geq 0}$. As before, the manager can divert cash flows for his private benefit and receives a fraction $\lambda \in (0, 1]$ of the diverted funds $Y_t - \hat{Y}_t$.

Upon termination, managers can match with a new firm and start afresh upon incurring a cost κ_A. We interpret cost κ_A as resulting from an instantaneous utility cost. This reduced-form specification captures a monetary equivalent to the salaries forgone during a stint of unemployment or the cost of acquiring information about potential employers. Similarly, 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. We maintain this simple reduced-form specification for the termination costs in the main discussion, which allows us to have a simple equilibrium characterization and intuitive comparative statics. In Section 7.1, we micro-found these costs in a search framework and show that the reduced-form specification is without loss of generality.

3.2 Principal-Agent Contracting Problem

Consider a firm-manager pair at the onset of the project. They enter into a contract $\Gamma = (C, \tau)$, which specifies a cumulative compensation process $C = \{C_t\}_{t \geq 0}$ for the manager and a termination clause τ. Both contractual elements are functions of the manager's history of reports $\hat{Y}$. Given that the manager has *limited liability*, the compensation process is positive and non-decreasing. Upon termination, at time $t = \tau$, the manager receives his outside option denoted by R, whereas the firm obtains its liquidation value denoted by L. These outside options are endogenous outcomes of the contracts in equilibrium and are specified in detail later.

Given a contract Γ, if the manager reports $\hat{Y}$, the firm's initial value at the onset of the project 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 initial value at the onset of the project 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 the dynamic nature of the contract, we keep track of the manager's continuation value at time t:

$$W_t(\hat{Y};\Gamma) \equiv \mathbb{E}\left[\int_t^\tau e^{-\gamma(s-t)}\left(dC_s + \lambda(dY_s - d\hat{Y}_s)\right) + e^{-\gamma(\tau-t)}R\right].$$[7]

The principal has all the bargaining power and makes a take-it-or-leave-it contract offer Γ to the agent. The agent decides whether to accept the offer. If he does, he chooses a feasible reporting strategy $\hat{Y}$ to maximize his payoff. The agent's strategy $\hat{Y}$ is incentive compatible if it maximizes his total expected payoff W_0. Without loss of generality, we will focus on incentive-compatible contracts that implement truthful reporting $\hat{Y} = Y$. Any contract that results in the agent diverting cash is inefficient and can be improved upon. The contracting problem boils down to obtaining an incentive-compatible contract that implements truth-telling and maximizes firm value, subject to delivering the agent an initial promised value W_0. Formally, the optimal contract solves:

$$\max_{W_0,\Gamma} F_0(Y;\Gamma) \tag{2}$$

subject to

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

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

Condition (PK) is the promise-keeping constraint that ensures the contract delivers an 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 cash flows truthfully.

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

[7] We observe from this expression that the agent's value at termination is his outside option, i.e., $W_\tau = R$.

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, 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. The extent to which market participants can coordinate contracts amongst different contracting parties is important as pointed out by e.g., Bloch and Gomes (2006); Gomes (2005). In particular, it gives rise to the possibility that a firm could coordinate among its contracts with its current and future managers. As the firm optimally designs all contracts simultaneously, it would take into account its endogenous liquidation value, an alternative contracting process we explore in Section 7.3.

3.3 Equilibrium

We now define the equilibrium, in which each firm-manager pair designs the optimal contract, taking as given the equilibrium outside options.

Definition 1 (Equilibrium)**.** *An equilibrium consists of* $\{\Gamma^*, W_0^*, F_0^*, R^*, L^*\}$ *such that:*

(i) Given (R^*, L^*)*, the contract* Γ^* *and* W_0^* *solves the firm-manager problem (2).*

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

$$R^* = W_0^* - \kappa_A \tag{3}$$

$$L^* = F_0^* - \kappa_P. \tag{4}$$

Equation (3) captures the idea that upon termination the manager can quit and immediately find another job at a different firm upon bearing the cost κ_A. He takes the expected payoffs offered by other firms W_0^* as given and computes his outside option. Similarly, equation (4) states that upon termination the firm can find another (identical) manager and obtain F_0^* upon bearing the cost κ_P.[8]

An equilibrium requires consistency between the equilibrium payoffs for firms and managers and their respective termination payoffs. Since each firm-manager pair takes as given

[8] A general formulation of the equilibrium conditions (3) and (4) requires a complementary condition for situations when the termination costs are prohibitively high that the rematching market shuts down: if $\kappa_A > W_0^*$ or $\kappa_p > F_0^*$, then $R^* = 0$ and $L^* = 0$. We introduce Assumption 1 in Section 3.4, which allows us to confine our attention to the cases where the rematching markets are always open.

the contracts other firms and workers enter in the economy, they are price-takers of the equilibrium values determined by equations (3) and (4). Given there is a continuum of principals and agents in our economy, 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. We focus on stationary equilibria in which equations (3) and (4) hold for positive values of 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 labor market rather than quit once and for all.

3.4 Equilibrium Characterization

We proceed to characterize the equilibrium of the continuous time model in two steps. First, we solve the contracting problem for individual firm-manager pairs in partial equilibrium, given their respective outside options. Second, we solve the equilibrium level of compensation together with the endogenous outside options.

Optimal Incentive Contract. The contracting problem in (2) consists of two separate parts: (1) the 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 characterization of both the equilibrium and the social optimum. Adapting Proposition 1 in DeMarzo and Sannikov (2006) to match our notation, the solution to this problem is characterized in the lemma below.

Lemma 3 (Optimal Incentive Contract). *The optimal contract Γ has the following features:*

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

$$dW_t = \gamma W_t dt - dC_t + \lambda(dY_t - \mu dt). \tag{5}$$

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:

$$dC_t = \begin{cases} 0, & \text{if } R \leq W_t < \bar{W} \\ W_t - \bar{W}, & \text{if } W_t \geq \bar{W}. \end{cases} \tag{6}$$

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

$$\tau = \min\{t | W_t = R\}. \tag{7}$$

The optimal contract has three key features. First, the manager is motivated through promises about his future compensation. To deter cash diversion, the sensitivity of the value promised to the manager 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.[9]

An implementation of this optimal contract includes offering 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. Dividend payment occurs after cash flows exceed a performance threshold.

Under the contract in Lemma 3, the firm value can be conveniently 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 this function.

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):*

$$rF(W; R, L) = \mu + \gamma W F'(W; R, L) + \frac{1}{2}\lambda^2\sigma^2 F''(W; R, L), \qquad \text{if } R \leq W < \bar{W} \tag{8}$$

$$F'(W; R, L) = -1, \qquad \text{if } W \geq \bar{W}, \tag{9}$$

with boundary conditions

$$F(R; R, L) = L \quad \text{and} \quad rF(\bar{W}; R, L) = \mu - \gamma\bar{W}. \tag{10}$$

The characterization of $F(W; R, L)$ in Corollary 1 allows us to conveniently compute the principal value and agent continuation value.

[9] We assume that the principals can commit not to renegotiate. Equivalently, the contract is renegotiation-proof as long as the renegotiation costs are at least κ_A for the managers and κ_P for the firms. Moreover, given those renegotiations will end up making the principals worse off, we conjecture that forward-looking principals will try to develop the commitment technology necessary to prevent renegotiation such as implementing a dispersed ownership structure that makes it costly to coordinate a contractual renegotiation. See Appendix B.4 for a general discussion on renegotiation-proof contracts in our setting.

Equilibrium Compensation. We now characterize the equilibrium compensation. As in our illustrative model, we focus our analysis on economies in which the rematching costs are not prohibitively high, ensuring that principals and agents form new outside matches in equilibrium. To do so, we introduce the following notation. For a given pair of $(R, L) \in [0, \frac{\mu}{\gamma}] \times [0, \frac{\mu}{r}]$, we denote the solution to the initial compensation level in the principal optimization problem (2) by $W_0(R, L) = \text{argmax}_{W_0} F(W_0; R, L)$.

Assumption 1. *The termination costs satisfy*

$$0 < \kappa_A \leq W_0(0, 0) \tag{11}$$

$$F(\kappa_A; 0, \bar{L}) - F(0; 0, \bar{L}) \leq \kappa_P \leq F(W_0(0, 0); 0, 0) - F(W_0(0, 0) - \kappa_A; 0, 0), \tag{12}$$

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

Assumption 1 sets bounds on the costs that firms and managers must incur to rematch. We impose this assumption for two reasons. First, it sets upper bounds on the termination costs, ensuring that the equilibrium outside options, R^* and L^*, are positive and the rematching market remains open. Second, it imposes strictly positive termination costs to guarantee that the equilibrium exists. The details are provided in Appendix A.5.

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

$$F'(W_0^*; R^*, L^*) = 0. \tag{13}$$

The intuition for this proposition is as follows. Recall that $F(W; R, L)$ represents the firm's payoff when it promises to deliver an initial value W to the manager, taking as given his outside option R and the firm's liquidation value L. As a result, each firm-manager pair maximizes the firm value at W_0^* as characterized in equation (13). Furthermore, the concavity of $F(W; R, L)$ ensures that (13) has a unique solution for the initial promised value.

4 Equilibrium Inefficiency

In this section, we characterize the socially optimal contract and compare it with the equilibrium one. We show that the 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 planner to intervene and increase social welfare.

4.1 Overcompensation

Social Optimum. To characterize the equilibrium inefficiency, we consider a planner who designs the contracts for all firm-manager pairs. Unlike the private parties, the planner internalizes the effect of individual contracts on the managers' outside options. In this regard, the planner can in principle choose contracts that distinguish between existing and future firm-manager matches. Future contracts influence the managers' outside options, whereas existing matches do not exert such an externality. This asymmetry, also discussed in Section 2, implies the planner's intervention is primarily needed for future contracts. However, implementing selective policies for existing versus future matches may seem infeasible. Therefore, we limit our planner to adopting a time-invariant contract, Γ, applicable to all matches.[10]

As in Section 2, following Dicks (2012) we consider a planner who aims to maximize shareholder values. This criterion allows us to isolate the general equilibrium effect in the clearest possible way. Formally, the planner chooses a contract Γ that delivers an initial compensation level to the manager W_0, while accounting for the levels of the outside option R and the liquidation value L:

$$\max_{\Gamma, W_0, R, L} F_0(Y; \Gamma), \tag{14}$$

subject to (PK) and (IC), as well as conditions (3) and (4).

The interpretation of the planner's problem (14) is as follows. When designing the optimal incentive contracts, the planner cannot mitigate the moral hazard problem associated with cash diversion. Thus, optimal incentive contracts are subject to the same incentive compatibility constraint as before. However, unlike the bilateral contracting problem in (2), the planner takes into account the impact of individual compensation levels on other managers' outside options and other firms' liquidation values. 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 solving 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 3 and of the firm value in Corollary 1 apply. However, as noted earlier, the planner takes into account how the choice of each manager's initial promised value feeds back into the equilibrium outside options. The following proposition accounts for these considerations when deriving the social optimum.

Proposition 2 (Socially Optimal Compensation)**.** *The socially-optimal level of compensa-*

[10] It is nevertheless insightful to explore the outcomes when this constraint is relaxed. We demonstrate that Pareto improvements can be achieved when we allow the time-zero contracts to be different from all future contracts, as detailed in Appendix B.2.

tion W_0^p satisfies the first order condition:

$$F'(W_0^p; R^p, L^p) + \frac{\partial}{\partial R} F(W_0^p; R^p, L^p) \leq 0, \tag{15}$$

which holds with equality if the solution $W_0^p > \kappa_A$; otherwise, $W_0^p = \kappa_A$.

The first term in condition (15), $F'(W_0; R, L)$, captures the partial equilibrium effect of changes in compensation levels on firm value. If the compensation level W_0 increases by \$1, the direct effect on firm value would be an amount $F'(W_0; R, L)$. The second term, $\frac{\partial}{\partial R} F(W_0; R, L)$, accounts for the general equilibrium effect induced by changes in equilibrium outside options in response to the change in compensation levels.

Although encoded into a single term, the general equilibrium effect encompasses two distinct components. First, according to equation (3), 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 equation (4), a \$1 increase in compensation W_0 corresponds to changes in the firms' liquidation value by $(F'(W_0; R, L) + \frac{\partial}{\partial R} F(W_0; R, L))/(1 - \frac{\partial}{\partial L} F(W_0; R, L))$. This calculation combines the two previous effects: the partial equilibrium effect and the general equilibrium effect via endogenous manager outside option. Interestingly, it suggests that when the planner accounts for two previous effects, the general equilibrium effect via endogenous firm liquidation value is also taken care of. The underlying intuition is straightforward: when firm value is maximized, the liquidation value is also maximized. This observation further suggests that the general equilibrium effect comes exclusively from the endogenous manager outside option. We revisit this insight in Section 7.3, where firms foresee the impact of their future contracts on their current ones and therefore coordinate among their own contracts.

It follows immediately from Proposition (2) that the equilibrium compensation exceeds the social optimal level. We summarize this discrepancy below.

Corollary 2 (Overcompensation)**.** *Relative to the planner's solution, the equilibrium features excessively high compensation:*

$$W_0^* > W_0^p.$$

The general equilibrium consideration pushes down the socially desirable compensation level. While individual firms accounts for the direct cost of increasing the initial value to the manager, they fail to internalize that such adjustment leads to higher equilibrium outside options, which imposes costs on other principals seeking to incentive their agents. Indeed, any increment in the outside option is detrimental to shareholder value since a higher outside option renders termination less effective as an instrument for incentive provision. That is,

$\frac{\partial}{\partial R}F(W_0; R, L) < 0$. Let's consider a scenario starting from an equilibrium outcome with the compensation level denoted by W_0^*. Locally, reducing the compensation level leads to a strict improvement in firm value. While the partial equilibrium effect is zero, $F'(W_0^*; R^*, L^*) = 0$, the general equilibrium gain is positive $-\frac{\partial}{\partial R}F(W_0^*; R^*, L^*) > 0$. This suggests that the social optimal compensation W_0^p lies on the upward sloping part of individual firm value function, i.e., $F'(W_0^p; R^p, L^p) > 0$. Absent the planner's intervention, individual principals would be inclined to increase the compensation they offer with the intention to increase shareholder value, failing to internalize the cost their individual compensation packages impose on other principals. Yet, such efforts to improve shareholder value would end up lowering it.

4.2 Insufficient Deferral and Termination

We now examine the dynamic structure of the equilibrium contract relative to the social optimum. We focus on two aspects: (1) the extent of compensation deferral and (2) managerial turnover. To do so, we define the time at which the manager receives his first payment:

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

We recall that τ, as defined in equation (7), represents the time at which the contract is terminated. With these notations at hand, we define for a given initial compensation W the price of an Arrow-Debreu security, $S(W)$, which pays \$1 when the manager receives his first compensation, and the price of an Arrow-Debreu security, $T(W)$, which pays \$1 upon the termination of the manager's contract:

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

We use $S(W_0)$ to measure the timing of managerial pay, where a higher value indicates that the manager is expected to receive his first compensation sooner. Similarly, we use $T(W_0)$ to measure the turnover rate, with a higher value indicating that the manager anticipates his contract will be terminated sooner.

Proposition 3 (Deferral and Turnover)**.** *Compared to the social optimum, the equilibrium features too little deferral, i.e., the payout threshold is closer to the initial promised value:*

$$\bar{W}^* - W_0^* < \bar{W}^p - W_0^p. \tag{16}$$

Further, the equilibrium contract pays the agent too soon and displays an excessively low *turnover:*

$$S^*(W_0^*) > S^p(W_0^p) \quad \textit{and} \quad T^*(W_0^*) < T^p(W_0^p). \tag{17}$$

Proposition 3 first notes that, in the equilibrium, the payout threshold is closer to the initial compensation than it is in the social optimum. This excessive frontloading is an immediate consequence of overcompensation. Recall Lemma 3: to compensate for delayed payment, the manager's continuation value W_t must grow in expectation at a drift γW_t. The cost of delaying payment is thus $(\gamma - r)W_t$, proportional to the value promised to the manager W_t. When the equilibrium displays overcompensation, i.e., $W_0^* > W_0^p$, it is also more costly to delay payments to the manager. Therefore, the firms find it desirable to pay the managers at a threshold closer to the initial promised value.

Overcompensation induces the firms to pay the managers too soon, as indicated by the first inequality in (17). The intuition again lies in the manager's continuation value drifting upward faster, i.e., $\gamma W^* > \gamma W^p$. Meanwhile, the relative distance between the payout threshold and the initial value is smaller. Combining these two factors, we can expect the manager's continuation value to reach the payout threshold sooner.

Overcompensation also leads to excessively long managerial tenure, as indicated by the second inequality in (17). Recall that the distance to termination at the onset of the contract is the same in the equilibrium and the social optimum: $W_0^* - R^* = W_0^p - R^p = \kappa_A$. Again, the manager's continuation value drifts upward faster away from the termination threshold. This effect reduces the likelihood of termination and the turnover rate in the equilibrium. On the other hand, as we concluded earlier, the continuation value is reflected earlier in the equilibrium than in the social optimum. 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.

4.3 Implications for Capital Structure

Our model allows us to examine the interactions between the provision of CEO incentives and capital structure. In their path-breaking paper on security design in partial equilibrium, DeMarzo and Sannikov (2006) focus on a capital structure implementation of the dynamic incentive contract featuring a combination of 1) inside equity, which is at the heart of our equilibrium incentive compensation contract and which easily accommodates dividends paid at the CEO's discretion out of the available amount of cash or credit, 2) perpetual debt with a coupon rD, and 3) a revolving credit line with limit CL and balance B subject to an interest rate γ.

We now compare the implementation above in the equilibrium contract Γ^* featuring overcompensation, too little deferral, and excessive tenure with that of the socially optimal contract Γ^p. In particular, we examine whether the equilibrium levels of long term debt and credit line limits deviate from those that would be chosen by the planner.

Proposition 4 (Long-Term Debt and Credit Line Limits)**.** *In addition to the fraction λ of inside equity granted to the manager, a credit line with limit $CL^* = \lambda^{-1}(\bar{W}^* - R^*)$ and a perpetual debt level $D^* = \frac{\mu}{r} - \frac{\gamma R^*}{r\lambda} - \frac{\gamma}{r}CL^*$ implement the equilibrium contract. Further, this implementation of the equilibrium contract with overcompensation features levels of credit line limits and perpetual debt that are lower than those implementing the socially optimal contract, i.e. $CL^* < CL^p$ and $D^* < D^p$.*

The intuition for why this implementation leads to an incentive compatible contract is simple. The first building block of the incentive contract is the fraction λ of inside equity held by the manager that makes sure that he does at least as well by paying dividends as by diverting cash. The second building block is the line of credit. When the credit line balance is B_t^*, the manager can at any time pay a dividend $CL^* - B_t^*$ that triggers default, but his benefit from doing so must be no greater than W_t. Hence, the credit line limit is set so that the payoff from this deviation is no higher than the payoff W_t that the manager obtains from waiting until the credit line balance is paid in full before paying dividends. Specifically, the credit line limit must satisfy $\lambda(CL^* - B_t^*) \leq (W_t^* - R^*)$ for any level of $B_t^* \geq 0$ so the manager never finds it optimal to divert funds. This is achieved when the credit line limit is no higher than $CL^* = \lambda^{-1}(\bar{W}^* - R^*)$. Then, the manager will want to pay dividends only once the credit line is repaid because the credit line balance is subject to interest rate γ but the manager earns interest at rate $r < \gamma$ on accumulated cash. The final component of the incentive contract is a perpetual debt level that makes sure that $\gamma R^* = \lambda(\mu - rD^* - \gamma CL^*)$ so that the profits to the firm preserve incentives.[11]

Further, Proposition 4 states that $D^* < D^p$ and $CL^* < CL^p$, which obtain from the fact that $\bar{W}^* > \bar{W}^p$ and $(\bar{W}^* - R^*) < (\bar{W}^p - R^p)$, respectively. Equation (16) also implies that $B_0^* < B_0^p$. Intuitively, the socially optimal contract features a capital structure that addresses overcompensation via higher long-term debt, and suboptimally low deferral via a higher initial credit line balance.

[11] If debt were too high, the manager would draw down the credit line immediately, while if it were too low and the firm's profit rate too high, the manager would build up cash reserves after the credit line was paid off in order to reduce termination risk. With the conditions in Proposition 4, the manager will pay dividends if and only if the credit line is fully repaid.

Table 1: Calibrated parameters

Parameter	Value	Moment	Data
Principal discount rate r	0.04	Annual interest rate	4%
Agent discount rate γ	0.09	Ward (2023); Chen et al. (2023)	
Cash flow mean μ	10	Normalization	
Cash flow volatility σ	9	Fraction with operating losses	10-15%
Severity of moral hazard λ	0.29	Ward (2023)	
Principal termination cost κ_P	15	Firing cost CEO replacement	6%
Agent termination cost κ_A	5.3	Forced turnover	2%

5 Quantitative Analysis

In this section, we evaluate the quantitative magnitudes of the compensation externalities characterized in Section 4 using a calibrated model.

5.1 Calibration

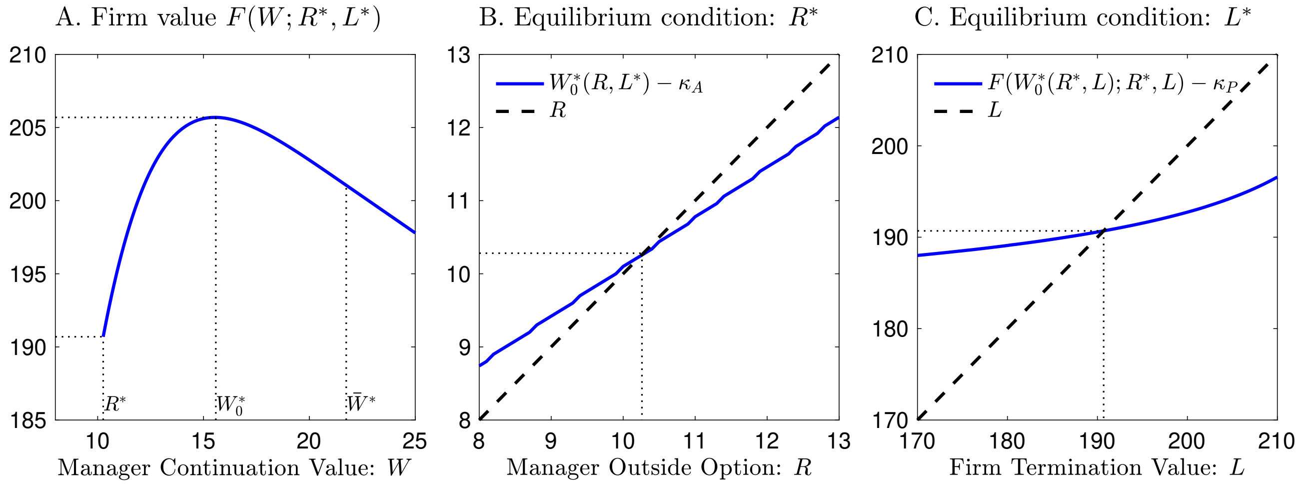
To calibrate the model we split our parameters into two sets. The first set of parameters are taken from the estimates in the literature as they apply directly to our setting. The second set of parameters is more unique to our model and does not have a clear counterpart in the literature. We calibrate these parameters to match data moments. Our calibration is summarized in Table 1.

We start by normalizing the average cash flow μ to 10. Next, the volatility of cash flows σ is set to match the fraction of firms reporting negative operating cash flows in a given year. Denis and McKeon (2018) report that between 1960 and 2016 this fraction increased from 5% in the earlier part of their sample up to 28% toward the end of their sample. Govindarajan et al. (2019) report this fraction to be between 10-15% for larger firms in recent years. We set σ to 9 which implies that 14% of firms in our model incur annual losses.

The principal's discount rate r is taken from Ward (2023) and set to 4%, which matches the annualized real interest rate in the economy. Ward (2023) estimates the manager's discount rate γ at 7%, while Chen et al. (2023) estimate is 11%. We settle for 9% in our baseline calibration. Finally, the extent of moral hazard λ is calibrated to 0.29 as per the estimate in Ward (2023).

We calibrate the principal's termination cost κ_P to align with the estimated firing costs borne by firms in the literature. Overall, the literature has found that shareholders bear substantial costs associated with firing CEOs. Notably, Taylor (2010) estimates these costs to be nearly 6% of firm assets in a structurally estimated model. Thus, we calibrate κ_P to

Figure 2: Equilibrium compensation



Notes: Panel A displays the firm value function for the equilibrium $\{R^*, L^*\}$. In Panel B, the black dashed line and blue solid line represent the left- and right-hand sides of the equilibrium condition (3), respectively, given the equilibrium L^*. The intersection of these two lines determines the equilibrium R^*. Similarly, in Panel C, the black dashed line and the blue solid line illustrate the left- and right-hand sides of the equilibrium condition (4), respectively, given the equilibrium R^*. The point where these two lines intersect pins down the equilibrium L^*.

15 to match a 6% loss in firm value from terminating and replacing the manager.

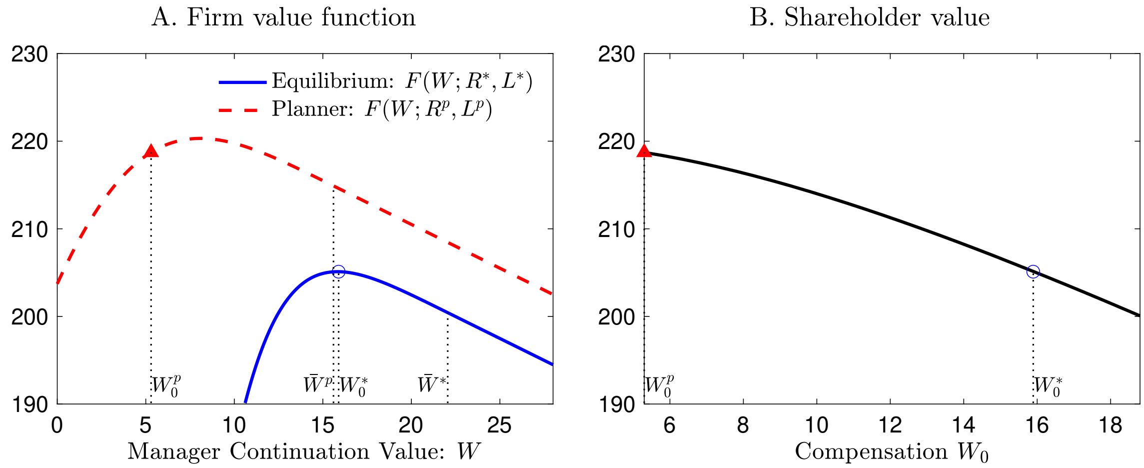
The manager's termination cost κ_A, on the other hand, is closely linked to their termination rate. While the literature indicates that the total annual turnover rate of CEOs is between 10% to 14% (see Fee and Hadlock, 2004; Graham et al., 2020), these numbers include exogenous turnover events like retirement. The turnover rate due to firings, which is our relevant data measure, is significantly lower. For instance, Taylor (2010) reports a forced turnover rate of approximately 2.3%, Eisfeldt and Kuhnen (2013) find a similar rate with a lower bound of around 1.6%, and Jenter and Kanaan (2015) find a rate of 2.8%. Considering these data measures, we calibrate κ_A to 5.3, which leads to a model-implied termination rate of 2.2%.

5.2 Baseline Analysis

Equilibrium. To begin with, we illustrate how the compensation level is determined in equilibrium in Figure 2. Panel B depicts $W_0^*(R, L) - \kappa_A$ obtained from (13) and $R^*(W_0)$ obtained from (3). The equilibrium R^* corresponds to the intersection of these two curves. Panel C depicts $F(W_0^*(R, L); R, L) - \kappa_P$ obtained from (13) and $L^*(F(W_0))$ obtained from (3), and shows the equilibrium L^*.

In the equilibrium, each firm-manager pair designs a contract taking the outside options

Figure 3: Socially optimal compensation



Notes: In Panel A, the blue solid line plots the firm value function for the equilibrium $\{R^*, L^*\}$, while the red dashed line plots the firm value function for the optimal $\{R^p, L^p\}$. Panel B displays the shareholder value obtained at each compensation level.

as given. Panel A depicts the firm's value function $F(W; R^*, L^*)$ in equilibrium. The first dotted line corresponds to the equilibrium $\{R^*, L^*\}$. The second dotted line corresponds to the value promised to the manager W_0^* and the value for the firm $F(W_0^*; R^*)$. The third dotted line depicts the reflecting boundary $\bar{W}$ for the optimal contract where payments to the manager take place.

Overcompensation. Building on this example, Figure 3 illustrates the socially optimal compensation level. Panel B depicts social welfare as a function of the compensation level, W_0. The maximum is obtained at W_0^p (leftward red triangle) and yields a social value of $F(W_0^p; R^p, L^p)$. The equilibrium corresponds to an initial value promised to the manager of W_0^* (blue circle) with associated social welfare equal to $F(W_0^*; R^*, L^*)$. 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 $F(W_0^p; R^p, L^p) - F(W_0^*; R^*, L^*) > 0$. Panel A depicts the respective value functions for the firms in the equilibrium, $F(W; R^*, L^*)$ (blue curve), and in the planner's solution, $F(W; R^p, L^p)$ (dashed red curve).

Deferral and Turnover. We now illustrate the insights obtained in Proposition 3 showing that overcompensation and insufficient deferral and turnover come hand in hand. First we note that the distance between the initial promised value and the payout threshold is larger in the socially optimal contract than in the equilibrium: $\bar{W}^p - W_0^p > \bar{W}^* - W_0^*$, as seen in Panel A of Figure 2. As a result, the manager's compensation features less deferral in the equilibrium than in the social optimum, which can be confirmed by comparing our proxies for pay deferral in our baseline calibration $S^*(W_0^*) = 0.78 > 0.65 = S^p(W_0^p)$. Finally, comparing our proxies for the implied turnover rate we obtain that the turnover rate in the equilibrium contract is too low relative to that of the socially optimal contract $T^*(W_0^*) = 0.17 < 0.21 = T^p(W_0^p)$.

5.3 Comparative Statics

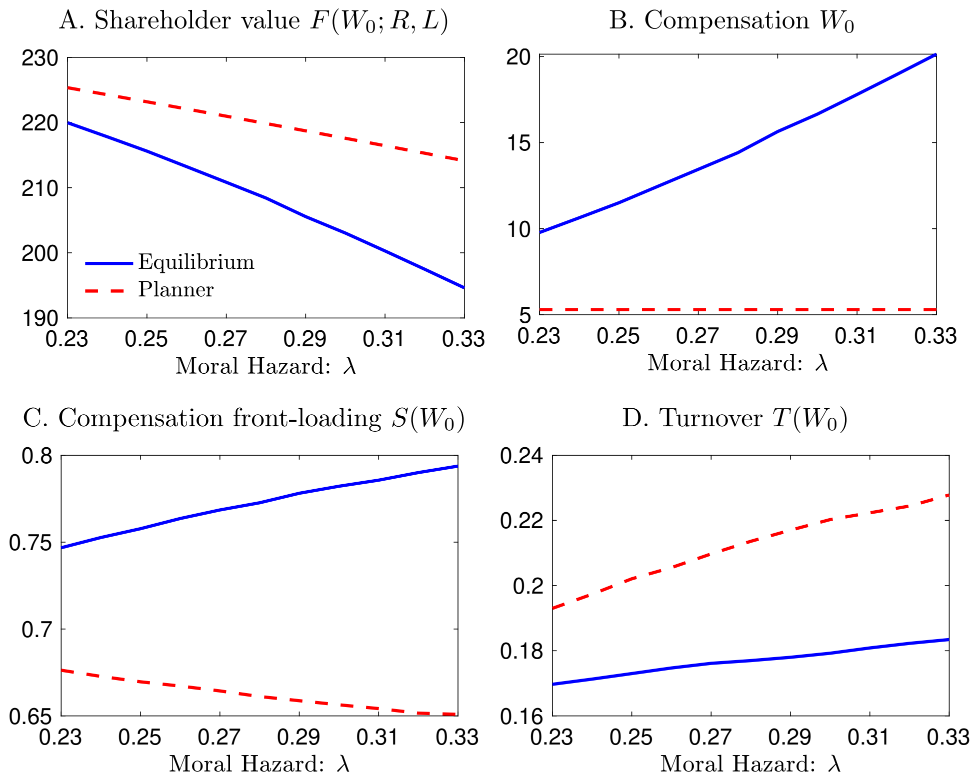
Next, we study comparative statics and show instances with more severe compensation distortions in the level and timing of pay.

Severity of Moral Hazard. Figure 4 depicts comparative statics with respect to the moral hazard parameter λ. As we show, the magnitude of the impact of a manager's compensation on others' compensation increases with the severity of the moral hazard problem. First, Panel A shows that firm value is decreasing in 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 costly terminations. Thus, firm value is decreasing in the severity of moral hazard. Moreover, the welfare gap between the social optimum and the equilibrium is increasing in λ. To see why that is the case, we note that equilibrium compensation is increasing in λ (Panel B). 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." Such an increase in expected managerial rents leads to the severity of overcompensation being increasing in λ. As a result, the equilibrium contract moves further away from the socially optimal contract, which entails a higher level of externalities as the degree of moral hazard increases (Panel A).

Finally, insufficient deferral (Panel C) and turnover (Panel D) are also compounded when there is more moral hazard since the gap between the socially optimal contract and the equilibrium contract grows larger. Intuitively, higher λ leads to greater overcompensation, which in turn makes it very costly for firms to postpone the compensation of an impatient manager. As a result, the manager gets paid sooner, inducing insufficient deferral. A higher λ also induces higher pay-performance sensitive manifested in the form of a higher volatility of the manager's continuation value. Higher volatility leads to a greater turnover rate in both contracts. However, such increment is attenuated in the equilibrium contract by the ever larger promised value to the manager, leading to insufficient turnover relative to the social optimum. Thus, our model implies that managerial overcompensation, as well as insufficient deferral and turnover are most severe in industries in which moral hazard is pervasive.

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

Figure 4: Comparative statics: severity of moral hazard

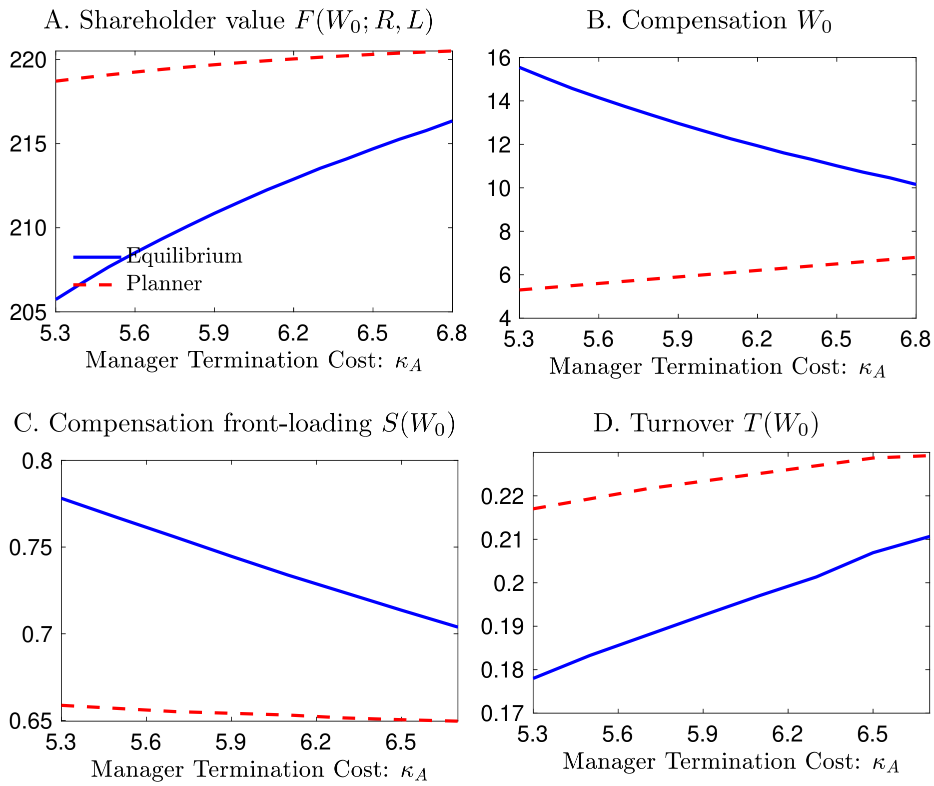


Notes: The figures compare the equilibrium and planner's outcomes as the severity of moral hazard changes. All other parameters are fixed at the calibrated values as reported in Table 1.

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). 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.

Termination Costs. We now explore the asymmetric effect of the termination costs, κ_A and κ_P, on the model's implications. Figure 5 depicts comparative statics with respect to κ_A. Panel A compares the levels of welfare in the social optimum $F(W_0^p; R^p, L^p)$ and the equilibrium $F(W_0^*; R^*, L^*)$. We observe that welfare in both the equilibrium and the social optimum is increasing in the manager's termination cost κ_A, but the gap between these two is decreasing in κ_A. Increasing κ_A is valuable because it leads to less frequent terminations given that there is "more room" for bad shocks to occur without triggering costly termination, since $W_0 - R = \kappa_A$. Importantly, in the 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 in the equilibrium contract (Panel B). Intuitively, a higher κ_A increases the

Figure 5: Comparative statics: agent termination cost

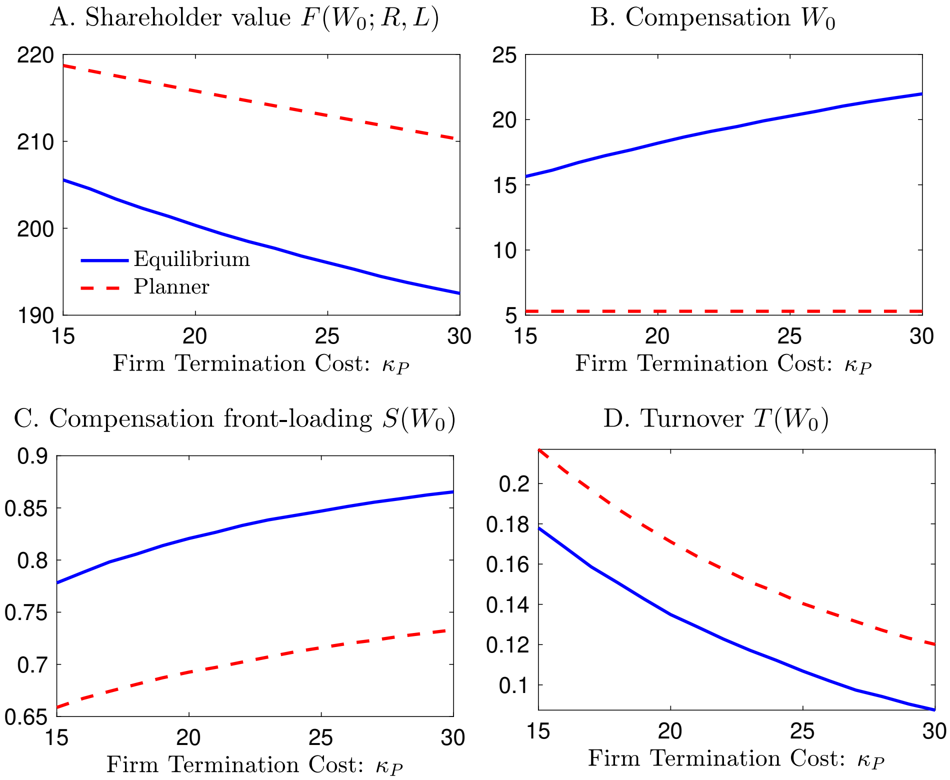


Notes: The figures compare the equilibrium and planner's outcomes as the agent termination cost changes. All other parameters are fixed at the calibrated values as reported in Table 1.

manager's cost to have his contract terminated. Such a force leads to less overcompensation and brings the equilibrium closer to the social optimum. As a result, the welfare gap is decreasing in κ_A. Furthermore, as κ_A increases the equilibrium features less front-loading, thereby bringing the level of deferral closer to that of the social optimum (Panel C). Similarly, the turnover rates in the equilibrium and the social optimum also show a narrower gap (Panel D).

Figure 6 depicts comparative statics with respect to κ_P. Panel A shows that, in contrast to the previous comparative statics, increasing κ_P reduces welfare and increases that the gap between the social optimum and the equilibrium contract. Panel B characterizes the role of κ_P on the degree of overcompensation. 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 equilibrium, leading to a larger welfare gap. The intuition is the following. A higher κ_P increases the firm's cost to terminate the contract, leading to more overcompensation (Panel B). Hence, the equilibrium will move further away from the planner's optimum, inducing a

Figure 6: Comparative statics: principal termination cost



Notes: The figures compare the equilibrium and planner's outcomes as the princiapl termination cost changes. All other parameters are fixed at the calibrated values as reported in Table 1.

larger welfare gap.

Moreover, Panels C and D compare the difference in the timing of pay and the turnover rate between the social optimum and equilibrium as κ_P increases. As expected, a higher κ_P leads to a greater discrepancy between the two contracts in both deferral and turnover rates.

Our 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.

6 Policy Implementation

As discussed above, the equilibrium contract features inefficiencies in pay levels, the timing of pay, and turnover. In this section, we study welfare-improving policy responses. Specifically, we start by considering the impact of non-compete clauses in executive contracts. In Section 6.1, we show how non-compete clauses reduce overcompensation and explore the extent to which they can improve shareholder value. Next, in Section 6.2, we examine how tax imposed on shareholders for their compensation packages and redistributing in a budget-neutral way back to firms can implement the planner's contract as an equilibrium.[12]

6.1 Noncompete Clauses

Noncompete clauses are prevalent in executive contracts (see Garmaise, 2009; Shi, 2023). These clauses reduce managers' outside options, making them a natural contractual tool for potentially alleviating the cost of dynamic agency frictions.

The effect of noncompete clauses is clear in our illustrative two-period model. The social optimum characterized in Lemma 2 can be implemented by noncompete clauses. In case (i), an extreme noncompete clause that completely prohibits managers from joining another firm effectively shuts down all outside matches. In case (ii), a more moderate noncompete clause can be employed, which restricts managers from working for competing firms with a probability of $1-\tilde{x} = 1-\frac{\kappa_A}{\lambda\mu}$. This probabilistic exclusion can also be interpreted as imposing a noncompete duration equivalent to a fraction $\tilde{x}$ of a period.

Similarly, noncompete reduces managers' outside options in our dynamic model. If a manager is subject to a noncompete clause for a duration of π, his outside option reduces to $e^{-\gamma\pi}W_0 - \kappa_A$.[13] Noncompetes can therefore curtail the extent of overcompensation in equilibrium and restore the effectiveness of termination as an incentive device. However, the exclusion also introduces a new externality that adversely affects other firms contracting with managers in the future. As a stronger noncompete clause reduces the manager's outside option, the restriction also hurts firms when they try to hire a replacement manager, effectively reducing their liquidation value to $e^{-r\pi}F_0 - \kappa_P$.

Combining the two effects mentioned above, the overall impact of noncompete clauses generally remains ambiguous. This conclusion aligns with the earlier insights from the two-period model. Recall that in the two-period model, the only tool available to reduce agents' outside options is to shut down outside matches. Such intervention is only worthwhile when the gains exceed the costs. However, in the full model, there are more margins for adjustment, and less costly interventions are available. In summary:

[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.

[13] Shi (2023) introduces the possibility of buyout for workers to be released from the clauses. Such buyout arrangement is particularly relevant in the executive labor market. Here, we treat noncompete clauses as employment exclusion for simplicity.

Lemma 4. *If firms include in the contracts a noncompete clause with a very short duration, i.e., $\pi \to 0$. The effect on equilibrium compensation W_0^* and shareholder value F_0^* is ambiguous. When $r/\gamma \to 0$, compensation W_0^* declines and shareholder value F_0^* improves.*

We take cautionary notes in interpreting the results in Lemma 4 and not extending it broadly. The lemma only considers a moderate noncompete clause with a short duration. If the noncompete clause becomes too severe, the rematching market could shut down, which hurts the firms. More generally, the negative externality brought about by noncompetes is also noted by Franco and Mitchell (2008) and Bond and Newman (2009). Indeed, the anticompetitive effects of noncompetes, which can hinder the reallocation of managers to more productive employment and inhibit the entry of new firms, must be weighed against their benefits in protecting employer investments. This complex trade-off is explored by Shi (2023). Here, we highlight how noncompetes, by limiting managers' outside options, can mitigate dynamic moral hazard externalities, thereby adding another layer to this intricate trade-off. This mechanism is also explored by Chen et al. (2023) quantitatively.

6.2 Taxing Managerial Compensation

We now study the extent to which tax-based policies can mitigate the compensation externalities discussed above.[14] This analysis is motivated by the empirical evidence documenting the response in the structure of compensation packages to the prevailing tax environment (Gorry et al., 2017). In particular, the fact that after 1993 corporations are only allowed to deduct compensation to their executives above 1 million dollars if it is performance-related compensation (Internal Revenue Code 162 (M)) has shifted compensation towards stock-options and bonuses (Hall and Liebman, 2000).

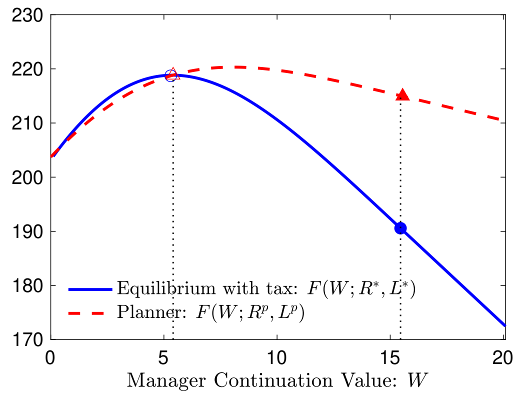
Consider in our model a tax-based policy response to tackle overcompensation and excessive managerial tenure that consists of two instruments: a state dependent corporate tax and a tax on managerial compensation. Specifically, the firms are taxed at a rate α_0 on their profits but receive a flow subsidy $\alpha_1 W$. 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:

$$\mathbb{E}\left[\int_0^{\tau} e^{-rt}((1-\alpha_0)dY_t + \alpha_1 W_t - (1+\alpha_I)dC_t) + e^{-r\tau}L\right]. \tag{18}$$

Figure 7 depicts the planner solution (dashed red curve) and the equilibrium attained

[14] For ease of exposition, we focus here on an all-equity financed implementation.

Figure 7: Policies realigning the equilibrium with the social optimum



Notes: The solid blue line represents shareholder equilibrium value with taxes. The dashed red line corresponds to the planner's solution. The policy experiment is conducted in the calibrated model with parameters reported in Table 1.

under this policy response (solid blue curve). That is, the red curve depicts the value function for the principal under the socially optimal contract from problem (14). The blue line corresponds to the value function of the principal attained in a bilateral contracting problem (as in Section 3.2), but in which the objective function for the principal is given by (18). We note that W_0^p, by design, maximizes the principal value under these tax scheme (i.e., is the argmax of the blue curve). Moreover, both of these contracts are identical since they start at the same initial payoff W_0^p, have the same payout boundary $\bar{W}^p$, the same pay-performance sensitivity λ, and are terminated at R^p. Therefore, the socially optimal contract is implemented in this numerical example as a market equilibrium under the tax scheme described above.

Intuitively, taxing the firm for every dollar paid to the manager $\alpha_I > 0$ reduces over-compensation as it increases the cost of offering a sizable 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 payout, thus addressing insufficient deferral. Together, these instruments exactly implement the planner's compensation contract Γ^p as an equilibrium.

Our findings suggest that the million-dollar rule described above should be further restricted from performance-related pay to incentive-based compensation with a significant deferral component such as stock-options with long vesting periods. By contrast, immediate cash bonuses should be excluded from this deduction, as they promote over-compensation, and do not address any of the discrepancies between the socially optimal contract and the equilibrium contract.

7 Extensions and Robustness

7.1 Endogenous Termination Costs

In this section, we micro-found the termination costs κ_A and κ_P in a search framework specified as follows. Upon termination, the firms post a vacancy to find a new manager, while the managers begin searching for a new job. Before filling the vacancy, the firms incur a flow cost of k, which encompasses both the recruiting costs and any disruption costs incurred while searching for a replacement manager. The vacancy is filled at rate η.[15] Given that there are equivalent measure of firms and managers, the managers are also rematched to a new firm at rate η. Upon being matched, the firms have all the bargaining power and set the compensation package for their managers as specified in Problem (2).

In the search equilibrium, the outside options satisfy:

$$\gamma R = \eta \left(W_0 - R\right)$$
$$rL = -k + \eta \left(F_0 - L\right),$$

which replaces the equilibrium conditions (3) and (4). These new conditions yield

$$R = \frac{\eta W_0}{\eta + \gamma} \quad \text{and} \quad L = \frac{\eta F_0 - k}{\eta + r}.$$

The implied termination costs are

$$\kappa_A = \frac{\gamma W_0}{\eta + \gamma} \quad \text{and} \quad \kappa_P = \frac{rF_0 + k}{\eta + r}.$$

These endogenous termination costs will have features similar to those we impose on the exogenous termination costs in Assumption 1 such that a unique interior equilibrium exists, as long as the vacancy cost is not too high, i.e., $k < \bar{k}$, where $\bar{k}$ leads to an equilibrium firm liquidation value of zero. We characterize the equilibrium compensation and the socially desirably level in the following lemma.

Lemma 5 (Search). *The equilibrium compensation W_0^* is characterized by equation* (13).

[15] We implicitly assume a Cobb-Douglas matching function $M(u, v) = \eta u^{1-a} v^a$, setting $a = 1$. Here, u represents the measure of unemployed managers, and v denotes the measure of vacant firms. We set $a = 1$ to ensure that the optimal bargaining power assigned to firms, in the absence of agency frictions, is 1, in accordance with the Hosios condition. Given that all firms and managers are ex-ante homogeneous, when moral hazard problems are absent, this random search specification with the appropriate bargaining weights is efficient. It is equivalent to an alternative competitive search setup.

Equation (15) that characterizes the socially optimal compensation W_0^p is modified to

$$F'(W_0^p; R^p, L^p) + \frac{\eta}{\eta + \gamma} \frac{\partial}{\partial R} F(W_0^p; R^p, L^p) = 0. \tag{19}$$

The insights in Section 4 would carry through with the endogenous termination costs here. That is, the equilibrium does not coincide with the social optimum in general, and, when moral hazard is sufficiently severe, the equilibrium would feature overcompesnation and insufficient deferral and turnover. The instruments discussed in Section 6 can align competitive equilibrium with the social optimum.

It is instructive to consider the outcomes in the search setting here when moral hazard problems are absent, i.e., when $\lambda = 0$. Since firms hold full bargaining power, this gives rise to an outcome akin to the Diamond paradox (see Diamond, 1971): all firms offer the agents their outside option, $W_0 = R$, which the agents invariably accept, leading to an equilibrium where the outside option R is zero.[16] Under these circumstances, no firm will find it desirable to deviate from this strategy. While the Diamond paradox often raises concerns about distributional consequences for worker wellbeing, the outcome is nevertheless efficient and termination never occurs. However, when agency friction is introduced, i.e., $\lambda > 0$, individual firms now find it desirable to deviate and offer the agents more than their outside option, $W_0 > R$, for incentive provision. This force breaks the Diamond paradox and leads to the equilibrium described here. Crucially, the equilibrium outside option affects the effectiveness of termination threats and, consequently, the extent agents can extract rent, which are socially costly and leads to sources of inefficiency.

7.2 Bargaining Power

In our baseline analysis, firms have all the bargaining power, i.e., they make take-it-or-leave-it contract offers to managers. Consequently, managers can only extract rents through their ability to divert cash, but not in negotiating compensation contracts with firms.

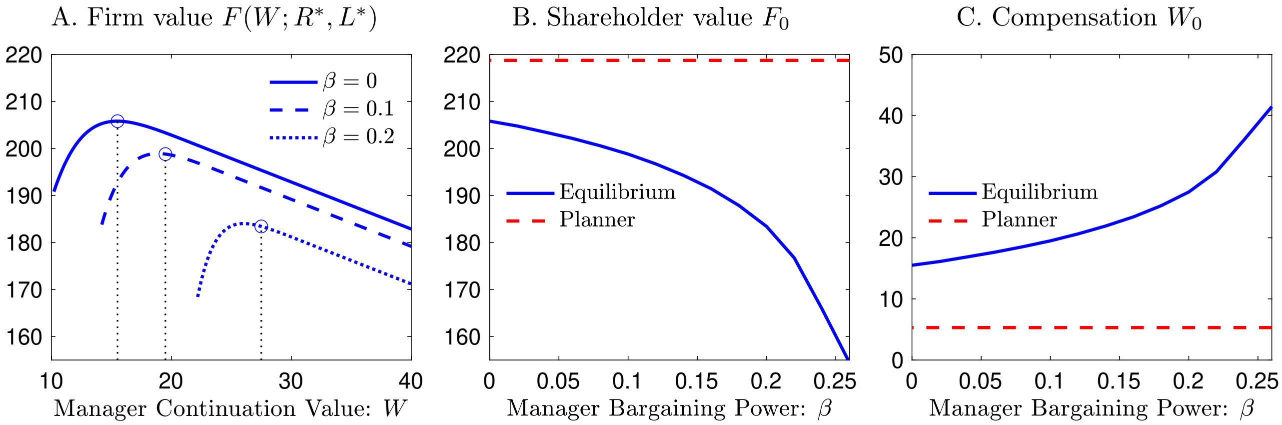
We now extend our baseline setting by allowing a general Nash bargaining between the firms and their managers. A firm-manager pair bargain to split the surplus generated by the match. Specifically, let $\beta \in [0, 1]$ denote the manager's bargaining power, and $1 - \beta$ the firm's bargaining power. Effectively, the pair bargain for an initial compensation level W_0 that solves:

$$\max_{W_0} \; (F(W_0; R, L) - L)^{1-\beta} (W_0 - R)^{\beta}. \tag{20}$$

This extension embeds our baseline case when the firm has all the bargaining power, i.e.,

[16] The zero outside option can be thought of as a normalization relative to the value of unemployment.

Figure 8: Comparative statics with respect to bargaining power β



Notes: We restrict our attention to agent bargaining power $\beta \in [0, \frac{\kappa_A}{\kappa_A+\kappa_P}]$. In our calibrated model, the upper bound $\frac{\kappa_A}{\kappa_A+\kappa_P}$ is 0.26. The equilibriun outcomes are computed for each level of bargaining power while maintaining the calibrated parameters reported in Table 1.

$\beta = 0$. In this case, the bargaining problem (20) becomes problem (2).

The following lemma characterizes how bargaining powers changes the equilibrium level of compensation.

Lemma 6 (Bargaining)**.** *If $\beta \le \frac{\kappa_A}{\kappa_A+\kappa_P}$, the equilibrium compensation W_0^* is characterized by:*

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

When agents have a higher bargaining power β, the equilibrium features a higher compensation, and the extent of overcompensation worsens, i.e., $\frac{\partial W_0^*}{\partial \beta} > 0$ and $\frac{\partial(W_0^*-W_0^p)}{\partial \beta} > 0$.

The insights in Lemma 6 are intuitive. When agents have no bargaining power, the principals are able to set the compensation package in the best interests of the shareholder, taking as given the outside options. However, as the agent bargaining power increases, they are able to extract more rent and obtain higher compensation. Still, if the agent bargaining power is limited, $\beta \le \frac{\kappa_A}{\kappa_A+\kappa_P}$, condition (21) implies that $F'(W_0^*;R^*,L^*) \ge -1$, suggesting that the initial promised value is below the payout threshold $W_0^* \le \bar{W}^*$.[17]

Figure 8 illustrates how agent bargaining power can worsen the extent of equilibrium overcompensation in our calibrated model. Panel A displays the equilibrium outcomes under three bargaining regimes. As agents gain a stronger bargaining power, the firm's value function deteriorates, a direct consequence of higher agent outside options. Furthermore, firms must concede by promising to the agents a higher pay, further eroding shareholder

[17] If the agent bargaining power strengthens beyond $\frac{\kappa_A}{\kappa_A+\kappa_P}$, their initial promised value exceeds the payout threshold, the excess amount $W_0^* - \bar{W}^*$ is immediately paid out as a signup bonus.

value. Panels B and C show that increasing the agent bargaining power from none to around 0.25 can more than double the compensation package and lead to disproportionately larger losses in shareholder value.

7.3 Firms Internalizing Endogenous Liquidation Value

The equilibrium inefficiencies arise from the firms' inability to coordinate their contracts. We now relax this assumption and consider an alternative contracting process in which firms can coordinate among their own contracts across time. When contracting with its current manager, the firm can foresee that its liquidation value at termination depends on its contract with the next 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. Formally, in problem (2), in addition to the (PK) and (IC) constraints, the firm takes into account the endogenous liquidation value according to equation (4).

Despite firms taking into account additional considerations, it turns out that the equilibrium characterization in Proposition 1 and the social optimum in Proposition 2 remain exactly unchanged. We formally describe this equivalence in the subsequent lemma.

Lemma 7 (One-Sided Coordination)**.** *When the firm accounts for its endogenous liquidation value, the equilibrium compensation W_0^* is also characterized by equation* (13)*. The socially optimal compensation is also characterized by equation* (15)*.*

The intuition for Lemma 7 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 their own contracts, the same externality as in the baseline economy remains in equilibrium. This is 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 on whether executives are paid too much. These features have been argued to be due to managerial rent extraction motives (Bebchuk and Fried (2003); Edmans et al. (2017)). As discussed in Bolton et al. (2006), there are major issues with this view: first, executive pay has been shown to increase particularly when CEOs move to a new firm (Falato et al., 2015); second, the growing transparency of CEO pay facilitated by institutional arrangements such as mandated disclosure and say on pay has been followed by increases rather than reductions in competitive CEO pay (Choi et al., 2021). In this paper, we develop a general equilibrium model featuring dynamic moral hazard and we find results consistent with these empirical findings. Our main finding indicates that in a laissez-faire equilibrium compensation is excessively high compared to the optimal benchmark. While each firm-manager pair chooses an optimally private contract, it fails to internalize its effect on the endogenous outside option available to managers. This mechanism induces larger compensation packages and good equilibrium outside options for managers in the economy, which in turn generates insufficient deferral and excessively long managerial tenure.

Our paper shows that these inefficiencies due to the overcompensation externality hold depsite shareholders holding full bargaining power. Inefficiencies are most prominent when shareholders have weak bargaining power and idiosyncratic volatility is high. All of these forces may have contributed to exacerbating overcompensation and over the past decades. 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.

The current manuscript suggests a number of avenues for future research, as the model here was intentionally kept simple and leaves out many interesting forces. When considering heterogeneity of manager quality, will learning about manager quality and the resulting signaling impact of termination on managers' outside option help to mitigate the externality identified here? More broadly, will the inefficiencies we highlight generate excessively high and short-term investment in both tangible and intangible assets? If managers can take actions whose consequences can only be observed in the distant future, will the competitive equilibrium feature different compensation patterns and different capital structures? 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))? What are the policy interventions that should address inefficiencies in these realistic scenarios?

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A Proofs

A.1 Proof of Lemma 1

Substituting the constraint (IC-1) in the principal's objective and organizing the terms, we obtain

$$\max_{x}\ 2(1-\lambda)\mu+(1-x)\left[p(\delta\lambda\mu-R)-(1-p)((1-\lambda)\mu-L)\right].$$

Imposing the equilibrium outside option and liquidation, $R=\delta\lambda\mu-\kappa_A$ and $L=(1-\lambda)\mu-\kappa_P$:

$$\max_{x}\ 2(1-\lambda)\mu+(1-x)\left[p\kappa_A-(1-p)\kappa_P\right].$$

If $\kappa_A\leq\frac{1-p}{p}\kappa_P$, the agents continue, i.e., $x=1$.[18] Thus, the shareholder value is $2(1-\lambda)\mu$. The agents are paid in the high state in period 1, $c=\lambda y$, making the expected compensation $\delta p\lambda y+\delta^2 p\lambda y=(\delta+\delta^2)\lambda\mu$.

If $\kappa_A>\frac{1-p}{p}\kappa_P$, the agents are terminated in the low state, i.e., $x=0$. The shareholder value is $2(1-\lambda)\mu+p\kappa_A-(1-p)\kappa_P$. The agents are rewarded in the high state in period 1 $c+\delta\lambda\mu=R+\lambda y$, making their expected compensation $\delta\left[p(R+\lambda y)+(1-p)R\right]=\delta(R+\lambda\mu)=(\delta+\delta^2)\lambda\mu-\delta\kappa_A$.

A.2 Proof of Lemma 2

If $\kappa_A\geq\delta\frac{\lambda}{1-\lambda}\kappa_P$, the outside option R hits zero before the liquidation value L does. In this case, the planner would wish to set $\tilde{x}\geq\frac{\kappa_A}{\delta\lambda\mu}$. Substituting the constraints (IC-1) and (1) into the planner's objective, organizing the terms, and denoting $\Delta\equiv p\delta\lambda-(1-p)(1-\lambda)$ for notational ease, we obtain:

$$\max_{x,\tilde{x}}\ 2(1-\lambda)\mu+(1-x)\left[(1-\tilde{x})\Delta\mu+p\kappa_A-(1-p)\kappa_P\right].$$

If $\Delta>0$, the planner would wish to terminate some of the projects for outside matches. By setting $\tilde{x}=\frac{\kappa_A}{\delta\lambda\mu}$, the shareholder value is: $2(1-\lambda)\mu+\left(1-\frac{\kappa_A}{\delta\lambda\mu}\right)\Delta\mu+p\kappa_A-(1-p)\kappa_P$. The conditions in this scenario imply that $\kappa_A>\frac{1-p}{p}\kappa_P$. Thus, the shareholder value increases by $\left(1-\frac{\kappa_A}{\delta\lambda\mu}\right)\Delta\mu$.

If $\kappa_A<\delta\frac{\lambda}{1-\lambda}\kappa_P$, the liquidation value L hits zero first. In this case, if $\Delta>0$, the planner wishes to shut down outside projects and would do so by setting $\tilde{x}=0$. The shareholder value is $2(1-\lambda)\mu+\Delta\mu$. Depends on whether termination takes place in equilibrium. If

[18] When $\kappa_A=\frac{1-p}{p}\kappa_P$, the principals are indifferent between terminating the agents or not. Since no termination makes the agents better off, we assume this to be the equilibrium.

$\kappa_A \le \frac{1-p}{p}\kappa_P$, the shareholder value improves by $\Delta\mu$. Othwerise, the shareholder value improves by $\Delta\mu - p\kappa_A + (1-p)\,\kappa_P$.

A.3 Proof of Lemma 3 and Corollary 1

See Proposition 1 in DeMarzo and Sannikov (2006).

A.4 Preliminary Results

We establish several preliminary results that will be used repeatedly later.

Lemma 8. *Let $F(W;R,L)$ and $G(W;R',L')$ be two solutions of* (8)-(10)*.*

(i) If $\bar{W}^F < \bar{W}^G$, then $F'(\bar{W}^F - \Delta) < G'(\bar{W}^G - \Delta)$ for all $\Delta > 0$. Further, $\bar{W}^F - W_0^F > \bar{W}^G - W_0^G$ and $F(W_0^F) > G(W_0^G)$;

(ii) If $W_0^F \le W_0^G$ and $F(W_0^F) > G(W_0^G)$, then $F'(W_0^F - \Delta) < G'(W_0^G - \Delta)$ for all $\Delta > 0$.

Proof. **Item (i).** We start by observing that $F''\left(\bar{W}\right) = 0$. We then differentiate equation (8) once and obtain that $F'''\left(\bar{W}\right) = (\gamma - r)\frac{2}{\lambda^2\sigma^2} > 0$. We also differentiate equation (8) twice and obtain that $F''''(\bar{W}) = -\gamma\bar{W}(\gamma - r)(\frac{2}{\lambda^2\sigma^2})^2 < 0$. Taking a Taylor expansion for $F(\cdot)$ and $G(\cdot)$ around $\bar{W}^F$ and $\bar{W}^G$ respectively, implies that locally $F'(\bar{W}^F - \varepsilon) < G'(\bar{W}^G - \varepsilon)$, since $\bar{W}^F < \bar{W}^G$. Now, suppose for a contradiction that there exists $\Delta > 0$ such that $F'(\bar{W}^F - \Delta) \ge G'(\bar{W}^G - \Delta)$. Pick the smallest such $\Delta > 0$. By continuity it must be that $F'(\bar{W}^F - \Delta) = G'(\bar{W}^G - \Delta)$. Further, it must be that $F''(\bar{W}^F - \Delta) < G''(\bar{W}^G - \Delta)$.

With this information, we have that, on the one hand, we can integrate backward from the payout boundary and using equation (10):

$$F(\bar{W}^F - \Delta) = F(\bar{W}^F) - \int_{\bar{W}^F - \Delta}^{\bar{W}^F} F'(x)dx = \left(\frac{\mu}{r} - \frac{\gamma}{r}\bar{W}^F\right) - \int_{\bar{W}^F - \Delta}^{\bar{W}^F} F'(x)dx.$$

$$G(\bar{W}^G - \Delta) = G(\bar{W}^G) - \int_{\bar{W}^G - \Delta}^{\bar{W}^G} G'(x)dx = \left(\frac{\mu}{r} - \frac{\gamma}{r}\bar{W}^G\right) - \int_{\bar{W}^G - \Delta}^{\bar{W}^G} G'(x)dx.$$

Subtracting the two equations above we obtain that:

$$F(\bar{W}^F - \Delta) - G(\bar{W}^G - \Delta) > \frac{\gamma}{r}(\bar{W}^G - \bar{W}^F), \tag{22}$$

where the last inequality follows from $F'(x) < G'(x)$ in the range of integration.

On the other hand, evaluating (8) at $\bar{W}^F - \Delta$ and $\bar{W}^G - \Delta$ respectively for $F(\cdot)$ and $G(\cdot)$ yields:

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

which is a contradiction to (22).

Assessing $F'(\bar{W}^F - \Delta) < G'(\bar{W}^G - \Delta)$ at $\Delta = \bar{W}^G - W_0^G$, we obtain $F'(W_0^F - (\bar{W}^G - W_0^G)) < G'(W_0^G) = 0$. It must be that

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

Finally, integrating backward from the respective payout boundaries to the peak points implies $F(W_0^F) > G(W_0^G)$.

Item (ii). We start with $F(W_0^F) > G(W_0^G)$. Equation (8) implies that $F''(W_0^F) > G''(W_0^G)$. Then locally $F'(W_0^F - \varepsilon) < G'(W_0^G - \varepsilon)$. We show that this relation can be extended out. Suppose not. Then we can find the smallest $\Delta > 0$ such that the relation is violated. By continuity it must be that $F'(W_0^F - \Delta) = G'(W_0^G - \Delta)$. Further, it must be that $F''(W_0^F - \Delta) < G''(W_0^G - \Delta)$.

With this information, on the one hand, we can integrate from the peak points:

$$\begin{aligned} F(W_0^F - \Delta) &= F(W_0^F) - \int_{W_0^F - \Delta}^{W_0^F} F'(x)dx \\ G(W_0^G - \Delta) &= G(W_0^G) - \int_{W_0^G - \Delta}^{W_0^G} G'(x)dx. \end{aligned}$$

Subtracting the two equations above we obtain that:

$$F(W_0^F - \Delta) - G(W_0^G - \Delta) > F(W_0^F) - G(W_0^G) > 0, \tag{23}$$

where the first inequality above follows from $F'(x) < G'(x)$ in the range of integration.

On the other hand, evaluating (8) at $W_0^F - \Delta$ and $W_0^G - \Delta$ respectively for $F(\cdot)$ and $G(\cdot)$ yields:

$$\begin{aligned} F(W_0^F - \Delta) - G(W_0^G - \Delta) &= \frac{\gamma}{r}(W_0^F - W_0^G)F'(W_0^F - \Delta) + \frac{\sigma^2\lambda^2}{2r}(F''(W_0^F - \Delta) - G''(W_0^G - \Delta)) \\ &< \frac{\gamma}{r}(W_0^F - W_0^G)F'(W_0^F - \Delta) \leq 0, \end{aligned}$$

which is a contradiction to (23).

□

Lemma 9. *The peak point of firm value function $W_0(R, L)$ satisfy*

$$0 < \frac{\partial}{\partial R} W_0(R, L) < 1.$$

Proof. Consider $R^F < R^G$. Let $F(W; R^F, L)$ and $G(W; R^G, L)$ be two solutions of (8)-(10). Using the results established by DeMarzo and Sannikov (2006), we know that $W_0^F < W_0^G$ and $F(W_0^F) > G(W_0^G)$. Using the result in item (ii) of Lemma 8, we obtain $F'(W_0^F - \Delta) < G'(W_0^G - \Delta)$ for all $\Delta > 0$. Integrating from the termination boundary to the respective peak points and subtracting yields:

$$F(W_0^F) - G(W_0^G) = \left(L + \int_{R^F}^{W_0^F} F'(W)dW \right) - \left(L + \int_{R^G}^{W_0^G} G'(W)dW \right) > 0.$$

It must be then that the integration range satisfies $W_0^G - R^G < W_0^F - R^F$. Therefore:

$$0 < \frac{W_0^G - W_0^F}{R^G - R^F} < 1. \tag{24}$$

Taking the limit as $R^G \to R^F$ from above implies $0 < \frac{\partial}{\partial R} W_0(R, L) < 1$.

□

Lemma 10. *The following firm value function $F(W; R, L)$ satisfies: $\forall W < \bar{W}$,*

$$\frac{\partial}{\partial R} F'(W; R, L) > 0, \tag{25}$$

$$\frac{\partial}{\partial L} F'(W; R, L) < 0. \tag{26}$$

Proof. Consider $R^F < R^G$. This implies that the two value functions for these respective outside options satisfy $F(W; R^F, L) > G(W; R^G, L)$, and therefore the payout boundaries satisfy $\bar{W}^F < \bar{W}^G$. We can now apply item (i) of Lemma 8. That is, we know that:

$$F'(\bar{W}^F - \Delta) < G'(\bar{W}^G - \Delta), \forall \Delta > 0. \tag{27}$$

Then $\forall W < \bar{W}^F$, the following holds:

$$F'(W) < G'\left(\bar{W}^G - (\bar{W}^F - W)\right) < G'(W).$$

The first inequality is obtained by setting $\Delta = \bar{W}^F - W$ in (27), and the second inequality follows from the concavity of $G(\cdot)$ and $\bar{W}^G - \bar{W}^F > 0$.

Taking the limit as $R^G \to R^F$ from above implies that $\frac{\partial}{\partial R} F'(W; R, L) > 0$. The proof of the second part of the lemma follows an identical structure as the argument above. □

A.5 Proof of Proposition 1 and Corollary 6

In addition to $\frac{\partial W_0(R,L)}{\partial R} > 0$ established in Lemma 9, the following properties are established in DeMarzo and Sannikov (2006):

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

We show existence and uniqueness of interior equilibrium under Assumption 1.

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

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

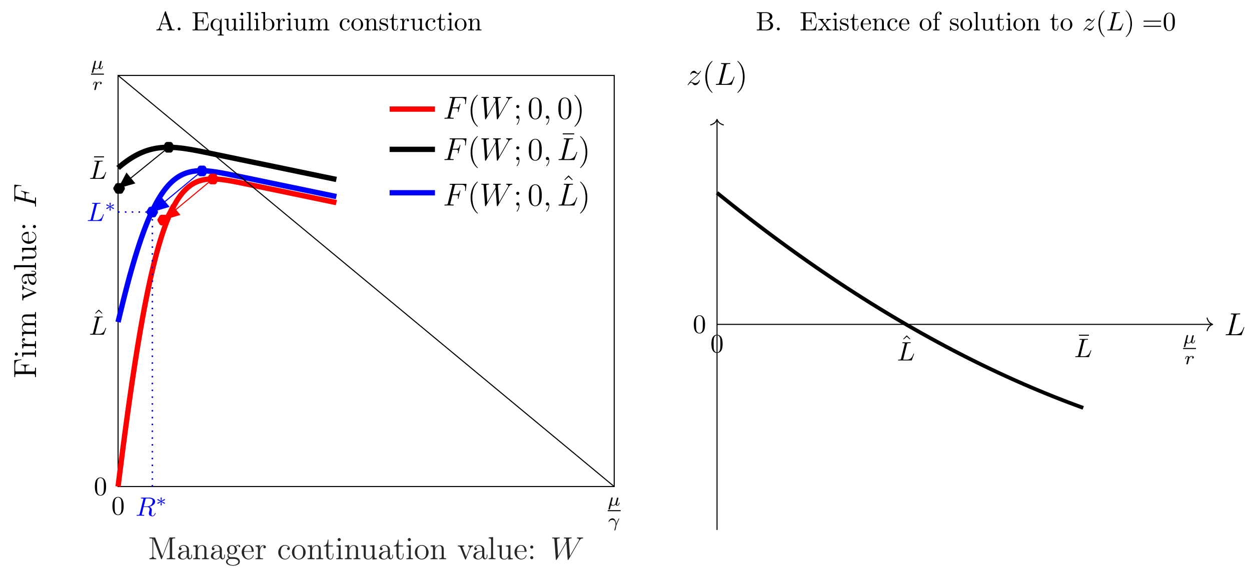
Let $R^* \equiv W_0(0, \hat{L}) - \kappa_A$ and $L^* \equiv F(R^*; 0, \hat{L})$. We have $R^* \geq W_0(0, \bar{L}) - \kappa_A = 0$ and $L^* \geq \hat{L} \geq 0$. Note that the pair of outside options (R^*, L^*) delivers the same firm value function as $(0, \hat{L})$, i.e., $F(W; R^*, L^*) = F(W; 0, \hat{L})$. 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 conditions (3) and (4) must hold at (R^*, L^*):

$$\begin{aligned} R^* &= W_0(R^*, L^*) - \kappa_A \\ L^* &= F(W_0(R^*, L^*); R^*, L^*) - \kappa_P. \end{aligned}$$

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

Notice that in the argument above we need the termination costs κ_A and κ_P to be strictly positive. Indeed, when termination is costless either on the firm side or on the manager side,

Figure 9: Illustration for equilibrium existence



equilibria may not exist. While these cases are technically interesting, we leave them aside.

Uniqueness. 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 $F'(W_0^F) = G'(W_0^G) = 0$.

Since $F(W_0^F) > G(W_0^G)$, according to item (i) of Lemma 8, it must be $\bar{W}^F < \bar{W}^G$. If this were not the case, we would find the contradiction that $F(W_0^F) \leq G(W_0^G)$. Item (i) of Lemma 8 also implies that:

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

Combining $W_0^F < W_0^G$ with $F(W_0^F) > G(W_0^G)$, item (ii) of Lemma 8 implies that $F'(W_0^F - \Delta) < G'(W_0^G - \Delta)$ for all $\Delta > 0$. Applying the equilibrium condition for the rematching cost of the firm we further obtain that:

$$\kappa_P = F(W_0^F) - F(R^F) = \int_{W_0^F - \kappa_A}^{W_0^F} F'(x)dx < \int_{W_0^G - \kappa_A}^{W_0^G} G'(x)dx = G(W_0^G) - G(R^G) = \kappa_P.$$

which is a contradiction, and therefore the equilibrium must be unique.

Finally, we solve the equilibrium condition. Taking the first-order condition with respect to W_0 and replacing the equilibrium conditions (3) and (4), we obtain equation (13).

A.6 Proof of Proposition 2

To obtain the planner's optimality condition, we take the total differential of the firm value in (14) with respect to W_0:

$$F'(W_0; R, L) + \frac{\partial F(W_0; R, L)}{\partial R}\frac{\partial R}{\partial W_0} + \frac{\partial F(W_0; R, L)}{\partial L}\frac{\partial L}{\partial W_0} = 0. \tag{28}$$

The first term in equation (28) captures the direct effect of changes in W_0; the next two terms captures the indirect effects induced by changes in equilibrium outside options in response to changes in W_0.

Differentiating equations (3) and (4) with respect to W_0 yields:

$$\frac{\partial R}{\partial W_0} = 1 \tag{29}$$

$$\frac{\partial L}{\partial W_0} = \frac{F'(W_0; R, L) + \frac{\partial F(W_0;R,L)}{\partial R}}{1 - \frac{\partial F(W_0;R,L)}{\partial L}}. \tag{30}$$

Substituting equations (29) and (30) in the first-order condition (28), reorganizing, and denoting the variables with superscript p for the planner's solution yields equation (15), adjusting for the possibility of a corner solution.

$$F'(R + \kappa_A; R, L) + \frac{\partial F(R + \kappa_A; R, L)}{\partial R} = 0. \tag{31}$$

A.7 Proof of Proposition 3

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 item (i) of Lemma 8, we obtain that $\bar{W}^p - \hat{W}^p > \bar{W}^* - W^*$. Therefore,

$$\bar{W}^p - W_0^p > \bar{W}^p - \hat{W}^p > \bar{W}^* - W_0^*, \tag{32}$$

where the first inequality follows from the fact that overcompensation implies that $\hat{W}^p > W_0^p$. Thus, we obtain (16).

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

$$r\tilde{S}(\Delta) = \gamma(\Delta + R)\tilde{S}'(\Delta) + \frac{1}{2}\lambda^2\sigma^2\tilde{S}''(\Delta), \tag{33}$$

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

We now claim 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 (33) 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.

A.8 Proof of Proposition 4

The validity of the implementation follows directly from Proposition 3 in DeMarzo and Sannikov (2006). That debt D is larger in the socially optimal contract than in the competitive equilibrium follow from $\bar{W}^p > \bar{W}^*$, as implied by the fact that $F(W; R^p, L^p) > F(W; R^*, L^*)$. Similarly, that the credit limit CL is larger in the socially optimal contract than in the competitive equilibrium follows from combining condition (16) and $W_0 = R + \kappa_A$.

A.9 Proof of Lemma 4

A noncompete clause of duration π affects the equilibrium conditions for manager's outside option and the firm's liquidation value as follows:

$$R = e^{-\gamma\pi} W_0(R, L) - \kappa_A, \tag{34}$$

$$L = e^{-r\pi} F\left(W_0(R, L); R, L\right) - \kappa_P. \tag{35}$$

We restrict our attention to a very short noncompete duration, $\pi \to 0$, such that the equilibrium conditions above imply positive R and L. Differentiating equations (34) and (35) with respect to π and imposing $\pi = 0$:

$$\frac{\partial R}{\partial \pi} = -\gamma W_0(R,L) + \frac{\partial W_0(R,L)}{\partial R}\frac{\partial R}{\partial \pi} + \frac{\partial W_0(R,L)}{\partial L}\frac{\partial L}{\partial \pi} \tag{36}$$

$$\frac{\partial L}{\partial \pi} = -rF\left(W_0(R,L); R, L\right) + \frac{\partial F\left(W_0(R,L); R, L\right)}{\partial R}\frac{\partial R}{\partial \pi} + \frac{\partial F\left(W_0(R,L); R, L\right)}{\partial L}\frac{\partial L}{\partial \pi}. \tag{37}$$

Equation (37) implies that:

$$\frac{\partial L}{\partial \pi} = \frac{-rF\left(W_0(R,L); R, L\right) + \frac{\partial F(W_0(R,L);R,L)}{\partial R}\frac{dR}{d\pi}}{1 - \frac{\partial F(W_0(R,L);R,L)}{\partial L}}$$

Substituting the effect $\partial L/\partial \pi$ in (36), we obtain:

$$\frac{\partial R}{\partial \pi} = -\frac{\gamma W_0(R,L)\left(1 - \frac{\partial F(W_0(R,L);R,L)}{\partial L}\right) + rF\left(W_0(R,L); R, L\right)\frac{\partial W_0(R,L)}{\partial L}}{1 - \frac{\partial W_0(R,L)}{\partial R} - \frac{\partial F(W_0(R,L);R,L)}{\partial L}}.$$

The overall effect on the equilibrium compensation:

$$\begin{aligned}
\frac{\partial W_0(R,L)}{\partial \pi} &= \frac{\partial W_0(R,L)}{\partial R}\frac{\partial R}{\partial \pi} + \frac{\partial W_0(R,L)}{\partial L}\frac{\partial L}{\partial \pi} \\
&= \frac{\partial R}{\partial \pi} + \gamma W_0(R,L) \\
&= -\frac{\gamma W_0(R,L)\frac{\partial W_0(R,L)}{\partial R} + rF\left(W_0(R,L); R, L\right)\frac{\partial W_0(R,L)}{\partial L}}{1 - \frac{\partial W_0(R,L)}{\partial R} - \frac{\partial F(W_0(R,L);R,L)}{\partial L}}.
\end{aligned}$$

In the expression above, given that $\frac{\partial W_0(R,L)}{\partial R} > 0$ but $\frac{\partial W_0(R,L)}{\partial L} < 0$, the overall effect is ambiguous. When $r/\gamma \to 0$, the former term dominates.

The overall effect on equilibrium shareholder value:

$$\begin{aligned}
\frac{\partial F\left(W_0(R,L); R, L\right)}{\partial \pi} &= \frac{\partial F\left(W_0(R,L); R, L\right)}{\partial R}\frac{\partial R}{\partial \pi} + \frac{\partial F\left(W_0(R,L); R, L\right)}{\partial L}\frac{\partial L}{\partial \pi} \\
&= \frac{\partial L}{\partial \pi} + rF\left(W_0(R,L); R, L\right) \\
&= -\frac{\gamma W_0(R,L)\frac{\partial F(W_0(R,L);R,L)}{\partial R} + rF\left(W_0(R,L); R, L\right)\frac{\partial F(W_0(R,L);R,L)}{\partial L}}{1 - \frac{\partial W_0(R,L)}{\partial R} - \frac{\partial F(W_0(R,L);R,L)}{\partial L}}.
\end{aligned}$$

In the expression above, given that $\frac{\partial F(W_0(R,L);R,L)}{\partial R} < 0$ but $\frac{\partial F(W_0(R,L);R,L)}{\partial L} > 0$, the overall effect is also ambiguous. When $r/\gamma \to 0$, the former term dominates.

A.10 Proof of Lemma 5

The proof follows the same steps as those in Section A.6 for Proposition 2. We incorporate the modified equilibrium relations between the outside options and the match values:

$$\frac{\partial R}{\partial W_0} = \frac{\eta}{\eta+\gamma} \tag{38}$$

$$\frac{\partial L}{\partial W_0} = \frac{\eta}{\eta+r}\frac{F'(W_0;R,L)+\frac{\eta}{\eta+\gamma}\frac{\partial F(W_0;R,L)}{\partial R}}{1-\frac{\eta}{\eta+r}\frac{\partial F(W_0;R,L)}{\partial L}}. \tag{39}$$

Substituting equations (38) and (39) in the first-order condition (15), reorganizing, and denoting the variables with superscript p for the planner's solution yields equation (19).

A.11 Proof of Lemma 6

In problem (20), we derive the first-oder condition with respect to W_0 and impose the equilibrium conditions (3) and (4):

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

Recall that $F'(W;R,L)\geq -1$ for $W\in[R,\bar{W}]$. Restricting our attention to situations that $\beta\leq\frac{\kappa_A}{\kappa_A+\kappa_P}$, we have an interior solution $W_0\leq\bar{W}$. We thus obtain condition (21).

Making explicit the dependence of equilibrium quantities on the parameter β, we now differentiate (21) with respect to β yielding:

$$F''(W_0^*;R,L)\frac{\partial W_0^*}{\partial\beta}+\frac{\partial F'(W_0^*;R,L)}{\partial R}\frac{\partial R}{\partial\beta}+\frac{\partial F'(W_0^*;R,L)}{\partial L}\frac{\partial L}{\partial\beta} = -\frac{1}{(1-\beta)^2}\frac{\kappa_P}{\kappa_A}<0.$$

The first term captures the partial equilibrium effect (i.e., fixing R and L): when the agent bargaining power β increases, the compensation level W_0 increases. The second and third terms account for the general equilibrium effects: R increases (i.e., $\frac{\partial R}{\partial\beta}>0$) and L decreases (i.e., $\frac{\partial L}{\partial\beta}$<0). Combining these with the results in Lemma 10 and the concavity of $F''(\cdot)<0$ we obtain that:

$$\frac{\partial W_0^*}{\partial\beta} = -\left[\underbrace{\frac{1}{(1-\beta)^2}\frac{\kappa_P}{\kappa_A}}_{>0}+\underbrace{\frac{\partial F'(W_0^*;R,L)}{\partial R}}_{>0}\underbrace{\frac{\partial R}{\partial\beta}}_{>0}+\underbrace{\frac{\partial F'(W_0^*;R,L)}{\partial L}}_{<0}\underbrace{\frac{\partial L}{\partial\beta}}_{<0}\right]/F''(W_0^*;R,L)>0,$$

which shows that these effects render the equilibrium compensation level W_0^* increasing in the agent's bargaining power β. Finally, since the optimal W_0^p is independent of the bargaining power, it also follows that $\frac{\partial(W_0^* - W_0^p)}{\partial\beta} > 0$.

A.12 Proof of Lemma 7

The firm effectively solves the following problem: $max_{W_0,L} F(W_0; R, L)$ subject to $L = F(W_0; R, L) - \kappa_p$. Now the firm internalizes that it is liquidation value is affected by its subsequent contracts:

$$\frac{\partial L}{\partial W_0} = F'(W_0; R, L)$$

Taking into account this affect, the optimality condition with respect to W_0 is:

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

Since $1 + \frac{\partial F(W_0;R,L)}{\partial L} > 0$, we can simplify the optimality condition to $F'(W_0; R, L) = 0$.

B Additional Results

B.1 Additional Results in the Two-Period Model

In this section, we consider an alternative welfare function where the planner assigns equal weight on principals and agents. We demonstrate that the condition for equilibrium overcompensation becomes more stringent compared to the one established in Section 2. Further, we characterize scenarios where the equilibrium can feature undercompensation.

When contemplating interventions that reduce agents' outside options, the welfare changes, computed as the change in the joint payoffs of the principals and agents, are positive if

$$p\delta\lambda > (1-p)(1-\lambda) + \delta^2\lambda.$$

Undercompensation arises when the principals use termination threats excessively to squeeze the agent's pay and incur significant termination costs. This occurs when the outcome in (i) of Lemma 1 dominates (ii):

$$\delta\kappa_A > p\kappa_A - (1-p)\kappa_P.$$

In such scenarios, the planner would like to increase the agents' outside options by paying them in the outside matches upfront such that the principals find termination threats unappealing, thereby avoiding the termination costs.

We summarize these insights in the lemma below.

Lemma 11 (Equal Welfare Weights: Two-Period Model)**.** *Under a social welfare function that puts equal weights on the principals and the agents,*

(i) If $p\delta\lambda > (1-p)(1-\lambda) + \delta^2\lambda$, the equilibrium features overcompensation.

(ii) Under scenario (ii) of Lemma 1, if $(1-p)\kappa_P > (p-\delta)\kappa_A$, the equilibrium features undercompensation.

In scenario (i), we can carry out a similar intervention as described in Lemma 2 to reduce agents' outside options. Combined with this intervention, we can achieve Pareto improvements by compensating the agents upfront at the time of signing the contract. Given that the surplus is bigger, the appropriate upfront payment can make the shareholders better off while delivering to the agents at least their equilibrium payoff.

B.2 Pareto Improvements with Time-Varying Contracts

We relax the constraint that the planner cannot set different contracts for existing matches at time-zero and all subsequent future matches. To correct for the externality via the outside options, the planner would only need to intervene in future contracts. It is without loss of generality to consider the planner setting initial compensation for the existing matches, $W_{0,e}$, and the future matches, $W_{0,f}$. The future compensation drives the outside options:

$$R = W_{0,f} - \kappa_A,$$
$$L = F(W_{0,f}; R, L) - \kappa_P,$$

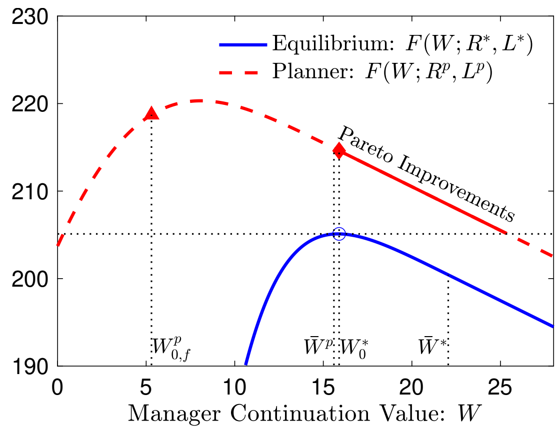
which in turn affect the shareholder value function for the existing matches $F(W; R, L)$. The following result shows the planner can achieve Pareto improvements.

Proposition 5 (Pareto Improvements)**.** *If the planner can selectively intervene in future contracts, the planner would set future compensation levels to $W^p_{0,f} \leq W^p_0$. For the time-zero matches, shareholder values can be improved while delivering to the managers at least their equilibrium payoff W^*_0, i.e.,*

$$F(W^*_0; R^p, L^p) > F(W^*_0; R^*, L^*).$$

Proof. For the time-zero matches, the sharehold value function $F(W; R, L)$ is affected by

Figure 10: Intervention in contracts for future matches and Pareto improvements



Notes: The blue solid line plots the firm value function with the equilibrium $\{R^*, L^*\}$. The red dashed line plots the firm value function with the optimal outside options $\{R^p, L^p\}$, where $W^p_{0,f} = \kappa_A$ and $R^p = 0$. The red solid region depicts areas where Pareto improvements can be obtained with the appropriate choice of $W^p_{0,e} \geq W^*_0$.

future compensation W_{0f} in the following way:

$$\frac{\partial F(W;R,L)}{\partial W_{0,f}} = \frac{\partial F(W;R,L)}{\partial R}\frac{\partial R}{\partial W_{0,f}} + \frac{\partial F(W;R,L)}{\partial L}\frac{\partial L}{\partial W_{0,f}}$$

$$= \frac{\partial F(W;R,L)}{\partial R} + \frac{\partial F(W;R,L)}{\partial L}\frac{F'(W_{0,f};R,L) + \frac{\partial F(W_{0,f};R,L)}{\partial R}}{1 - \frac{\partial F(W_{0,f};R,L)}{\partial L}}.$$

Let's first reduce the compensation for future matches from the equilibrium level locally, setting $W_{0,f} = W^*_0 - \varepsilon$. Letting $\varepsilon \to 0$, the expression above becomes

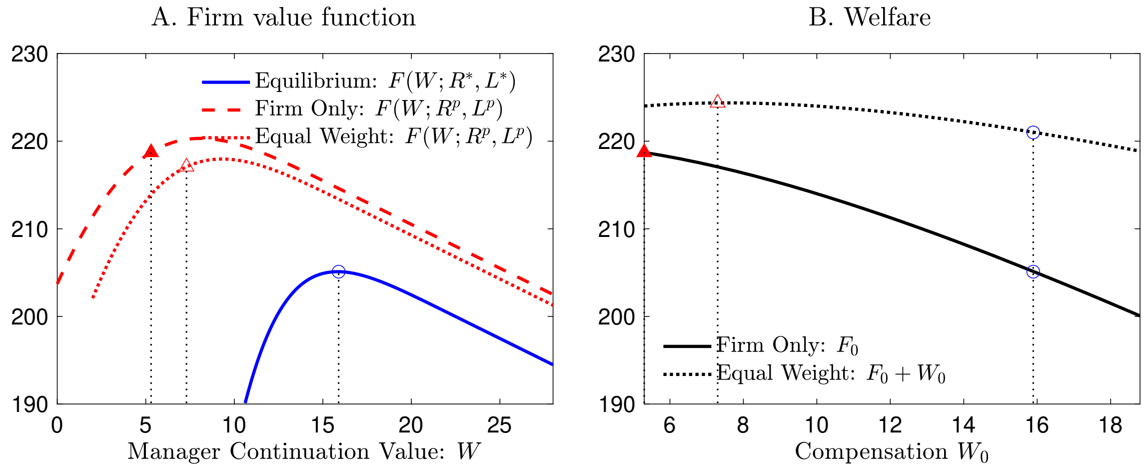
$$\frac{\partial F(W;R,L)}{\partial R} + \frac{\partial F(W;R,L)}{\partial L}\frac{\frac{\partial F(W^*_0;R,L)}{\partial R}}{1 - \frac{\partial F(W^*_0;R,L)}{\partial L}} < 0,$$

which implies that reducing $W_{0,f}$ will lead to an improvement in the firm value function. That is, the Pareto frontier shifts out.

If equation (15) has an interior solution, the expression above is negative at $W_{0,f} = W^p_0$. Thus $W^p_{0,f} < W^p_0$. Otherwise, the expression above is negative at $W_{0,f} = \kappa_A$, in which case $W^p_{0,f} = W^p_0 = \kappa_A$. It follows then that the shareholder value is higher than the equilibrium one when setting $W^p_{0,e} = W^*_0$, i.e., $F(W^*_0; R^p, L^p) > F(W^*_0; R^*, L^*)$. □

Figure 10 displays the optimal compensation for future matches and the resulting impact on time-zero matches. In this case, the future compensation is at the corner $W^p_{0,f} = \kappa_A$ and the agent outside option is zero. It leads to an upward shift in the firm value, implying

Figure 11: Alternative welfare criteria



Notes: Relative to Figure 3, in Panel A, the red dotted line plots firm value function with the optimal $\{R^p, L^p\}$ when the planner assigns equal welfare weights to principals and agents. In Panel B, the black dotted line displays the welfare value obtained at each compensation level.

that the Pareto frontier shifts outward. The solid red line captures the strictly Pareto improving allocations. Finally, if the planner only cares about shareholder value, it would set $F'(W^p_{0,e}; R^p, L^p) = 0$, the peak point in the new firm value function.

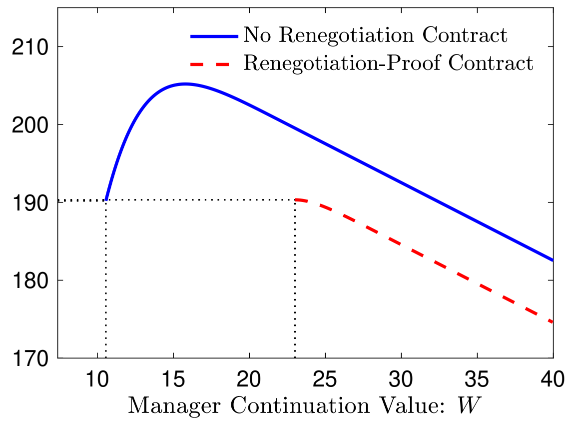
B.3 Welfare Criteria

We also explore an alternative welfare criterion in which the planner places equal weights to principals and agents and maximizes social welfare as represented as $F_0 + W_0$. Under this criterion, the planner no longer treats payments to agents as pure costs. The dashed line in Panel B of Figure 11 depicts the social welfare as a function of W_0. Interestingly, the equilibrium under our baseline calibration still features overcompensation. However, the planner would not want to reduce the outside option all the way down to zero. Instead, there would be an optimal interior solution for W_0 (red hollow triangle) at which the sum of the principal and the agent value is maximized. The dotted red line in Panel A depicts the value function for the principal under the social optimum for this criterion.

B.4 Renegotiation-Proof Contracts

Our baseline results can be interpreted as either a case in which the principal can commit not to renegotiate or in which the cost of renegotiation is prohibitively high such that at least one of the parties prefers not to renegotiate. Nevertheless, a natural question is how equilibrium outcomes are altered when the principals cannot commit to not engaging in

Figure 12: Renegotiation proofness: firm value function $F(W; R, L)$



Notes: The blue dashed line plots the equilibrium firm value function when principals can commit not to renegotiate. The red dotted line plots the firm value function for scenarios where principals lack such commitment power and contracts are thus renegotiation-proof, computed by fixing the previous equilibrium values of $\{R^*, L^*\}$.

ex post regenotiation and there is no costs for such renegotiation. This section studies equilibrium with renegotiation-proof contracts, building on the partial equilibrium analysis in Section IV.B of DeMarzo and Sannikov (2006).

We restrict our attention to contracts such that, after any history, there is no other contract that both parties would prefer to the continuation contract. As before, if renegotiation were to occur, we assume that the principals have full bargaining power and make a take-it-or-leave-it offer to their agents. In the baseline case in which the principal can commit not to renegotiate, the value function has an increasing portion, i.e., the interval of continuation values $[R, W_0]$. When the continuation value of the agent enters this region, the continuation contract does not satisfy the property stated above. That is, there is another contract that both parties would strictly prefer to the continuation contract, namely recommitting to the initial contract, that delivers a higher payoff to both the principal and the agent. To make the contract renegotiation-proof the continuation value of the agent cannot enter the increasing portion of the value function. This is achieved by finding $\tilde{R} > R$ such that the process by which the agent's continuation value evolves, previously described in equation (5), is modified to

$$dW_t = \gamma W_t dt - dC_t + \lambda(dY_t - \mu dt) + dP_t,$$

where the non-decreasing process P_t makes the continuation value reflect at $\tilde{R}$ and the payoff to the principal from such a contract satisfies $F'(\tilde{R}; R, L) = 0$. The contract is stochastically terminated whenever the process is reflected at $\tilde{R}$. Naturally, the principal would offer an initial value $W_0 = \tilde{R}$ to the agent. At termination, the principal obtains a liquidation value

$L = F(W_0; R, L)$.

In our general equilibrium setting, the renegotiation proof contracts described above would not satisfy Assumption 1 in general. In particular, when the principal termination cost $\kappa_P > 0$, the liquidation value for the principal would not be consistent with the value it would get from contracting with a new agent net of the termination cost. In such situations, it would not be possible to obtain an equilibrium in which principals and agents rematch after a termination. Figure 12 illustrates the above insights. In particular, it depicts the firm's value function in the baseline equilibrium (solid blue line) compared to the firm's value function that would be obtained under the same outside options but when the contract must be renegotiation proof (dashed red line).