Corporate Governance by Workers*

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Abstract

We study how workers' private information about managerial performance shapes equity financing and compensation structures. We develop a simple moral-hazard model in which a manager exerts unobservable effort and workers observe that effort before deciding whether to stay with the firm. When workers are compensated partly in equity, their decision to quit following low managerial effort disciplines the manager, generating internal corporate governance. This mechanism introduces a novel link between equity financing and labor contracting: worker equity both incentivizes managerial effort and exerts downward pressure on wages, since underpayment is necessary for the manager to lose surplus when workers leave. In equilibrium, workers are optimally paid entirely in equity and below the monopsony-optimal compensation level, trading off profit extraction against the strength of managerial incentives. The model proposes a new governance mechanism by worker departure and provides a new explanation for the prevalence of worker equity compensation.

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1 Introduction

Firms employ many individuals, and the individuals working for a firm often know more about the firm than anyone else. This paper asks a simple question: how does worker private information influence the optimal capital structure of a firm?

We show, in a simple and classical moral-hazard model, that when workers have private information, monitoring can be partially delegated to workers through the choice of capital structure. Suppose workers are paid partially in equity: workers have an incentive to leave the firm if they observe sufficiently low effort from the manager. Worker equity compensation thus entails a tradeoff for the manager: increasing worker equity decreases the direct share of output captured by the manager, but generates additional incentives because managerial effort increases worker retention, which influences firm output and thus the manager's own profits. We show that worker equity compensation robustly emerges as an equilibrium outcome in our model. Interestingly, worker monitoring also produces downwards pressure on wages, because workers must be underpaid for the manager to lose surplus when workers quit. This paper thus provides a novel explanation for the pervasive practice of compensating workers using equity, and also introduces a new theoretical link between information frictions and the equilibrium level of worker compensation.

We analyze a simple static moral-hazard model of firm financing, most similar to Holmstrom and Tirole (1997), to which we add a worker component. There is a manager, who produces output by exerting costly private effort; when she is not a full residual claimant on output, she will be unable to commit to exerting the efficient level of effort. There is a competitive representative investor, who has a lower cost of capital than the manager, meaning that it is welfare-improving for the investor to participate in the firm's capital structure. There is a representative worker, with a random reservation wage, who produces some exogeneous output if she is employed at the firm. We assume the worker can observe the manager's effort, and condition her decision whether to work at the firm on the manager's effort.

We first consider a benchmark where the manager and investor hold equity shares in the firm, but the worker is paid a fixed wage. The manager and investor then face a classic tradeoff: equity granted to investors increases the efficiency of financing, but decreases the manager's incentives for effort. The worker's compensation does not interact with this tradeoff: the manager simply chooses the fixed wage which maximizes profit extracted from the worker, which is equal to the markdown between the worker's output and her wage multiplied by the probability that the worker accepts the wage offer. Intuitively, under fixed-wage contracts, the manager's effort does not affect the worker's payoffs and thus the probability that the worker quits; the manager effort problem is fully separated from the worker wage-setting problem.

The core contribution of our paper is that, when the worker is paid with general wageand-equity contracts, the manager effort problem and the worker compensation problem
become entangled, because manager effort affects worker retention. When the worker is paid
in equity, her compensation depends on the firm's output, so she will leave if she observes
sufficiently low effort. This influences the firm's total output, and thus the net profits of
the manager; thus, the manager takes into account the effects of her effort not only on total
output, but also on worker retention.

Interestingly, this channel does not always induce higher managerial effort: the incentive effects of worker retention are linked to a monopsony-pricing problem. The firm's total profit extracted from workers is a monopsony revenue function: the product of the "markdown" – the difference between worker output and expected compensation – and the probability of worker retention. At the monopsony-revenue-maximizing compensation level – the optimal fixed wage for the worker – this revenue function is flat: increases in markdown have no first-order effect on revenues, since they are perfectly offset by decreases in the probability of worker retention. Thus, when the worker is paid at the monopsony-optimal level, even if her compensation has an equity component, the manager does not internalize the effects of her effort on compensation, because workers quitting has no first-order effect on expected revenues at this point.

We show that the optimal contract always pays workers less than the monopsony-optimal level. In this range, the monopsony profit function is locally increasing in worker compensation, implying that worker retention serves as an effective discipline device for the manager in this range. By committing to a contract which under-compensates workers, the manager increases her own effort incentives, because effort increases effective worker pay, improving retention, and thus increasing the manager's own payoffs. In simpler terms, under the optimal contract, the manager works harder because her firm earns large profits from underpaying workers, and she knows that the underpaid workers will quit if they observe her slacking off.

The comparative statics of our model are thus driven by the dual role of workers as both monitors and as profit sources for the firm. Interestingly, the tradeoff between these two roles is navigated not through the fraction of equity compensation – full-equity compensation is always optimal in our model – but rather through the overall level of worker compensation. As compensation decreases from the monopsony-optimal level, workers are more effective as monitors for the manager, but profit extraction from workers is less efficient. The optimal compensation level trades off these two forces. Workers are more underpaid when output is

more sensitive to manager effort, since the role of workers as monitors is more important. Conversely, when profits from workers are comparatively important for the firm, manager incentive provision through workers is more costly, and the optimal contract tends to underpay workers less.

The primary contribution of our paper is to consider the implications of workers' private information about firms for corporate finance and worker compensation. We contribute mainly to two literatures.

Our contribution to the corporate finance literature is that we analyze the implications of workers' private information for optimal capital structure. We provide a new answer to the classic question of why workers are often compensated using equity. A classic idea in the literature is that equity is ineffective for inducing effort from regular workers, because equity grants infinitesemal effort incentives when the number of workers is large (Holmstrom, 1982). The worker monitoring channel we propose does not suffer from this "dilution" problem: when a large number of workers are paid in equity, it remains true that each individual worker has incentives to quit if the firm is doing sufficiently poorly.

Oyer (2004) argues that worker equity compensation improves worker retention, when wage adjustment is costly and the firm's equity value is related to the worker's outside options. Our theory is distinct: rather than insuring workers against outside-option risk, the primary purpose of equity in our setting is to give workers incentive to monitor managers. There are a number of other theories explaining worker equity compensation, including incentive and sorting theories (Oyer and Schaefer, 2005), theories based on worker equity as a defense against hostile takeovers (Pagano and Volpin, 2005), and institutional explanations based on the accounting and tax treatment of employee equity compensation (Blasi, Conte and Kruse, 1996; Hall and Murphy, 2002, 2003; Freeman, Kruse and Blasi, 2010). Our goal is of course to provide a new theoretical channel, not to argue against the relevance of other channels discussed in prior literature.

We also relate to a corporate finance literature on the idea of *internal governance* of firms. Acharya, Myers and Rajan (2011) studies how subordinate managers contribute to providing incentives for top management, and derives implications for investment and dividend policy. Acharya, Myers and Rajan focus on *succession* incentives: non-CEO managers' effort incentives come from the potential to be promoted to CEO. We instead focus on the *exit* decisions of regular workers, who in our model have no promotion prospects; our results on equity compensation and the underpayment of workers are distinct from the results of Acharya, Myers and Rajan. Technically, the model and results of Acharya, Myers and Rajan are also distinct from ours. Acharya, Myers and Rajan assume that CEO investment and

manager effort are complements: this is needed for manager behavior to discipline CEO effort. We instead assume workers and the CEO have additively separable contributions to output: the worker disciplines the CEO not by exerting low effort, but by leaving the firm entirely.

We also contribute to a literature on the determinants of worker wages. In simple industrial-organization models of wage setting, optimal worker pay trades off markdowns with retention, as in classic monopolistic price-setting problems. A classic literature on moral hazard emphasizes that, in their capacity as *agents* imperfectly observed by firm management, workers should be *overpaid* somewhat relative to their outside options (Solow, 1979; Shapiro and Stiglitz, 1984; Yellen, 1984).

We consider workers in their capacity as *principals*, disciplining the efforts of firm leadership in an incentive-compatible way, through their credible threats to quit if they observe leadership shirking. An interesting distributional consequence of our channel is that workers are only effective principals if they are undercompensated. Relative to the fixed-wage benchmark, the optimal wage-and-equity compensation contract increases firm profits, but unambiguously lowers worker surplus, relative to the monopsony-optimal fixed wage.

The paper proceeds as follows. We introduce the model in Section 2. We discuss the fixed-wage benchmark in Section 3. Our main results are in Section 4. We discuss the assumptions of our model in Section 5, and conclude in Section 6.

2 Setup

There is a single project, which requires a fixed upfront investment of I. There are three agents: a manager, a representative worker, and competitive investors, . There is no discounting and all agents are risk-neutral.

Output. The project's output is the sum of contributions from the manager and the worker. As is standard in the static moral-hazard literature, we assume the manager exerts effort e, at some private cost c(e), where c is convex. Output is:

 $e + \epsilon$

where ϵ is some mean-zero shock. Thus, output is equal to e in expectation; "noise" is included only to justify why we cannot contract directly on managerial effort, and we will largely disregard it going forwards, focusing on expected output e. We will assume the worker observes e, and can condition her decision to quit on e.

We assume the worker produces fixed output Δ . She has a random outside option

 $\omega \sim F(\cdot)$, which can be thought of as a wage offer from a competing firm, which is not observed by the manager at the time the compensation contract is written. The firm's expected output is thus $e + \Delta$ if the worker works, and e if she does not. The worker thus has a simple binary decision whether or not to work, we assume away continuous worker effort in the baseline model. There are thus also no complementarities in production: the only interactions between the worker and manager problems will be informational in nature.

Investment. A group of competitive investors can provide funding for the firm. Investment is valuable because investors' cost of funds is 1, and the CEO's cost is some higher number $\theta > 1$. Let I be the amount invested by the investors, and (1 - I) by the CEO. The investors' zero-profit condition implies that I must eventually equal investors' expected payoffs from the firm.

Contracts. We consider a simple set of wage-and-equity contracts. Workers can be paid through a combination of a fixed wage ψ , and an equity share s_W in the firm's residual profits. The manager and investor each receive equity shares s_M, s_I respectively. All parties have limited liability, implying that ψ, s_W, s_I, s_M must all be nonnegative. Moreover, equity shares must add to 1:

$$s_W + s_M + s_I = 1.$$

We could impose $\Delta \geq \psi$ – workers are never paid a fixed wage greater than their fixed output – though this will never be binding, since the firm would never want to pay the worker more than her output. Restricting attention to equity contracts – is not without loss of generality, but substantially simplifies our analysis technically.

A compensation contract is thus described by a triple ψ , s_W , s_M . If the worker chooses to work, the expected payoffs of each party are:

$$Payof f_W = \psi + s_W \left(e + \Delta - \psi \right) \tag{1}$$

$$Payof f_{M} = s_{M} (e + \Delta - \psi)$$

$$Payof f_{I} = s_{I} (e + \Delta - \psi)$$
(2)

where, since all agents are risk-neutral, we suppress the $E[\epsilon] = 0$ terms in payoffs for

¹There are several closely related ways to motivate financing in moral hazard models. Holmstrom and Tirole (1997) assume that the firm has fixed initial wealth A, necessitating a fixed amount I - A in external financing. Jensen and Meckling (1976) allow the scale of the firm to vary depending on the amount of external financing. In our model, we fix the size of the firm's investment, and assume there is a constant gap between the costs of inside and outside financing; this setup has economically similar intuitions to these models, and is analytically convenient for our setting. Our model can be thought of as simply fixing the "shadow value of equity", as discussed in Tirole (2010, ch. 3.4).

notational simplicity. Intuitively, the manager and investor each receive their equity shares of residual output $(y + \Delta - \psi)$, and the worker gets her wage and her equity share.

If the worker leaves the firm, the manager and investors' payoffs are instead:

$$Payof f_M = \frac{s_M}{s_M + s_I} e \tag{3}$$

$$Payoff_I = \frac{s_I}{s_M + s_I}e$$

That is, since both the worker's wage and her equity share of output are cancelled if she leaves the firm, output y is divided among the manager and investor proportional to their equity shares s_M, s_I : output is lower, but M and I are less diluted than when the worker is compensated using equity.

The game's timing is as follows.

- 1. The CEO proposes a contract s_M, s_W, ψ .
- 2. Investment I is determined through investors' zero-profit condition.
- 3. The manager chooses effort e.
- 4. The worker observes her outside option ω and manager effort e, and decides whether to quit.
- 5. Firm payoffs are realized and the game ends.

3 Fixed-Wage Contracts

We first consider the case in which workers are paid fixed wages, with no equity component. This serves to illustrate the mechanics of our model, allows us to define a few economic constructs which are useful for analyzing the general problem, and will be used as a benchmark to compare the general optimal contract to.

We solve the model backwards. In stage 4, suppose $s_W = 0$, so the worker is paid a fixed wage ψ if she works, and attains her outside option ω otherwise. The worker works if $\omega < \psi$, and quits otherwise, so the firm retains the worker with probability $F(\psi)$.

In stage 3, fixing contract parameters s_M , ψ and investment I, the manager's final expected payoff is:

$$s_M \left[e + (\Delta - \psi) F(\psi) \right] - c(e) - \theta (1 - I) \tag{4}$$

In words, the manager gets a share s_M of total firm output, which consists of her output y and surplus extracted from workers $(\Delta - \psi) F(\psi)$; she pays her private effort cost c(e), and her cost of capital $\theta(1-I)$. The manager's effort has no effect on the worker and investment terms, implying that the manager's FOC for e is simply:

$$s_M = c'(e) \tag{5}$$

Concavity of $c(\cdot)$ implies that (5) has a unique solution, which we can define as:

$$e_{FW}^{*}(s_{M}) \equiv \{e : c'(e) = s_{M}\}$$
 (6)

where FW is short for "fixed-wage".

Before proceeding to the investor's problem, note that the $(\Delta - \psi) F(\psi)$ term in (4) reflects the markdown $(\Delta - \psi)$ between worker output Δ and the wage ψ , multiplied by the retention probability $F(\psi)$, which is one minus the likelihood that the worker quits. Just as a monopolist's price-setting decision trades off increased markups against decreased sale quantities, the firm's monopsonistic wage-setting decision trades off larger markdowns with lower worker retention probabilities.

Definition 1. The worker profit function $\Pi(\Gamma)$ is the total expected surplus extracted by the firm from the workers, at a compensation level Γ :

$$\Pi(\Gamma) \equiv (\Delta - \Gamma) F(\Gamma) \tag{7}$$

We use Γ here to denote total expected compensation paid to the worker, which in later parts may consist of equity and wage compensation; in this section, we simply have $\Gamma = \psi$. We can ensure concavity of the worker wage-setting problem through the following classical assumption.

Assumption 1. $\Pi(\cdot)$ is strictly concave:

$$\Pi''(\Gamma) < 0 \tag{8}$$

This "decreasing marginal revenues" condition leads the manager's problem to be strictly concave; related conditions are commonly imposed for tractability in imperfect-competition models (Bulow and Pfleiderer, 1983; Caplin and Nalebuff, 1991) as well as the related literature on one-dimensional screening problems (Myerson, 1981; Maskin and Riley, 1984).

Assumption 1 implies that there is a unique maximizer Γ^* of Π , satisfying:

$$\Gamma^* = \{\Gamma : \Pi'(\Gamma) = 0\} \tag{9}$$

and that:

$$\Gamma < \Gamma^* \implies \Pi'(\Gamma) > 0, \ \Gamma > \Gamma^* \implies \Pi'(\Gamma) < 0$$
 (10)

Investment is determined in stage 2. Using the definitions of $\Pi(\psi)$ and $e_{FW}^*(s_M)$, the firm's expected output at a contract s_M, ψ is simply:

$$e_{FW}^{*}\left(s_{M}\right)+\Pi\left(\psi\right)$$

Investors receive a share s_I of output, implying that I must satisfy the zero-profit condition:

$$I = (1 - s_M) (e_{FW}^* (s_M) + \Pi (\psi))$$
(11)

Plugging (11) into the manager's problem and simplifying, the manager's payoff is ultimately:

$$(s_M + \theta (1 - s_M)) [e_{FW}^* (s_M) + \Pi (\psi)] - c (e_{FW}^* (s_M)) - \theta$$
 (12)

In the first stage, the manager chooses s_M and ψ to maximize (12). This contract design problem is straightforwards. It is unambiguously optimal to set wages to maximize $\Pi(\psi)$, which from (9) implies $\psi = \Gamma^*$. The choice of s_M navigates a classic tradeoff between financing and incentive provision. Differentiating (12) and setting to 0, we have:

$$\frac{\partial}{\partial s_M}: (\theta - 1) \left[e_{FW}^* (s_M) + \Pi (\Gamma^*) \right] = \left[(s_M + \theta (1 - s_M)) - c' (e_{FW}^* (s_M)) \right] \frac{\partial e_{FW}^*}{\partial s_M}$$
(13)

When s_M increases, the LHS captures the marginal cost from reduced financing, which is the cost difference $(\theta - 1)$ multiplied by total output. The RHS captures the marginal output gains from increasing the manager's effort incentives. Applying the implicit function theorem to (6), we have:

$$\frac{\partial e_{FW}^*}{\partial s_M} = \frac{1}{c''\left(e_{FW}^*\left(s_M\right)\right)}$$

Moreover, (6) implies that $c'(e_{FW}^*(s_M)) = s_M$; substituting into (13), we have the FOC:

$$(\theta - 1) \left[e_{FW}^* \left(s_M \right) + \Pi \left(\Gamma^* \right) \right] = \frac{\theta \left(1 - s_M \right)}{c'' \left(e_{FW}^* \left(s_M \right) \right)} \tag{14}$$

Expression (14), alongside $\psi = \Gamma^*$, thus characterize the optimal contract. Intuitively, when

workers are paid a fixed wage, the contract design problem separates cleanly into the problem of optimally extracting profits from workers through the wage ψ , and optimally trading off manager incentive provision and financing capacity through the equity share s_M .

What is interesting about the general contract, which we analyze next, is that these problems become entangled: when the worker is paid in equity, worker retention affects manager incentives, and the manager internalizes this effect in determining the level of worker compensation.

4 Results

4.1 Worker Retention

When the worker holds equity s_W , we can write her expected compensation conditional on e, ψ, s_W , which we wrote as (1) above, as follows.

Definition 2. Define the worker's expected compensation $\Gamma(e, \psi, s_W)$ as:

$$\Gamma(e, \psi, s_W) \equiv s_W(e + \Delta - \psi) + \psi \tag{15}$$

Since the worker observes e, she leaves the firm in stage 4 if $\Gamma(e, \psi, s_W)$ is less than her outside option ω . The probability the firm retains the worker is thus $F(\Gamma(e, \psi, s_W))$, generalizing the $F(\psi)$ term in Section 3 above. Worker retention is thus sensitive to managerial effort:

$$\frac{d}{de}F\left(\Gamma\left(e,\psi,s_{W}\right)\right) = f\left(\Gamma\left(e,\psi,s_{W}\right)\right)s_{W}$$

Increasing effort increases retention, since it increases expected worker compensation $\Gamma(e, \psi, s_W)$. Effort affects retention more when s_W is higher, since workers who are paid more in equity have compensation which is more sensitive to firm output.

4.2 Manager Effort

The manager's expected payoff, fixing I, is:

$$\underbrace{\int_{\omega=\Gamma(e,\psi,s_{W})}^{\infty} \frac{s_{M}}{s_{M}+s_{I}} e \, dF\left(\omega\right)}_{Worker\ Quits} + \underbrace{\int_{\omega=-\infty}^{\Gamma(y,\psi,s_{W})} s_{M}\left(e+\Delta-\psi\right) dF\left(\omega\right)}_{Worker\ Works} - c\left(e\right) - \theta\left(1-I\right) \quad (16)$$

Intuitively, the manager's payoff is either (2) or (1), depending on whether the realization of ω makes the worker work or quit. (16) simplifies slightly to:

$$\frac{s_M}{s_M + s_I} e\left(1 - F\left(\Gamma\left(e, \psi, s_W\right)\right)\right) + s_M\left(e + \Delta - \psi\right) F\left(\Gamma\left(e, \psi, s_W\right)\right) - c\left(e\right) - \theta\left(1 - I\right) \tag{17}$$

One interpretation of (17) is that, viewing workers as stakeholders in the firm, granting equity to workers seems to further dilute the manager's direct incentives to work. The manager's effective equity share in the firm is s_M if the worker stays, and the higher amount $\frac{s_M}{s_M+s_I}$ if the worker quits, since dilution decreases and the manager's effective equity stake in the firm is higher. We could differentiate (16) with respect to e, and we would find that the manager's effort incentives are a weighted average of s_M and $\frac{s_M}{s_M+s_I}$, plus a boundary term reflecting the surplus effect on marginal workers. We will not pursue this approach; instead, we will develop an elementary accounting trick to express the manager's objective in a more economically meaningful form.

A simple derivation in Appendix A.1 shows that:

$$(s_M + s_I)(e + \Delta - \psi) - e = \Delta - \Gamma(e, \psi, s_W)$$
(18)

Essentially, (18) is an accounting identity, which views workers as an "external" component of the firm, even when they are compensated through equity. In this view, the LHS of (18) is the total amount extracted from worker employment by managers and investors: the difference between their smaller share $(s_M + s_I)$ of the increased output $(e + \Delta - \psi)$, and output e without the worker. This mechanically must equal the total contribution of employed workers to the firm, which is their output Δ minus their expected compensation $\Gamma(e, \psi, s_W)$.

Rearranging (18) slightly, we have:

$$s_M \left(e + \Delta - \psi \right) - \frac{s_M}{s_M + s_I} e = \frac{s_M}{s_M + s_I} \left(\Delta - \Gamma \left(e, \psi, s_W \right) \right) \tag{19}$$

Substituting (19) into (16), we can write the manager's payoff as:

$$\int_{\omega=\Gamma(e,\psi,s_W)}^{\infty} \frac{s_M}{s_M+s_I} e \, dF\left(\omega\right) + \int_{\omega=-\infty}^{\Gamma(e,\psi,s_W)} \left[\frac{s_M}{s_M+s_I} \left[e + \Delta - \Gamma\left(e,\psi,s_W\right) \right] \right] dF\left(\omega\right) - c\left(e\right) - \theta\left(1-I\right)$$

$$= \frac{s_M}{s_M + s_I} e + \frac{s_M}{s_M + s_I} F\left(\Gamma\left(e, \psi, s_W\right)\right) \left(\Delta - \Gamma\left(e, \psi, s_W\right)\right) - c\left(e\right) - \theta\left(1 - I\right) \tag{20}$$

Using the definition of the worker profit function $\Pi(\cdot)$ in (7), we can simplify (20) further to:

$$= \max_{e} \underbrace{\frac{s_{M}}{s_{M} + s_{I}}}_{Manager\ Output} + \underbrace{\frac{s_{M}}{s_{M} + s_{I}}}_{Profit\ Extracted\ From\ Workers} (C(e, \psi, s_{W})) - c(e) - \theta(1 - I)$$

$$(21)$$

An economic interpretation of (20) is that the manager receives a share $\frac{s_M}{s_M+s_I}$ of firm profits, which are the sum of her own output y, and the expected profit $\Pi\left(\Gamma\left(e,\psi,s_W\right)\right)$ extracted from workers. As in Section 3, profit extracted from workers is the product of the markdown $(\Delta - \Gamma\left(e,\psi,s_W\right))$ and the retention probability $F\left(\Gamma\left(e,\psi,s_W\right)\right)$. In the general case, however, manager effort influences the worker profit component of (21), through its effect on expected compensation $\Gamma\left(e,\psi,s_W\right)$.

Differentiating (21), the manager's optimal effort must satisfy:

$$\frac{s_M}{s_M + s_I} \left(1 + \Pi' \left(\Gamma \left(e, \psi, s_W \right) \right) \frac{\partial \Gamma}{\partial e} \right) - c' \left(e \right) = 0$$

From (15), we have that:

$$\frac{\partial \Gamma}{\partial e} = s_W$$

which gives us the following simple form for the manager's effort choice.

Proposition 1. Under a contract s_M, s_W, ψ , optimal manager effort $e^*(s_M, s_W, \psi)$ is the unique solution to:

$$c'(e) = \frac{s_M}{s_M + s_I} \left(1 + \Pi' \left(\Gamma \left(e, \psi, s_W \right) \right) s_W \right) \tag{22}$$

Notice that Assumption 1 that $\Pi(\cdot)$ is concave, together with the convexity of $c(\cdot)$ and the fact that Γ is affine in y, trivially implies that the manager's effort objective is strictly concave in y. That is, taking another derivative of (21):

$$\frac{\partial^2}{\partial y^2}: \ \Pi''(\Gamma) s_W^2 - c''(y) < 0$$

implying that (22) is a necessary and sufficient condition for the manager's optimal choice of y.

Proposition 1 captures the core economic force in our paper. When workers are compensated using equity, and workers observe managers' effort, workers' exit decisions will depend on managers' effort choices. Since workers' exits can also influence firm profits, managers consider the effects of their effort on worker retention, as captured by the $\Pi'(\Gamma(e, \psi, s_W)) s_W$ term in (22). We call this the worker monitoring channel.

Interestingly, the strength of this channel is closelly linked to the level of worker compensation, as captured by $\Gamma(e, \psi, s_W)$, because it determines the slope $\Pi'(\Gamma(e, \psi, s_W))$. Consider the monopsony-optimal compensation level Γ^* , defined in (9): worker monitoring is completely ineffective at this point, because $\Pi'(\Gamma^*) = 0$: small changes in Γ from Γ^* have no marginal effect on profits, since the change in markdowns is perfectly offset by changes in retention rates. This is analogous to optimal monopoly pricing: at the profit-maximizing price, the monopolist must be indifferent to small changes in price. The magnitude of s_W is immaterial: while compensation and thus retention are more sensitive to manager effort the larger s_W is, these retention shifts do not influence the profits the firm and its manager capture from worker employment.

Worker monitoring is only effective when $\Gamma < \Gamma^*$, and workers are undercompensated relative to the monopsony-optimal point. In this range, $\Pi'(\Gamma^*) > 0$: the manager increases expected profits extracted from workers by increasing compensation, and internalizes this effect in her effort decisions. Formally, by increasing e, the manager increases effective compensation Γ by an amount dependent on worker equity s_W , which increases profits Π since $\Pi'(\Gamma) = 0$, which increases the manager's own payoffs. This contributes an additional term $\Pi'(\Gamma) s_W$ to the manager's FOC in (22). In intuitive terms, underpaid workers are more effective as monitors than optimally-paid workers, because the marginal profits to the firm from increasing retention are high only when workers are underpaid.

With these intuitions in mind, we move on to characterize investment and then the optimal contracting problem faced by the manager.

4.3 Investment

Next, we analyze the investors' decision in period 2. The investor's expected payoff is:

$$\underbrace{\int_{\omega=\Gamma(e,\psi,s_{W})}^{\infty} \frac{s_{I}}{s_{M}+s_{I}} e^{*}\left(s_{M},s_{W},\psi\right) dF\left(\omega\right)}_{Worker\ Quits} + \underbrace{\int_{\omega=-\infty}^{\Gamma(y,\psi,s_{W})} s_{I}\left(e^{*}\left(s_{M},s_{W},\psi\right)+\Delta-\psi\right) dF\left(\omega\right)}_{Worker\ Works}$$

$$(23)$$

This is simply (16), with s_M replaced by the investor's share s_I . As with the manager's problem, this simplifies substantially to the equivalent of (21):

$$= \underbrace{\frac{s_I}{s_M + s_I} e^* \left(s_M, s_W, \psi\right)}_{Manager\ Output} + \underbrace{\frac{s_I}{s_M + s_I} \Pi \left(\Gamma \left(e^* \left(s_M, s_W, \psi\right), \psi, s_W\right)\right)}_{Profit\ Extracted\ From\ Workers}$$
(24)

Investors are competitive, so investment I must be equal to (24). Substituting this into the manager's objective function (21), and disregarding a constant θ term, the manager's objective can be written as:

$$\mathcal{M} = \frac{s_M + \theta s_I}{s_M + s_I} \left[e^* \left(s_M, s_W, \psi \right) + \Pi \left(\Gamma \left(e^* \left(s_M, s_W, \psi \right), \psi, s_W \right) \right) \right] - c \left(e^* \left(s_M, s_W, \psi \right) \right)$$
(25)

Expression (25) shows that the manager's classic moral-hazard problem can be framed as a commitment problem. When the manager increases effort, she influences both her own payoffs and investors' payoffs, through both the direct effect $e^*(s_M, s_W, \psi)$ and the worker-profit effect on $\Pi(\Gamma(e^*(s_M, s_W, \psi)))$. The zero-profit condition implies that investors' payoffs ultimately accrue to the manager, through increased investment. But the manager cannot commit to internalizing this effect, because investment I is fixed in stage 3 when the manager chooses effort; thus, the manager would always like to commit to a higher level of effort than $e^*(s_M, s_W, \psi)$.

Alternatively, we can write (25) as:

$$\mathcal{M} = \underbrace{\frac{s_M + \theta s_I}{s_M + s_I} e^* \left(s_M, s_W, \psi\right) - c\left(e^* \left(s_M, s_W, \psi\right)\right)}_{Manager\ Surplus} + \underbrace{\frac{s_M + \theta s_I}{s_M + s_I} \Pi\left(\Gamma\left(e^* \left(s_M, s_W, \psi\right), \psi, s_W\right)\right)}_{Worker\ Surplus}$$
(26)

Expression (26) separates surplus into two concave components attributable to manager effort and worker surplus extraction: the first term is concave in e, since $c(\cdot)$ is convex, and the second is concave in Γ from (8). In this framing, the manager would like to commit to extracting all surplus from workers, by setting compensation Γ^* , and also exerting optimal effort, which is characterized by the FOC:

$$c'(e) = \frac{s_M + \theta s_I}{s_M + s_I}$$

However, the manager's inability to commit means effort will be inefficiently low. The goal of contract design is to optimally trade off losses to the two components of (26).

4.4 Optimal Contract Design

Finally, we consider the manager's choice of contract s_M, s_W, ψ in the first stage. We prove a number of claims characterizing the optimal contract, and then provide a first-order condition illustrating the main tradeoff the manager faces.

Claim 1. The optimal financing structure features strictly positive internal and external

equity $s_{M}^{*}, s_{I}^{*} > 0$.

On the one hand, raising equity from external investors is cheaper due to their lower cost of capital $1 < \theta$. On the other hand, external equity dilutes manager's stake in the firm, reducing effort incentive. The reason for strictly positive external equity $(s_I^* > 0)$ is as follows. Suppose the entire firm is owned by manager (and possibly also partially by the worker), there is no "wedge" between the manager's ex-ante payoff objective (25) and his ex-post effort objective (16). Since the manager's ex-post effort choice is optimized, marginal reduction in effort due to small equity dilution (s_I) also has a zero marginal cost on his ex-ante payoff. In contrast, by raising capital from investors, there is a discrete benefit of $\theta - 1$ per dollar raised. Hence, the optimal financing structure must feature some external equity.

Claim 2. The optimal contract must have $\Gamma \leq \Gamma^*$, and thus $\Pi'(\Gamma) \geq 0$.

Proof sketch. At any compensation level where $\Gamma > \Gamma^*$, $\Pi'(\Gamma) < 0$, implying from (22) of Proposition 1 that managerial effort is weakly lower than if workers held no equity compensation; also, $\Pi(\Gamma) < \Pi(\Gamma^*)$ by the definition of Γ^* . Thus, a deviation to a fixed-wage contract paying $\psi = \Gamma^*$ increases both the manager and worker components of (26).

The full proof is presented in Appendix A.3.

Claim 2 simply formalizes the intuitions we discussed after Proposition 1: it is always optimal to weakly undercompensate workers relative to Γ^* , since worker monitoring is only effective in this range.

Proposition 2. The optimal contract always compensates the worker entirely in equity: the fixed wage $\psi^* = 0$ and $s_W^* \in (0,1)$.

Intuitively, if worker compensation has a cash component, the manager can always marginally swap the cash payment for equity payment, while maintain the total compensation to the worker (under the manager's original effort level). Such a modification makes the worker's payoff and hence his departure decision more sensitive to the firm's performance, providing a stronger effort incentive for the manager. Since the manager ex-ante prefers to commit to a higher effort level, the modified contract is therefore an improvement. Furthermore, the higher managerial effort in turn increases firm value and hence compensation to the worker. Since workers are underpaid relative to the monopsony-optimal level, increasing worker compensation additionally benefits the manager payoff. Hence, the optimal contract should fully load on equity compensation.

Proposition 3. The optimal contract always has $\Gamma < \Gamma^*$, because a small deviation from Γ^* to $\Gamma^* - \epsilon$ dominates a contract paying Γ^* .

Proof sketch. Recall we expressed the manager's surplus \mathcal{M} as the sum of manager and worker surplus terms, both of which are concave. If workers are compensated fully in equity, resulting in the point Γ^* , worker surplus Π is maximized, and the manager surplus term is not. A small decrease in s_W from this point thus has no first-order effect on Π , since $\Pi'(\Gamma^*) = 0$, but increases managerial effort, which has a first-order increase on the manager surplus term. The full proof is presented in Appendix A.5.

Claim 3 strengthens the result of Claim 2: it is always strictly optimal to compensate the worker less than Γ^* . Together, Claims 2 and 3 imply that the optimal contract is always a full-equity contract which induces expected compensation lower than Γ^* . Thus, the optimal contract problem reduces to the choice of $\frac{s_M}{s_M+s_I}$, which affects the amount of investment and the manager's baseline level of incentives; and s_W , which affects the tradeoff between worker surplus extraction, and manager incentive provision through worker monitoring.

A technical observation is that, as s_W decreases, manager effort cannot monotonically increase, since from (38) worker monitoring is completely ineffective when $s_W = 0$. The proof of Claim 3 implies that there always exist values of s_W that can increase manager effort; the intermediate value theorem, and the continuity of all outcomes in input parameters, then implies that there must exist some pairs of s_W values which induce identical manager effort levels, but different values of $\Pi(\cdot)$. In any such pair, the choice of s_W which induces a lower $\Pi(\cdot)$ is dominated, since the manager surplus component of (26) is identical, but worker surplus is lower.

In characterizing the optimal contract, it is convenient to change variables to s_W and $k \equiv \frac{s_M}{s_M + s_I}$, since the ratio k appears in the manager's effort FOC, (22). We now provide an FOC for the optimal choice of s_W .

Proposition 4. The optimal choice of s_W , fixing $k \equiv \frac{s_M}{s_M + s_I}$, satisfies:

$$[(\theta + (1 - \theta) k) - c'(e^*(k, s_W))] \frac{de^*}{ds_W} + (\theta + (1 - \theta) k) \Pi'(\Gamma(e^*(k, s_W), s_W)) \frac{d\Gamma}{ds_W} = 0 \quad (27)$$

Where:

$$\frac{d\Gamma}{ds_W} = e^* \left(k, s_W \right) + \Delta + s_W \frac{de^*}{ds_W} \tag{28}$$

$$\frac{de^*}{ds_W} = \frac{k \left(\Pi' \left(s_W \left(e^* \left(k, s_W \right) + \Delta \right) \right) + s_W \left(e^* \left(k, s_W \right) + \Delta \right) \Pi'' \left(s_W \left(e^* \left(k, s_W \right) + \Delta \right) \right) \right)}{c'' \left(e \right) - \frac{s_M}{s_M + s_I} \Pi'' \left(s_W \left(e + \Delta \right) \right) s_W}$$
(29)

Intuitively, Proposition 4 states that, at the optimal contract, the effect of a small change in s_W on the manager and worker components of surplus should be equal. These terms are the products of "wedge" terms:

$$[(\theta + (1 - \theta) k) - c'(e^*(k, s_W))], \Pi'(\Gamma(e^*(k, s_W), s_W))$$

and "passthrough" terms $\frac{de^*}{ds_W}$ and $\frac{d\Gamma}{ds_W}$, which ultimately each depend on the curvature properties of the cost function $c(\cdot)$ and the profit function $\Pi(\cdot)$.

A simple implication of Proposition 4 is that $\frac{de^*}{ds_W}$ must be negative at the optimal contract: if $\frac{de^*}{ds_W} > 0$, then all terms in (27) are positive, and an increase in s_W unambiguously makes the manager better off. In the range where both effort and worker compensation are below their optimal values, (27) can only hold if $\frac{de^*}{ds_W}$ is negative and $\frac{d\Gamma}{ds_W}$ is positive.

Proposition 5. The optimal choice of $k \equiv \frac{s_M}{s_M + s_I}$ satisfies:

$$\underbrace{(1-\theta)\left[e^{*}\left(k,s_{W}\right)+\Pi\left(\Gamma\left(e^{*}\left(k,s_{W}\right),s_{W}\right)\right)\right]}_{Financing\ Benefits} + \underbrace{\left[\left(\theta+\left(1-\theta\right)k\right)-c'\left(e^{*}\left(k,s_{W}\right)\right)\right]\left[\frac{\partial e^{*}}{\partial k}-\frac{\partial e^{*}}{\partial s_{W}}\frac{s_{W}\frac{\partial e^{*}}{\partial k}}{e^{*}\left(k,s_{W}\right)+\Delta+s_{W}\frac{\partial e^{*}}{\partial s_{W}}}\right]}_{Effort\ Costs} = 0 \quad (30)$$

where $\frac{\partial e^*}{\partial s_W}$ is defined in (29), and:

$$\frac{\partial e^*}{\partial k} = \frac{1 + \Pi'(s_W(e + \Delta)) s_W}{c''(e) - \frac{s_M}{s_M + s_I} \Pi''(s_W(e + \Delta)) s_W}$$
(31)

Intuitively, (30) states that the choice of the ratio $k \equiv \frac{s_M}{s_M + s_I}$ – the relative shares of manager versus investor equity – is pinned down by the classic tradeoff between financing and incentive provision, generalizing (13) in the fixed-wage problem in Section 3. The first term in (30) reflects the marginal financing gains from increasing k, and the second term reflects the net cost from reducing the manager's effort, multiplied by the "wedge"

$$(\theta + (1 - \theta) k) - c' (e^* (k, s_W))$$

The effort term is slightly complex, because changing k changes the worker component of profit as well as the manager's effort; the $\frac{\partial e^*}{\partial s_W}$ term in (30) reflects the shift in worker equity

 s_W needed to keep worker profit Π constant, which in turn has a feedback effect on the manager's optimal effort level. Essentially, we derive (30) in Appendix A.7 by differentiating \mathcal{M} with respect to k, and then substituting the s_W FOC from (27) and simplifying, to eliminate the effects of k on the worker profit component of surplus.

4.5 Model Simulations

We parametrize the manager's effort cost simply as a quadratic function:

$$c\left(e\right) = \frac{ae^2}{2}\tag{32}$$

and we assume the worker's outside option ω is uniformly distributed on $[0, \Delta]$, implying a quadratic profit function:

$$\Pi(\Gamma) = (\Delta - \Gamma) F(\Gamma) = \frac{\Gamma(\Delta - \Gamma)}{\Delta}$$
(33)

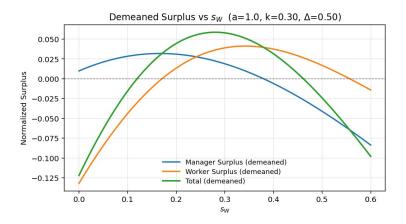
for $\Gamma \in [0, \Delta]$. The manager component of surplus is thus more important when a is small and effort costs are less convex, and the worker component is more important when Δ is larger. Throughout the simulations, we maintain $\theta = 1.5$. For any contract s_M, s_W , we then solve for the manager's optimal effort using the result of Proposition 1, and then use (26) to evaluate the manager and worker components of surplus.

We illustrate the intuition behind the optimal choice of s_W in Figure 1. Here, fixing some k, we plot the manager and worker components of surplus in (26), as well as their sum. There is some interior level of s_W which implements the monopsony-optimal wage, Γ^* : this is the value which maximizes the orange worker surplus line. However, as we argued in Claim 2, this is never the optimal contract, because the orange worker surplus component is locally flat in s_W at this point, whereas the slope of the blue manager surplus line is positive. Thus, a small decrease in s_W from this point has a first-order effect on the blue manager component of surplus, through improving the manager's incentives for effort, at the cost of only a second-order decrease in the orange worker component.

As s_W decreases further, we reach a local maximum for the manager component of surplus. Decreasing s_W past this point decreases managerial effort, since the reduced value of s_W offsets the increase in $\Pi'(\Gamma)$ in the manager's effort FOC in Proposition 22. It is thus never optimal to decrease s_W past the peak of the blue line. As the FOC in Proposition 4 shows, the optimal s_W thus lies between the peaks of the blue and orangelines, trading off the gains of lowering s_W for managerial effort, and the losses for worker profit extraction.

Figure 1: Manager and Worker Components of Profit

Notes. This figure illustrates how, for fixed k, the choice of worker equity share s_W trades of the manager and worker components of surplus. The blue and orange colored lines show the manager and worker component of surplus in (26), each normalized to have mean-0 over the plotted range. The green line shows their sum.



In Figure 2, we solve for the optimal contract – characterized by a k, s_W pair for any set of parameters – as we vary a and Δ . We illustrate the results by plotting the ratios of managerial effort e and worker compensation Γ to their optimized values, as well as the ratio of the manager and worker components of surplus to their optimized values. Intuitively, the manager component of surplus is more distorted when the worker component is relatively important, and vice versa. When a decreases and the firm's output is quantitatively more dependent on manager surplus, the red lines decrease, whereas the blue lines increase: workers are more underpaid and worker profit extraction is less efficient, but manager effort and the manager component of surplus increase. Conversely, when Δ increases and worker surplus is more important, the blue lines decrease – the manager component of the problem is more distorted – and the red lines increase – the worker component is less distorted.

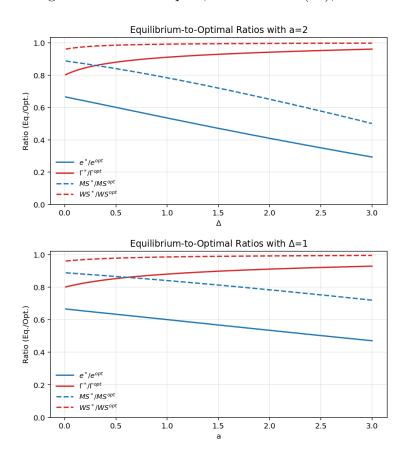
5 Discussion of Model Assumptions

5.1 Technical Structure

Linear Contracts. Our model takes a textbook tradeoff between manager incentive provision and competitive financing in a risk-neutral setting, and adds a worker component. The manager and investment component is similar to Tirole (2010, ch. 3.2), which is adapted from Holmstrom and Tirole (1997); a difference is that we cannot work in the simple two-outcome,

Figure 2: Comparative Statics

Notes. This figure illustrates how features of the optimal contract vary as we shift a, the coefficient on managers' costs in (32), and Δ , which parametrizes the worker profit function in (33). In each panel, we show four lines: manager effort divided by its optimal value, fixing the value of k at the optimal contract; worker compensation Γ divided by its optimal value; and the ratios of manager and worker surplus, as defined in (26), to their maximized values.



high-low return setting of Holmstrom and Tirole (1997) because the possibility of workers leaving decreases surplus, implying that our contracts must specify payouts for more than two possible output states. We instead assume that managerial output is a random variable whose expectation is increasing in effort, and restrict attention to affine contracts – fixed wages, plus equity shares of output.

This restriction on contracts is technically substantive: there is no reason why linear contracts should be optimal among general contracts in our setting. The upside of this simplification is that we are able to derive technically simple and economically intuitive results. An interesting extension, which we leave to future work, is to characterize the generally optimal contracts in our setting.

The moral hazard literature is vast, and we disregard many other forces analyzed in the literature, such as risk aversion Holmström (1979), dynamics, imperfect observability, and other forces.

Representative Worker. We assume that there is a representative worker, whose outside option is randomly distributed. It is immaterial for the model whether this represents a single worker or a mass of identical workers: exit decisions are equivalent in both cases, and our model does not suffer from the classic incentive-dilution problem in Holmstrom (1982). However, our model does not exactly apply when there is a continuum of workers with a distribution of reservation wages, because the exit decisions of some workers would change firm surplus and thus the payoffs to other workers.

The representative worker assumption is a technical simplification, which allows us to analyze interactions between workers' decisions and the manager's decision, while disregarding interactions between workers. We sacrifice some realism here to sharpen the economic insights the stylized model produces. Analyzing the richer interactions between multiple workers compensated with equity is a potentially interesting direction for future work.

We also assume for simplicity that the worker perfectly observes the manager's effort, and we limit investors to simply providing capital, without any way to observe or discipline the manager's effort decisions through contracting.

5.2 Substantive Assumptions

Worker Knowledge. A core assumption of our model is that employees observe valuerelevant information about the firm. This is consistent both with how public companies regulate employee trading, and with empirical evidence that worker-generated signals predict fundamentals and returns. U.S. public firms must disclose whether they maintain insider-trading policies and procedures and file them with the Form 10-K (or explain non-adoption) under Item 408(b) of Regulation S-K, making such policies near-universal in practice among listed firms. These policies typically impose quarterly trading windows or blackouts (e.g., from late quarter-end until after earnings) and allow ad-hoc "special blackouts" around pending material events. While directors and officers face stricter rule-based constraints, firm blackout policies routinely extend beyond executives to broad groups of employees likely to encounter material nonpublic information (MNPI).

There are also a number of empirical papers arguing that workers have private information about firms they work at. In firms with employee stock purchase plans (ESPPs), higher aggregate employee purchases predict future stock returns (Babenko and Sen, 2016). Employees' stock option exercise decisions – distinct from executives' exercise decisions – also predict returns (Huddart and Lang, 2003).

Employee-generated signals outside trading also forecast fundamentals and returns. Changes in crowdsourced employer reviews by *current* employees predict one-quarter-ahead earnings surprises and future stock returns (Green et al., 2019); broader measures of employee satisfaction correlate with long-run abnormal returns (Edmans, 2011) and, across countries, with future profitability and earnings surprises (Edmans et al., 2024).

Employee turnover is also negatively associated with future firm performance (Li et al., 2022). In our model, this could be driven both by selection – employees compensated with equity are more likely to leave if the firm is doing poorly – and causal effects – employees leaving further decreases the firm's output.

Labor Market Power. We assume that firms have market power in labor markets. This is motivated by a large recent literature that finds evidence for quantitatively meaningful labor market *markdowns*: wages are set well below workers' marginal revenue product to the firm, consistent with imperfect competition in labor markets (Berger, Herkenhoff and Mongey, 2022; Yeh, Macaluso and Hershbein, 2022; Lamadon, Mogstad and Setzler, 2022; Kroft et al., 2025). Two complementary findings which underpin this interpretation are that firm-specific labor-supply elasticities can be quite low (Dube et al., 2020); and that greater labor-market concentration is associated with lower wages (Azar, Marinescu and Steinbaum,

²Under SEC Rule 10b5-1 (as amended in 2022), directors and officers may not trade under a newly adopted or modified 10b5-1 plan until a *cooling-off* period has elapsed: the later of (i) 90 days after adoption/modification or (ii) two business days after the issuer files its next periodic report (Form 10-Q or 10-K), capped at 120 days. Under Sarbanes-Oxley 306, during a "pension plan blackout period" (when plan participants are temporarily restricted from trading issuer equity in an individual account plan), directors and executive officers are prohibited from trading the issuer's equity securities outside the plan; issuers must give advance notice and file a Form 8-K announcing the blackout.

2022).

6 Conclusion

In this paper, we analyzed how workers' private information influences firm capital structure. When informed workers are paid partially in equity, they have an incentive to leave the firm if managers shirk. Worker equity compensation thus partially delegates to workers the problem of monitoring the firm: the manager understands that shirking can induce workers to quit, and thus exerts increased effort to influence worker retention. Interestingly, private information also affects the level of worker compensation: the worker monitoring channel only works when workers are undercompensated relative to the monopsony-optimal wage, since only at this point does the manager lose surplus when workers leave. We thus provide a novel explanation for the common practice of compensating workers using equity, and we also introduce a new link between information frictions and the level of worker compensation.

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Internet Appendix

A Proofs

A.1 Derivation of (18)

We have:

$$(s_M + s_I) (e + \Delta - \psi) - e$$

$$= (s_M + s_I) (\Delta - \psi) - e (1 - s_M - s_I)$$

$$= (1 - s_W) (\Delta - \psi) - e s_W$$

Now, using the definition of $\Gamma(y, \psi, s_W)$ in (15),

$$\Delta - \Gamma(e, \psi, s_W) = \Delta - (\psi + s_W (e + \Delta - \psi))$$

$$= (\Delta - \psi) (1 - s_W) - es_W$$
(34)

implying that:

$$(s_M + s_I)(e + \Delta - \psi) - e = \Delta - \Gamma(e, \psi, s_W)$$

A.2 Proof of Claim 1

If $s_M^*=0$, condition (22) implies that manger's optimal effort $e^*=0$. The payoff in (25) is therefore bounded by $\theta \max_{\Gamma} \Pi(\Gamma)$. This is implemented by granting the worker a fixed wage, and is therefore dominated by the optimal contract (14) in this case. Hence, $s_M^*>0$.

Define $k \equiv \frac{s_I}{s_M} \in [0, \infty)$. The ex-post optimal effort $e^*(s_W, \psi, k)$ solves

$$\frac{1}{1+k} \left[1 + \Pi'(\Gamma(s_W, \psi, e^*)) s_W \right] = c'(e^*)$$
(35)

and the ex-ante contract design problem can be written as

$$\max_{s_W,\psi,k} \left(\frac{1-\theta}{1+k} + \theta \right) \left[e^* + \Pi \left(\Gamma \left(s_W, \psi, e^* \right) \right) \right] - c \left(e^* \right). \tag{36}$$

We therefore need to show $k^* > 0$.

Calculate the impact of k on e^* , and totally differentiate (35) with respect to k:

$$c''(e^*)\frac{\partial e^*}{\partial k} = -\frac{1}{(1+k)^2} \left[1 + \Pi'(\Gamma(s_W, \psi, e^*)) s_W \right] + \frac{1}{1+k} \Pi''(\Gamma) s_W^2 \frac{\partial e^*}{\partial k}.$$

Hence,

$$\frac{\partial e^*}{\partial k} = \frac{-\frac{1}{(1+k)^2} \left[1 + \Pi'(\Gamma(s_W, \psi, e^*)) s_W \right]}{c''(e^*) - \frac{1}{1+k} \Pi''(\Gamma) s_W^2} < 0.$$

At k=0,

$$\left| \frac{\partial e^*}{\partial k} |_{k=0} \right| = \frac{1 + \Pi'(\Gamma(s_W, \psi, e^*)) s_W}{c''(e^*) - \Pi''(\Gamma) s_W^2} \le \frac{1 + \Pi'(\Gamma(s_W, \psi, e^*))}{c''(e^*)},$$

which is bounded as long as c''(e) is bounded away from 0 for any e.

Next, consider the impact of k on the manager's design objective around a neighbourhood of k = 0. Totally differentiate (36) with respect to k:

$$-\frac{1-\theta}{(1+k)^{2}}\left[e^{*}+\Pi\left(\Gamma\left(s_{W},\psi,e^{*}\right)\right)\right]+\left[\left(\frac{1-\theta}{1+k}+\theta\right)\left[1+\Pi'\left(\Gamma\right)s_{W}\right]-c'\left(e^{*}\right)\right]\frac{\partial e^{*}}{\partial k}.$$

Using (35) to plug in the expression for $c'(e^*)$, the total derivative becomes

$$-\frac{1-\theta}{\left(1+k\right)^{2}}\left[e^{*}+\Pi\left(\Gamma\left(s_{W},\psi,e^{*}\right)\right)\right]+\frac{\theta k}{1+k}\left[1+\Pi'\left(\Gamma\right)s_{W}\right]\frac{\partial e^{*}}{\partial k}.$$

Evaluating around k=0, the total derivative is

$$\frac{\theta - 1}{(1 + k)^2} \left[e^* + \Pi \left(\Gamma \left(s_W, \psi, e^* \right) \right) \right] > 0.$$

Hence, a marginal increase in k over 0 strictly improves the manager's payoff and therefore $k^* > 0$.

A.3 Proof of Claim 2

We show that any contract with $\Gamma > \Gamma^*$, thus $\Pi'(\Gamma) < 0$, is strictly dominated by a fixed-wage contract which deviates to the worker profit-maximizing wage Γ^* . To see this, consider a contract s_M, s_W, ψ which induces some $\tilde{\Gamma} > \Gamma^*$, which from (10) implies that $\Pi'(\tilde{\Gamma}) < 0$.

From (26), the manager's payoff can be written as:

$$\mathcal{M} = \underbrace{\frac{s_M + \theta s_I}{s_M + s_I} e - c(e)}_{Manager\ Surplus} + \underbrace{\frac{s_M + \theta s_I}{s_M + s_I} \Pi\left(\Gamma\left(e, \psi, s_W\right)\right)}_{Worker\ Surplus}$$
(37)

where we suppress the e^* notation for notational simplicity.

From (22) of Proposition 1, the manager's effort \tilde{e} under the contract we are considering satisfies:

$$c'(\tilde{e}) = \frac{s_M}{s_M + s_I} \left(1 + \Pi'(\tilde{\Gamma}) s_W \right) < \frac{s_M}{s_M + s_I} < \frac{s_M + \theta s_I}{s_M + s_I}$$
(38)

Now, consider a new contract where we simply replace the worker's compensation with a fixed wage contract paying the profit-maximizing wage, Γ^* :

$$\psi = \Gamma^*$$

Since $\Pi'(\Gamma^*) = 0$, the manager's effort \hat{e} under the new fixed-wage contract is determined by:

$$c'(\hat{e}) = \frac{s_M}{s_M + s_I} < \frac{s_M + \theta s_I}{s_M + s_I}$$
(39)

Comparing (38) and (39), clearly $\tilde{e} < \hat{e}$, and furthermore both are below the value of e which maximizes the manager surplus term in (37), which satisfies:

$$c'\left(e^*\right) = \frac{s_M + \theta s_I}{s_M + s_I}$$

Thus, convexity of the manager surplus term implies that the manager surplus term in (37) is higher under \hat{e} than \tilde{e} , that is:

$$\frac{s_M + \theta s_I}{s_M + s_I} \hat{e} - c(\hat{e}) > \frac{s_M + \theta s_I}{s_M + s_I} \tilde{e} - c(\tilde{e})$$

Now, the worker surplus term is also clearly higher under the new contract:

$$\Pi\left(\Gamma^{*}\right) > \Pi\left(\tilde{\Gamma}\right)$$

Thus, both terms of (37) are higher under the new contract, and the manager strictly prefers the new contract. We have thus shown that all contracts with $\Gamma > \Gamma^*$ and thus $\Pi'(\tilde{\Gamma}) < 0$ are strictly dominated.

A.4 Proof of Proposition 2

First, it is clear that the optimal $s_W^* < 1$. Otherwise, $s_W^* = 1$ implies that $s_M^* = s_I^* = 0$ and the managerial payoff is therefore 0 which is strictly dominated by the trivial contract of no worker and no external equity financing $s_W = \psi = s_I = 0$ and $s_W = 1$.

Second, $s_W^* > 0$. Otherwise, if $s_W^* = 0$, then the worker is on fixed wage contract. The optimal contract in this case is characterized by $\Pi'(\Gamma^*) = 0$. Fixing $\frac{s_I}{s_M}$, all worker contracts (ψ, s_W) that generating worker payoff Γ^* implement the same outcome for all players. In particular, one such contract is pure equity of s_W as in Section A.5.1. This contract is dominated by a small reduction in s_W as in Section A.5.4.

Hence, $s_W^* \in (0, 1)$.

Next, we show $\psi^* = 0$. Suppose otherwise that $\psi^* > 0$. The proof contains two steps.

Step 1: We show that the derivative $\Pi'(\Gamma^*) > 0$ when $\psi^* > 0$. Calculate the impact of ψ on e^* , and totally differentiate (35) with respect to ψ :

$$c''(e^*)\frac{\partial e^*}{\partial \psi} = \frac{s_M}{s_M + s_I} s_W \Pi''(\Gamma) \left(\frac{\partial \Gamma}{\partial \psi} + \frac{\partial \Gamma}{\partial e} \frac{\partial e^*}{\partial \psi}\right) = \frac{s_M}{s_M + s_I} s_W \Pi''(\Gamma) \left(1 - s_W + s_W \frac{\partial e^*}{\partial \psi}\right).$$

Hence

$$\frac{\partial e^*}{\partial \psi} = \frac{\frac{s_M}{s_M + s_I} s_W \Pi''(\Gamma) (1 - s_W)}{c''(e^*) - \frac{s_M}{s_M + s_I} s_W^2 \Pi''(\Gamma)} < 0,$$

which in turn implies that

$$\frac{s_M}{s_M + s_I} s_W \Pi''(\Gamma) \left(1 - s_W + s_W \frac{\partial e^*}{\partial \psi} \right) < 0.$$

The concavity of Π further implies

$$\left(1 - s_W + s_W \frac{\partial e^*}{\partial \psi}\right) > 0.$$

Since by assumption $\psi^* > 0$, it must be a critical point of (36). Totally differentiate with respect to ψ :

$$\left\{ \frac{s_M + \theta s_I}{s_M + s_I} \left[1 + \Pi' \left(\Gamma \left(s_W, \psi, e^* \right) \right) s_W \right] - c' \left(e^* \right) \right\} \frac{\partial e^*}{\partial \psi} + \frac{s_M + \theta s_I}{s_M + s_I} \Pi' \left(\Gamma \left(s_W, \psi, e^* \right) \right) \left(1 - s_W \right) = 0,$$

which, using (35), becomes

$$\left\{ \frac{\theta s_I}{s_M + s_I} \left[1 + \Pi' \left(\Gamma \left(s_W, \psi, e^* \right) \right) s_W \right] \right\} \frac{\partial e^*}{\partial \psi} + \frac{s_M + \theta s_I}{s_M + s_I} \Pi' \left(\Gamma \left(s_W, \psi, e^* \right) \right) \left(1 - s_W \right) = 0,$$

or equivalently

$$\Pi'\left(\Gamma\left(s_{W},\psi,e^{*}\right)\right) = \frac{-\frac{\theta s_{I}}{s_{M}+s_{I}}\frac{\partial e^{*}}{\partial \psi}}{\frac{\theta s_{I}}{s_{M}+s_{I}}\left(1-s_{W}+s_{W}\frac{\partial e^{*}}{\partial \psi}\right)+\frac{s_{M}}{s_{M}+s_{I}}\left(1-s_{W}\right)} > 0.$$

Step 2: We shall construct another contract with $\psi^{\dagger} = \psi^* - \epsilon$ that generates higher payoff to the manager. As a notational convention, we denote by variables with * the ones under the conjectured optimal contract and those with † the ones under the newly constructed contract. Define s_W^{\dagger} such that

$$\Gamma\left(s_{W}^{\dagger}, \psi^{\dagger}, e^{*}\right) = s_{W}^{\dagger}\left(e^{*} + \Delta - \psi^{*} + \epsilon\right) + \psi^{*} - \epsilon = s_{W}^{*}\left(e^{*} + \Delta - \psi^{*}\right) + \psi^{*} = \Gamma\left(s_{W}^{*}, \psi^{*}, e^{*}\right).$$

Hence

$$s_W^{\dagger} = \frac{s_W^* \left(e^* + \Delta - \psi^* \right) + \epsilon}{\left(e^* + \Delta - \psi^* + \epsilon \right)} = s_W^* + \frac{\left(1 - s_W^* \right) \epsilon}{\left(e^* + \Delta - \psi^* + \epsilon \right)} > s_W^*.$$

It is possible to choose a small ϵ such that $\psi^{\dagger}>0$ and $s_W^{\dagger}<1$ hold. Define

$$s_M^{\dagger} = s_M^* \frac{1 - s_W^{\dagger}}{1 - s_W^*} \text{ and } s_I^{\dagger} = s_I^* \frac{1 - s_W^{\dagger}}{1 - s_W^*}$$

that maintain the equity ratio between the manager and the investor: $s_M^{\dagger}/s_I^{\dagger} = s_M^*/s_I^*$. Using the fact that $\Pi'(\Gamma(s_W^*, \psi^*, e^*)) > 0$ from Step 1,

$$\frac{s_{M}^{\dagger}}{s_{M}^{\dagger}+s_{I}^{\dagger}}\left[1+\Pi'\left(\Gamma\left(s_{W}^{\dagger},\psi^{\dagger},e^{*}\right)\right)s_{W}^{\dagger}\right]=\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\Pi'\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{\dagger}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\Pi'\left(\Gamma^{*}\right)s_{W}^{*}\right]=c_{M}^{*}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{\dagger}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{\dagger}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{\dagger}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{\dagger}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{\dagger}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{\dagger}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{\dagger}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{\dagger}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{\dagger}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{\dagger}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{\dagger}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{\dagger}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{*}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{*}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{*}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{*}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{*}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{*}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)s_{W}^{*}\right)s_{W}^{*}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{*}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{*}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{I}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{*}\right]>\frac{s_{M}^{*}}{s_{M}^{*}+s_{M}^{*}}\left[1+\left(\Gamma\left(s_{W}^{*},\psi^{*},e^{*}\right)\right)s_{W}^{*}\right]>\frac{s_{M}^{*}}{s_{M}^{$$

Hence, the managerial effort under † contract is higher: $e^{\dagger} \geq e^*$. From (35) and $\Pi' > 0$ from Step 1,

$$\frac{s_M^* + \theta s_I^*}{s_M^* + s_I^*} \left[1 + \Pi'(\Gamma^*) s_W \right] > \frac{s_M^*}{s_M^* + s_I^*} \left[1 + \Pi'(\Gamma^*) s_W \right] = c'(e^*).$$

Comparing the managerial payoff under the two contracts and using the fact that $e^{\dagger} > e^*$, we have

$$\frac{s_M^\dagger + \theta s_I^\dagger}{s_M^\dagger + s_I^\dagger} \left[e^\dagger + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^\dagger \right) \right) \right] - c \left(e^\dagger \right) > \frac{s_M^* + \theta s_I^*}{s_M^* + s_I^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right) \right) \right] - c \left(e^* \right) = \frac{s_M^* + \theta s_I^*}{s_M^* + s_I^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right) \right) \right] - c \left(e^* \right) = \frac{s_M^* + \theta s_I^*}{s_M^* + s_I^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right) \right) \right] - c \left(e^* \right) = \frac{s_M^* + \theta s_I^*}{s_M^* + s_I^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right) \right) \right] - c \left(e^* \right) = \frac{s_M^* + \theta s_I^*}{s_M^* + s_I^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right) \right) \right] - c \left(e^* \right) = \frac{s_M^* + \theta s_I^*}{s_M^* + s_I^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right) \right) \right] - c \left(e^* \right) = \frac{s_M^* + \theta s_I^*}{s_M^* + s_I^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right) \right) \right] - c \left(e^* \right) = \frac{s_M^* + \theta s_I^*}{s_M^* + s_I^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right) \right) \right] - c \left(e^* \right) = \frac{s_M^* + \theta s_I^*}{s_M^* + s_I^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right) \right) \right] - c \left(e^* \right) = \frac{s_M^* + \theta s_I^*}{s_M^* + s_I^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right) \right) \right] - c \left(e^* \right) = \frac{s_M^* + \theta s_I^*}{s_M^* + s_I^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right) \right) \right] - c \left(e^* \right) = \frac{s_M^* + \theta s_I^*}{s_M^* + s_I^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right) \right) \right] - c \left(e^* \right) = \frac{s_M^* + \theta s_I^*}{s_M^* + s_I^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right) \right) \right] - c \left(e^* \right) = \frac{s_M^* + \theta s_I^*}{s_M^* + s_I^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right) \right) \right] - c \left(e^* \right) = \frac{s_M^* + \theta s_I^*}{s_M^* + s_M^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right) \right) \right] - c \left(e^* \right) = \frac{s_M^* + \theta s_I^*}{s_M^* + s_M^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right) \right) \right] - c \left(e^* \right) = \frac{s_M^* + \theta s_I^*}{s_M^* + s_M^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right) \right) \right] - c \left(e^* \right) = \frac{s_M^* + \theta s_I^*}{s_M^* + s_M^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right) \right) \right] - c \left(e^* \right) = \frac{s_M^* + \theta s_I^*}{s_M^* + s_M^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right) \right) \right] - c \left(e^* \right) = \frac{s_M^* + \theta s_I^*}{s_M^* + s_M^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right) \right) \right] - c \left(e^* \right) = \frac{s_M^* + \theta s_I^*}{s_M^* + s_M^*} \left[e^* + \Pi \left(\Gamma \left(s_W^\dagger, \psi^\dagger, e^* \right$$

where the last equality follows from the construction of \dagger contract. The contradiction with optimality of the * contract implies that $\psi^* = 0$.

A.5 Proof of Proposition 3

From Claim 2, we restrict attention to full-equity contracts, implying that the choice variables are are s_M and s_W . For analytical convenience, we instead choose s_W and the ratio:

$$k \equiv \frac{s_M}{s_M + s_I}$$

Thus, a contract is described by a pair k, s_W . We prove the result in a number of steps.

A.5.1 There exists an equity-only contract which implements Γ^*

Consider effort \tilde{e} , defined as the unique solution to:

$$c'\left(\tilde{e}\right) = k\tag{40}$$

From (15), a worker who is paid fully in equity, under effort \tilde{e} , attains:

$$\Gamma = s_W (\tilde{e} + \Delta)$$

Now, clearly the profit-maximizing wage $\Gamma^* < \Delta$, since $\Pi(\Delta) = 0$ and the firm makes no profits from paying the workers their marginal product. Thus, there exists \tilde{s}_W which solves:

$$\tilde{s}_W = \frac{\Gamma^*}{\tilde{e} + \Delta} < 1 \tag{41}$$

At this full-equity contract \tilde{s}_W , using the definition of Γ in (15), we can write the manager's effort FOC (22) as:

$$c'(e) = k(1 + \Pi'(s_W(e + \Delta))s_W)$$
 (42)

At effort level \tilde{e} , we have:

$$c'(\tilde{e}) = k\left(1 + \Pi'(\tilde{s}_W(\tilde{e} + \Delta))\tilde{s}_W\right) = k\left(1 + \Pi'(\Gamma^*)\tilde{s}_W\right) = k \tag{43}$$

Hence, \tilde{e} is optimal for the manager under s_M, s_I, \tilde{s}_W . Proposition 1 states that the manager's FOC always has a unique solution, implying that \tilde{e} is the unique level of effort under s_M, s_I, \tilde{s}_W .

A.5.2 Fixing k, all contracts which implement Γ^* induce the same level of manager effort

Suppose a contract induces $\Gamma = \Gamma^*$ as an outcome. The manager's effort level is determined by:

$$c'(e) = k(1 + \Pi'(\Gamma^*) s_W) = k$$

since $\Pi'(\Gamma^*) = 0$. Clearly, manager effort is always equal to \tilde{e} as defined in (40).

A.5.3 A small deviation from \tilde{s}_W to $\tilde{s}_W - \delta$ decreases \tilde{e}

To show this, we simply show that:

$$\frac{\partial e}{\partial s_W} \mid_{s_W = \tilde{s}_W} < 0$$

To do this, we apply the implicit function theorem to (42) at the contract \tilde{s}_W . Defining:

$$\Lambda \equiv c'(e) - k \left(1 + \Pi'(s_W(e + \Delta)) s_W\right)$$

$$\frac{\partial \Lambda}{\partial e} = c''(e)$$

$$\frac{\partial \Lambda}{\partial s_W} = -\left[k \left(\Pi'(\tilde{s}_W(\tilde{e} + \Delta)) + \tilde{s}_W(\tilde{e} + \Delta)\Pi''(\tilde{s}_W(\tilde{e} + \Delta))\right)\right]$$

where \tilde{e} is defined in (40). Now, we have by assumption:

$$\Pi'\left(\tilde{s}_W\left(\tilde{e} + \Delta\right)\right) = \Pi'\left(\Gamma^*\right) = 0$$

Thus, we have:

$$\frac{\partial e}{\partial s_W} \mid_{s_W = \tilde{s}_W} = \frac{k \tilde{s}_W \left(\tilde{e} + \Delta \right) \Pi'' \left(\tilde{s}_W \left(e + \Delta \right) \right)}{c'' \left(e \right)} \tag{44}$$

Now, we assumed Π'' is everywhere negative and c'' is everywhere positive, and k, \tilde{s}_W and $\tilde{e} + \Delta$ are everywhere positive, so we have shown that $\frac{\partial e}{\partial s_W}|_{s_W = \tilde{s}_W} < 0$.

A.5.4 A small deviation from \tilde{s}_W to $\tilde{s}_W - \delta$ increases \mathcal{M}

Differentiating (26) with respect to s_W , we have:

$$\frac{d\mathcal{M}}{ds_W} : \left[\frac{s_M + \theta s_I}{s_M + s_I} - c'(\tilde{e}) \right] \frac{\partial e}{\partial s_W} + \Pi'(\Gamma(\tilde{s}_W)) \frac{\partial \Gamma}{\partial s_W} \mid_{\Gamma = \Gamma^*}$$
(45)

But, since $\Gamma(\tilde{s}_W) = \Gamma^*$ by definition of \tilde{s}_W , we have $\Pi'(\Gamma(\tilde{s}_W)) = 0$, hence the second term vanishes, regardless of the sign and magnitude of $\frac{\partial \Gamma}{\partial s_W}|_{\Gamma = \Gamma^*}$. This is the economic core of the proof: at \tilde{s}_W , which induces the monopsony-optimal compensation level Γ^* , changes in s_W have no effect on the worker surplus component of \mathcal{M} , because $\Pi'(\Gamma^*) = 0$: changes in worker compensation have no first-order effect on Π .

In contrast, a small downwards deviation from \tilde{s}_W unambiguously increases the manager surplus component of \mathcal{M} , because effort is always too low due to the manager's commitment problem. To see this, note that the manager's FOC at \tilde{s}_W , (43), implies:

$$c'\left(\tilde{e}\right) = \frac{s_M}{s_M + s_I}$$

Substituting into (45), and using that $\Pi'(\Gamma(\tilde{s}_W)) = 0$, we have:

$$\frac{d\mathcal{M}}{ds_W}\mid_{s_W=\tilde{s}_W} = \left[\frac{s_M + \theta s_I}{s_M + s_I} - \frac{s_M}{s_M + s_I}\right] \frac{\partial e}{\partial s_W}\mid_{s_W=\tilde{s}_W} = \left[\frac{\theta s_I}{s_M + s_I}\right] \frac{\partial e}{\partial s_W}\mid_{s_W=\tilde{s}_W}$$

Now, clearly $\frac{\theta s_I}{s_M + s_I} > 0$; intuitively, $\frac{\theta s_I}{s_M + s_I}$ is the gap between the value of investment, $\frac{s_M + \theta s_I}{s_M + s_I}$, and the amount the manager internalizes due to I being fixed, which is the smaller amount $\frac{s_M}{s_M + s_I}$, or k in (40). Moreover, we showed in Appendix A.5.3 above that $\frac{\partial e}{\partial s_W} \mid_{s_W = \tilde{s}_W} < 0$: decreasing s_W slightly increases manager effort. Thus, we have shown that

$$\frac{d\mathcal{M}}{ds_W}\mid_{s_W=\tilde{s}_W} < 0$$

and that a small deviation from \tilde{s}_W to $\tilde{s}_W - \delta$ increases \mathcal{M} , intuitively because it increases managerial effort e, and the increase induces a first-order increase in the manager-surplus component of (26).

A.5.5 A small deviation from \tilde{s}_W to $\tilde{s}_W - \delta$ decreases Γ

Finally, we must show that decreasing \tilde{s}_W to $\tilde{s}_W - \delta$ in fact decreases expected worker compensation, which is not fully trivial because it increases managerial output e. We show this by contradiction. Consider some $\hat{s}_W = \tilde{s}_W - \delta$. For sufficiently small δ , (44) implies that the induced effort level $\hat{e} > \tilde{e}$. Suppose for sake of contradiction that $\hat{\Gamma} \geq \Gamma^*$. The manager's FOC at \hat{s}_W is:

$$c'\left(\hat{e}\right) = \frac{s_M}{s_M + s_I} \left(1 + \Pi'\left(\hat{\Gamma}\right)\hat{s}_W\right)$$

The assumption that $\hat{\Gamma} \geq \Gamma^*$ implies that $\Pi'(\hat{\Gamma}) \leq \Pi'(\Gamma^*)$, hence:

$$\frac{s_M}{s_M + s_I} \left(1 + \Pi' \left(\hat{\Gamma} \right) \hat{s}_W \right) \le \frac{s_M}{s_M + s_I} = c' \left(\tilde{e} \right)$$

But this then implies:

$$c'(\hat{e}) \le c'(\tilde{e}) \implies \hat{e} \le \tilde{e}$$

which contradicts that $\hat{e} > \tilde{e}$.

A.5.6 Completing the Proof

We showed in Appendix A.5.4 that the \tilde{s}_W -contract, constructed as the pure-equity contract which induces Γ^* , is strictly dominated by a small deviation $\hat{s}_W = \tilde{s}_W - \delta$. Appendix A.5.5 verified that the \hat{s}_W contract in fact induces a level of compensation $\hat{\Gamma} < \Gamma^*$. Appendix A.5.2 showed that any wage-and-equity contract which induces Γ^* compensation induces identical outcomes to the \tilde{s}_W -contract, since worker equity compensation has no effect on the manager's outcomes at Γ^* . Thus, we have shown that any contract which induces compensation level Γ^* is strictly dominated by the \hat{s}_W contract, which pays the workers a strictly lower amount $\hat{\Gamma} < \Gamma^*$.

Now, Claim 2 showed that it is never optimal to have $\Gamma > \Gamma^*$, as all such contracts are weakly dominated by $\Gamma = \Gamma^*$. Thus, we have now shown that all contracts with $\Gamma \geq \Gamma^*$ are strictly dominated by the small-deviation contract \hat{s}_W , which pays $\hat{\Gamma} < \Gamma^*$, which proves Claim 3.

A.6 Proof of Proposition 4

First, note that, with $k \equiv \frac{s_M}{s_M + s_I}$, we have:

$$\frac{s_M + \theta s_I}{s_M + s_I} = \theta + (1 - \theta) k \tag{46}$$

We differentiate manager surplus \mathcal{M} in (26) with respect to s_W and set to zero, holding the ratio $\frac{s_M}{s_M + s_I}$ fixed:

$$\frac{\partial}{\partial s_{W}}: \left[(\theta + (1 - \theta) k) - c' (e^{*} (k, s_{W})) \right] \frac{de^{*}}{ds_{W}} + (\theta + (1 - \theta) k) \Pi' (\Gamma (e^{*} (k, s_{W}), s_{W})) \frac{d\Gamma}{ds_{W}}$$

where, with slight abuse of notation, we use $\frac{d\Gamma}{ds_W}$ to denote:

$$\frac{d\Gamma}{ds_W} \equiv \frac{d}{ds_W} \Gamma\left(e^*\left(k, s_W\right), s_W\right)$$

This is (27). Now, using (15), note that for full-equity contracts, $\psi = 0$, we have:

$$\Gamma\left(e, s_W\right) = s_W\left(e + \Delta\right) \tag{47}$$

which implies:

$$\frac{d}{ds_W}\Gamma = \frac{d}{ds_W}\left(s_W\left(e^*\left(k, s_W\right) + \Delta\right)\right) = e^*\left(k, s_W\right) + \Delta + s_W\frac{de^*}{ds_W}$$

This is (28). Finally, we can calculate $\frac{de^*}{ds_W}$ by applying the implicit function theorem to the manager's effort FOC. Using (47), we can write (22) as:

$$\Lambda = c'(e) - \frac{s_M}{s_M + s_I} (1 + \Pi'(s_W(e + \Delta)) s_W) = 0$$
(48)

We then have:

$$\frac{\partial \Lambda}{\partial e} = c''(e) - \frac{s_M}{s_M + s_I} \Pi''(s_W(e + \Delta)) s_W$$

$$\frac{\partial \Lambda}{\partial s_W} = -\left[k\left(\Pi'(s_W(e + \Delta)) + s_W(e + \Delta)\Pi''(s_W(e + \Delta))\right)\right]$$

From which we get:

$$\frac{de^*}{ds_W} = \frac{k \left(\Pi' \left(s_W \left(e^* \left(k, s_W \right) + \Delta \right) \right) + s_W \left(e^* \left(k, s_W \right) + \Delta \right) \Pi'' \left(s_W \left(e^* \left(k, s_W \right) + \Delta \right) \right) \right)}{c'' \left(e \right) - \frac{s_M}{s_W + s_T} \Pi'' \left(s_W \left(e + \Delta \right) \right) s_W}$$

this is (29).

A.7 Proof of Proposition 5

We differentiate manager surplus \mathcal{M} in (26) with respect to k, to get:

$$\frac{\partial \mathcal{M}}{\partial k} = \underbrace{(1-\theta)\left[e^{*}\left(k,s_{W}\right) + \Pi\left(\Gamma\left(e^{*}\left(k,s_{W}\right),s_{W}\right)\right)\right]}_{Financing} + \underbrace{\frac{\partial e^{*}}{\partial k}\left[\left(\theta + \left(1-\theta\right)k\right) - c'\left(e^{*}\left(k,s_{W}\right)\right)\right] + \underbrace{\frac{\partial e^{*}}{\partial k}\left[\left(\theta + \left(1-\theta\right)k\right)\Pi'\left(\Gamma\left(e^{*}\left(k,s_{W}\right),s_{W}\right)\right)\frac{\partial \Gamma}{\partial e^{*}}\frac{\partial e^{*}}{\partial k}\right]}_{Worker\ Profit} \tag{49}$$

where we used (46) in Appendix A.6 to express $\frac{s_M + \theta s_I}{s_M + s_I}$ in terms of k. Intuitively, (49) has 3 terms: shifting k impacts financing I, manager effort through e^* , and worker profit through Π . We can simplify slightly further by nothing that $\frac{\partial \Gamma}{\partial e^*} = s_W$, implying that the worker profit term can be written as:

$$(\theta + (1 - \theta) k) \Pi' (\Gamma (e^* (k, s_W), s_W)) s_W \frac{\partial e^*}{\partial k}$$

$$(50)$$

We can eliminate the worker profit term in (49), intuitively, by shifting s_W together with k to hold Π fixed. Technically, this involves substituting the s_W FOC, (27) of Proposition (4), into the k FOC in (49). First, we apply the implicit function theorem to the manager's effort FOC, (48) in Appendix A.6, to calculate $\frac{de^*}{dk}$:

$$\frac{\partial \Lambda}{\partial e} = c''(e) - \frac{s_M}{s_M + s_I} \Pi''(s_W(e + \Delta)) s_W$$
$$\frac{\partial \Lambda}{\partial k} = 1 + \Pi'(s_W(e + \Delta)) s_W$$

Hence we have:

$$\frac{\partial e^*}{\partial k} = \frac{\frac{\partial \Lambda}{\partial k}}{\frac{\partial \Lambda}{\partial e}} = \frac{1 + \Pi'\left(s_W\left(e + \Delta\right)\right)s_W}{c''\left(e\right) - \frac{s_M}{s_M + s_I}\Pi''\left(s_W\left(e + \Delta\right)\right)s_W}$$
(51)

This gives (31). Now, note that we can write (27) of Proposition 4 as:

$$[(\theta + (1 - \theta) k) - c'(e^*(k, s_W))] \frac{\partial e^*}{\partial s_W} = -(\theta + (1 - \theta) k) \Pi'(\Gamma(e^*(k, s_W), s_W)) \left(e^*(k, s_W) + \Delta + s_W \frac{\partial e^*}{\partial s_W}\right)$$

We can multiply both sides by:

$$\frac{s_W \frac{\partial e^*}{\partial k}}{e^* (k, s_W) + \Delta + s_W \frac{\partial e^*}{\partial s_W}}$$

To get:

$$(\theta + (1 - \theta) k) \Pi' (\Gamma (e^* (k, s_W), s_W)) s_W \frac{\partial e^*}{\partial k} = -[(\theta + (1 - \theta) k) - c' (e^* (k, s_W))] \frac{\partial e^*}{\partial s_W} \frac{s_W \frac{\partial e^*}{\partial k}}{e^* (k, s_W) + \Delta + s_W \frac{\partial e^*}{\partial s_W}}$$
(52)

Now, the LHS of (52) is identical to the worker profit term (50) of the manager's FOC with respect to k. We can thus substitute (52) in to (49), getting:

$$\frac{\partial \mathcal{M}}{\partial k} : (1 - \theta) \left[e^{*}(k, s_{W}) + \Pi \left(\Gamma \left(e^{*}(k, s_{W}), s_{W} \right) \right) \right] + \\
\frac{\partial e^{*}}{\partial k} \left[(\theta + (1 - \theta) k) - c' \left(e^{*}(k, s_{W}) \right) \right] + \\
\left[(\theta + (1 - \theta) k) - c' \left(e^{*}(k, s_{W}) \right) \right] \frac{\partial e^{*}}{\partial s_{W}} \frac{s_{W} \frac{\partial e^{*}}{\partial k}}{e^{*}(k, s_{W}) + \Delta + s_{W} \frac{de^{*}}{ds_{W}}} \right]$$

This allows us to group the last two terms, into:

$$\frac{\partial \mathcal{M}}{\partial k}: (1-\theta) \left[e^{*}\left(k, s_{W}\right) + \Pi\left(\Gamma\left(e^{*}\left(k, s_{W}\right), s_{W}\right)\right)\right] + \\ \left[\left(\theta + (1-\theta) k\right) - c'\left(e^{*}\left(k, s_{W}\right)\right)\right] \left[\frac{\partial e^{*}}{\partial k} - \frac{\partial e^{*}}{\partial s_{W}} \frac{s_{W} \frac{\partial e^{*}}{\partial k}}{e^{*}\left(k, s_{W}\right) + \Delta + s_{W} \frac{de^{*}}{ds_{W}}}\right]$$

This gives (30).