Subjective Performance Evaluations, Collusion, and Organizational Design[*]

Veikko Thiele[†]

Queen's School of Business

Queen's University

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Abstract

Many scholars have emphasized the importance of subjective performance evaluations in employment relationships to provide employees with appropriate effort incentives. While the previous literature has focused on subjective evaluations conducted directly by the firm owner (principal), we investigate when delegating subjective appraisals to managers (supervisors) is optimal. Managers are equipped with the expertise to better evaluate employees' contributions to firm value, but can be biased in their evaluation because of potential collusion. We find that delegating performance appraisals to managers is optimal when employees' potential contributions to firm value are relatively low. However, to ensure the impartiality of managers, their compensations must be higher than would otherwise be efficient, and effort incentives for their subordinates must be relatively low. In this proposition, the paper provides a rationale for the existence of hierarchical firm structures, the prevalence of high wage differentials, and the use of low-powered incentives within hierarchical firms.

Keywords: Subjective performance measurement, delegation, supervision, appraisals, collusion, relational contracts, hierarchies, incentives.

JEL classification: D82, D86.

1   Introduction

A prevalent phenomenon in many employment relationships is that employees' contributions to firm value are highly complex, and therefore comprehensive performance measures are not available [Prendergast and Topel, 1996, Prendergast, 1999, Kambe, 2006]. For instance, the performance of employees in human resources departments can generally not be quantified by explicit measures. Even if performance measures are available, they do not generally capture all dimensions of relevant tasks appropriately [Holmström and Milgrom, 1991]. It is commonly argued, for example, that the performance of a firm's sales force can easily be quantified by using available sales data. Yet, even in sales, available performance measures fail to reflect to the full extent the importance of *all* relevant tasks. This is particulary true for tasks which have a rather long-term effect on sales, such as customer care. In the absence of comprehensive and objective performance measures, firms must rely on alternative mechanisms to motivate their employees. One alternative is to use subjective performance evaluations, which are prevalent components of incentive schemes in virtually all firms (see, e.g., Prendergast and Topel [1993], Gibbs [1995], Prendergast [1999], Gibbs, Merchant, Van der Stede, and Vargus [2004], and Gibbons [2005]).

The importance of subjective evaluations in employment contracts has long been recognized in the economic and management literature. Since the seminal work of Bull [1987], researchers have analyzed the optimal application of subjective performance appraisals in principal-agent relationships characterized by moral hazard (see, e.g., MacLeod and Malcomson [1989], Baker, Gibbons, and Murphy [1994], and Levin [2003]). In this context, the recent literature emphasizes the importance of trust and reputation, because incentive payments based on subjective evaluations cannot be legally enforced. It should be noted, however, that the literature on subjective performance evaluations is incomplete in two ways. First, analyzing simple principal-agent models is certainly appropriate to investigate the optimal incentive provision in small firms, but is evidently inadequate for large firms consisting of multiple hierarchy levels. In reality, middle managers, not firm owners, assess the performance of employees as a basis for incentive pay-

ments [Prendergast and Topel, 1993]. Clearly, middle managers are not residual claimants and thus do not share the same objectives as the firm owners.

On the one hand, delegating the responsibility for subjective evaluations to middle managers can augment the credibility of associated incentive payments. On the other hand, doing so might introduce collusive behavior (e.g., Tirole [1986], Tirole [1988], Laffont and Martimort [1997]), which leads to biased appraisals. Put differently, middle managers can be 'loyal' to their subordinates and hence be overly benevolent when it comes to appraising their performance (*collusion-down*).[1] Conversely, a strong 'loyalty' towards the firm can lead to undue critical, or even unfair, assessments (*collusion-up*), which in turn would render incentive payments based on these assessments ineffective.

The second omission in the economic literature is the extent of the information asymmetry problem between the firm owner (principal) and the employee (agent). While the firm owner is unable to observe how much effort the employee implements (moral hazard), she is commonly assumed to possess the required expertise to fully comprehend the employee's contribution to firm value. Again, this assumption appears to be innocuous for investigating incentive provisions within small firms. For large corporations, however, assessing employees' contributions necessitates highly specialized knowledge which direct supervisors have at best, but not firm owners.

To better understand how performance evaluations are organized in firms, it is imperative to investigate the value of incorporating a supervisor (middle manager) into the evaluation process. This raises two important questions. First, when is it optimal for firm owners to employ supervisors to evaluate the performance of employees? Put differently, what drives the hierarchical design of organizations? Second, how do firms prevent biased appraisals which would clearly jeopardize the effectiveness of associated incentive schemes? More specifically, how must employment contracts be adjusted to ensure unbiased performance evaluations?

To answer these research questions, we examine a repeated employment relationship between a risk-neutral principal and a risk-neutral and wealth-constrained agent [Sappington,

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[1]The systematic overrating of employees' performance is also called *leniency bias* in the management literature; see, e.g., Levy and Williams [2004].

1983]. We focus on so-called knowledge workers whose contributions to firm value are too complex to be completely captured by objective performance measures. In such a situation, any incentive payment must be based upon subjective evaluations. We adopt a model based on Demougin and Fluet [2001] in which the optimal incentive contract consists of a base wage and a performance bonus. In our model, we also allow for various complexity levels of the agent's task, which in turn determine how well the agent's performance can be assessed by the principal. We investigate and contrast two alternatives for subjectively evaluating the agent's contribution to firm value. In the first, the principal directly evaluates the agent's performance (*centralization*). The principal, however, lacks the required expertise to fully comprehend the agent's contribution to firm value, a deficiency which constitutes the downside of centralization. Moreover, incentive payments based on subjective evaluations require a sufficient reputation on the side of the principal to be reliable. We identify the optimal self-enforcing incentive contract for centralization and demonstrate how this contract responds to the complexity of the agent's task.

Second, we consider the case in which the agent's performance is evaluated by a supervisor (*delegation*). This alternative differs from centralization (i.e., the case in which the evaluation is conducted directly by the principal) in two important aspects. Firstly, the supervisor is not the residual claimant, and thus is not necessarily motivated to maximize the firm's profit. Secondly, the supervisor is equipped with the expertise to fully comprehend the agent's contribution to firm value. As pointed out earlier, however, empowering the supervisor to subjectively evaluate the agent's performance can create incentives for the involved parties to engage in harmful side-contracting. We therefore derive the optimal employment contracts for delegation which impede potential collusion, and thus guarantee the supervisor's neutrality in the evaluation process.

Our analysis provides novel insights into the efficient design of employment contracts as well as the efficient structure of organizations. First, while it is well known that subjective performance evaluations can lead to low-powered incentives in simple principal-agent relationships (centralization), we find that the same observation can be made for situations where subjective appraisals are delegated to third parties. This study therefore offers an additional theoretical explanation for the phenomenon that performance pay is less prevalent in practice than in the-

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ory [Baker, Jensen, and Murphy, 1988, Brown, 1990, Parent, 2002].[2] The reasons for these observations, however, are drastically different. For subjective evaluations conducted directly by the firm owner (centralization), previous literature has emphasized that low-powered incentives constitute a safeguard against opportunistic behavior, and thus facilitate the reliability of otherwise non-enforceable incentive payments.[3] In contrast, whenever the responsibility for subjective evaluations is delegated to a middle manager (delegation), we find that low-powered incentives are aimed at deterring the involved parties from harmful side-contracting.

The second fundamental observation refers to situations in which a middle manager is in charge of evaluating employees' performance (delegation). Whenever the manager is inclined to be too 'loyal' to the subordinates with respect to their performance evaluations (potential collusion-down), we find that his compensation must be high, providing the middle manager with economic rents. High compensations for middle managers are indispensable in this context to make biased performance appraisals less attractive, thus ensuring middle managers' impartiality in the evaluation process. This observation therefore provides an explanation for the prevalence of high earning differentials between different hierarchy levels in firms (see, e.g., Murphy [1985] and Baker, Gibbs, and Holmström [1994]). According to our analysis, high earning differentials—and thus high compensations for managers—constitute an important safeguard against biased internal performance evaluations, which would clearly jeopardize the effectiveness of associated incentive payments.

Our analysis also reveals that delegating the responsibility for subjective evaluations to a middle manager can be optimal despite potential collusion. Delegation can be preferred as it facilitates accurate appraisals of employees' performance, and therefore improves the effectiveness of associated incentive schemes. Interestingly, middle managers' ability to better assess their subordinates' performance can be sufficient to justify a decentralized evaluation process even though ensuring middle managers' impartiality imposes additional costs. Specifically, we find that a decentralized evaluation process is more likely to be optimal when employees' indi-

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[2]Other potential explanations include the multi-dimensionality of effort, whereby some dimensions can be more easily measured than others [Holmström and Milgrom, 1991, Feltham and Xie, 1994, Hellmann and Thiele, 2008], and the so-called crowding-out effect, whereby monetary incentives may degrade intrinsic motivation (see, e.g., Deci [1971], Frey and Oberholzer-Gee [1997], Benabou and Tirole [2003]).

[3]See, e.g., Baker et al. [1994] for a thorough discussion.

vidual contributions to firm value are relatively insensitive to effort. In sum, our study points out that the necessity for subjective but accurate performance evaluations provides a rationale for the existence of hierarchical firms.

In addition to providing insights into the efficient design of organizations, this study also makes fundamental contributions to the contract theory literature. Specifically, this paper is the first to model subjective performance evaluations in large hierarchical firms, which in turn requires accounting for collusive behavior.[4] We therefore embed collusive behavior in a three-level hierarchy with subjective evaluations and repeated interactions. Surprisingly, the economic literature dealing with collusion in three-level agency relationships has restricted its investigations to static environments (see, e.g., Tirole [1986], Villadsen [1995], Strausz [1997], Vafaï [2005], and Celik [2009]). Intuitively, one can expect that reputational effects emerging from repeated interactions can render side-contracting unprofitable. We derive collusion-proofness conditions in a repeated game environment, and illustrate how employment contracts need to be adjusted to impede harmful side-contracting within firms.

Our model also allows for a critical assessment of the recent trend to flatten the hierarchical structure of firms [Dopson and Stewart, 1990, Rajan and Wulf, 2006]. Building on our analysis, we discuss how the recent transformation of organizations is likely to affect the efficiency of incentive schemes within these firms. Although it is commonly argued that flatter hierarchies can substantially reduce firms' costs, we point out that this conclusion must be handled with care. Specifically, our study accentuates that flatter hierarchies dilute incentive schemes based on subjective evaluations, and thus impair the efficiency of these firms.

There is a growing body of literature investigating the application of subjective performance measures in incentive contracts. One stream, notably Bull [1987], MacLeod and Malcomson [1989], and Levin [2003], has considered optimal incentive provisions in situations in which the principal relies exclusively on subjective performance appraisals because objective (i.e., verifiable) measures are not available. In contrast, Baker et al. [1994], Schmidt and Schnitzer [1995],

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[4]In a recent paper, Grund and Przemeck [2008] investigate potential drivers of biased performance appraisals in supervisor-agent relationships. Similar to our study, they assume that the supervisor is not the residual claimant, and thus does not share the same objectives with the principal. However, like previous literature, they focus on two-layered organizations.

Pearce and Stacchetti [1998], and have investigated the optimal combination of subjective and objective performance measures in incentive contracts. Despite the availability of objective performance measures, subjective evaluations are found to be an integral part of incentive schemes in agency relationships that are characterized by moral hazard.[5]

Our study, however, differs from existing literature in two key aspects. First, we consider a situation in which the principal lacks the expertise to fully identify the agent's contribution to firm value. In doing so, we accentuate the fact that firm owners—as principals—are rarely able to observe and thoroughly assess each employee's individual contribution to firm value. This is particularly true for so-called knowledge workers, whose contributions are generally complex, with the result that an appropriate evaluation requires comprehensive knowledge. Second, past research studies restricted their attention to subjective performance evaluations conducted by the principal. Since it is of high practical relevance, we consider a framework whereby the evaluation process can be delegated to a competent supervisor. In this case, employment contracts need not only to provide sufficient effort incentives, but also to ensure the supervisor's impartiality in the evaluation process.

This paper proceeds as follows. Section 2 introduces the basic model. In section 3, we derive and investigate the optimal contracts for the principal's two alternatives to provide the agent with effort incentives: (i) to directly evaluate the agent's performance (centralization); and (ii) to delegate the responsibility for subjective evaluations to a competent supervisor (delegation). Section 4 then identifies and discusses the optimal organizational design. In section 5, we illustrate and discuss the properties of employment contracts by accounting for the optimal firm structure. We then emphasize in section 6 some managerial and empirical implications which can be derived from our framework. Section 7 summarizes the key insights and concludes.

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[5]See also Hayes and Schaefer [2000] for empirical evidence.

2 The Model

Consider an infinitely repeated employment relationship between a principal and an agent. Both parties are risk-neutral and their patience is reflected by the mutually shared discount rate $r > 0$. Moreover, the agent is financially constrained and his reservation utility is normalized to zero. In every period, the agent is in charge of producing output which contributes to firm value. The agent's contribution to firm value $V \in \{V_L, V_H\}$ can be either high (V_H) or low (V_L), where $\Delta V \equiv V_H - V_L$. While the agent can observe V, the principal lacks the expertise to fully comprehend the agent's contribution to firm value. Nevertheless, the principal receives an unbiased signal $\widetilde{V} = V$ with probability $\theta \in (0, 1)$ which reveals the agent's actual contribution V. This signal can also be observed by the agent, but not by third parties. The probability θ reflects the complexity of the agent's task, and thus, how much expertise is required to fully comprehend the agent's contribution to firm value. However, the agent's contribution V is too complex to be verifiable by third parties.

By implementing effort $e \in \mathbb{R}^+$, the agent determines the likelihood of whether the contribution to firm value V will be high or low. Formally, let

$$\text{Prob}\{V = V_H | e\} = \rho(e) \in [0, 1)$$

be the twice continuously differentiable probability that the agent's contribution V will be high, where $\rho'(e) > 0$ and $\rho''(e) \leq 0$. Moreover, $\rho(0) = 0$, $\rho'(0) = \infty$, and $\lim_{e \to \infty} \rho(e) < 1$. Effort is non-observable and imposes strictly convex increasing costs $c(e)$ with $c(0) = c'(0) = 0$.

Since the agent's contribution to firm value V is non-verifiable, the principal cannot use this information in a court-enforceable incentive contract. Nevertheless, the principal can offer the agent a relational incentive contract based upon her subjective evaluation of the agent's performance, henceforth referred to as *centralization*. More specifically, in addition to a base wage α, the principal can promise to pay the agent a bonus β in the event that she observes a high contribution to firm value V_H.[6] The payment of β, however, cannot be legally enforced so the principal's promise needs to be reliable from the agent's perspective. We assume that the agent initially trusts the principal but plays a grim trigger strategy: Once the principal reneges

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[6]The binary structure of the information system implies that the optimal contract must be a bonus contract.

on her promise to pay the bonus β despite having observed a high contribution to firm value (i.e., $\widetilde{V} = V_H$), the agent will henceforth refuse to implement effort. The same applies to other potential agents as the principal earns a bad reputation in the labor market (see, e.g., Bull [1987]).

As previously mentioned, the principal lacks the required expertise to fully recognize the agent's contribution to firm value. As an alternative to directly evaluating the agent's performance (*centralization*), the principal can delegate this task to a middle manager, henceforth referred to as supervisor.[7] The involvement of a supervisor in the evaluation process as a basis for incentive payments is henceforth referred to as *delegation*. The supervisor is risk-neutral and his reservation utility is zero.[8] Moreover, the supervisor is equipped with the expertise to fully identify the agent's contribution to firm value.[9] The principal can utilize the supervisor's information advantage by making the agent's incentive payment contingent upon the supervisor's performance appraisal. Furthermore, the supervisor's assessment can be made public, which in turn renders the incentive contract under delegation court-enforceable. In exchange for the evaluation of the agent's performance, the principal offers the supervisor the payment w^S. However, as we will discuss in more detail in Section 3.2, delegating the subjective appraisal can provoke side-contracting between the supervisor and either the principal or the agent. Once the principal colludes with the supervisor, the agent will henceforth refuse to implement effort, which clearly stems from his grim trigger strategy.

The timing is as follows. At date 0, the principal determines the organizational design (centralization or delegation), and offers the agent an employment contract $w^A(\alpha, \beta)$. If the principal decided in favor of delegation, she also offers the supervisor a compensation w^S. At date 1, after accepting his contract, the agent implements effort e. At date 2, the agent's

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[7]The supervisor could also conduct other tasks which contribute to firm value. This paper, however, focuses on the principal's preference for employing a supervisor in order to obtain contractible measures of the agent's performance.

[8]We briefly discuss in section 4 the effect of a strictly positive reservation utility on the optimal organizational design.

[9]Alternatively, we could assume that the supervisor cannot perfectly observe the agent's contribution V, and instead receives a signal $\widetilde{V}_S = V$ with probability θ_S. However, as long as the supervisor is more likely than the principal to observe the agent's actual contribution (i.e., $\theta < \theta_S$), it becomes clear from our subsequent analysis that we obtain the same qualitative results, but add more complexity to the model.

contribution to firm value V is realized, and his performance is subjectively evaluated either by the principal (centralization) or by the supervisor (delegation). If the principal decided to delegate the subjective appraisal of the agent's performance to the supervisor (delegation), the latter potentially colludes with the principal or with the agent. Finally, all payments are made.

3   Organizational Design and the Provision of Incentives

3.1   Direct Performance Evaluations (Centralization)

We begin our analysis by investigating the optimal relational incentive contract based on the principal's direct appraisal of the agent's performance. Although it cannot be legally enforced, the principal's promise to pay a bonus β_c could be credible from the agent's perspective if both parties interact for an infinite number of periods. Hence, we need to identify the reputational equilibrium at which the principal is not tempted to renege on her promise to pay β_c, and the relational incentive contract is thus self-enforcing (see, e.g., Holmstrom [1981], Bull [1987], and Thomas and Worrall [1988]).

In order to derive the optimal self-enforcing incentive contract, we first need to characterize the principal's best fallback position. Suppose for a moment that the principal and the agent interact only for one period. To motivate effort, the principal could promise to pay the agent a bonus $\beta_c > 0$ if she observes that the contribution to firm value is high.[10] Once this occurs, however, the principal would renege on her promise since the payment of β_c cannot be legally enforced, and there is no future benefit from cooperation. Clearly, the agent anticipates this opportunistic behavior and thus refuses to implement effort. It can therefore be deduced that the optimal spot contract is characterized by $\alpha_c^* = \beta_c^* = 0$, which in turn provides the principal with the profit $\bar{\bar{\Pi}} = V_L$.

After characterizing the principal's best fallback position, we can now derive the self-enforcement condition which ensures that incentive payments based on her subjective evaluations are credible. As emphasized earlier, the principal can promise to pay the agent a bonus

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[10]In the remainder of this paper, the subscript 'c' refers to *centralization*, and the subscript 'd' to *delegation*.

$\beta_c > 0$ whenever she observes a high contribution to firm value V_H. To characterize the self-enforcement condition for this relational incentive contract, suppose for a moment that the principal notices in fact a high contribution (i.e., $\widetilde{V} = V_H$). In this case, she pays the agent the bonus β_c if

$$-\beta_c + \frac{\Pi^c}{r} \geq \frac{\bar{\Pi}}{r}, \qquad (1)$$

where Π^c denotes the principal's expected profit if she directly evaluates the agent's performance (centralization). Clearly, the principal adheres to her promise if paying the bonus β_c but sustaining the employment relationship based on a direct performance evaluation yields a higher expected profit than the best fallback $\bar{\Pi}$.

We can now turn to the principal's maximization problem. The principal's objective is to find a credible bonus contract (α_c^*, β_c^*) which maximizes the difference between the expected contribution to firm value and the agent's expected wage, while ensuring the agent's participation in this employment relationship. The optimal bonus contract (α_c^*, β_c^*) thus solves[11]

$$\max_{\alpha_c, \beta_c, e} \Pi^c(\alpha_c, \beta_c, e) = V_L + \Delta V \rho(e) - \alpha_c - \rho(e)\theta\beta_c \qquad (2)$$

s.t.

$$\alpha_c + \rho(e)\theta\beta_c - c(e) \geq 0 \qquad (3)$$

$$e \in \arg\max_{\tilde{e}} \alpha_c + \rho(\tilde{e})\theta\beta_c - c(\tilde{e}) \qquad (4)$$

$$\alpha_c \geq 0 \qquad (5)$$

$$\Pi^c(\alpha_c, \beta_c, e) - \bar{\Pi} \geq r\beta_c. \qquad (6)$$

Condition (3) is the agent's participation and (4) his incentive constraint. Furthermore, (5) is the liability limit constraint guaranteeing that payments to the agent are non-negative. Finally, (6) is the self-enforcement condition (derived from (1)) ensuring that the principal's promise to pay $\beta_c > 0$ is credible.

Before we derive the optimal bonus contract, let us first consider the agent's incentive constraint (4). Observe that (4) is equivalent to

$$\beta_c(e, \theta) = \frac{c'(e)}{\rho'(e)\theta}, \qquad (7)$$

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[11]Note that maximizing the expected profit for a single period is equivalent to maximizing the present value of all future expected profits. This is because reneging does not occur in the reputational equilibrium so expected profits are identical in every period.

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with $\beta_c(e, \theta)$ as the required bonus to induce an arbitrary effort level e.[12] To ensure the sufficiency of the first-order approach, we assume that the expected bonus

$$B(e) \equiv \rho(e)\theta\beta_c(e, \theta) = \frac{\rho(e)c'(e)}{\rho'(e)} \tag{8}$$

is convex in e.[13] It becomes clear from (7) that the principal can induce the same effort level with a lower incentive bonus if the agent's task is less complex, which is reflected by a higher θ. This can be observed because the agent's contribution to firm value becomes more likely to be noticed by the principal, which in turn improves effort incentives. We summarize this important observation in the next lemma.

Lemma 1 *Suppose the agent's task becomes more complex (i.e., θ decreases). Then, the principal needs to offer the agent a higher bonus β_c in order to induce the same effort level.*

The next proposition characterizes the optimal bonus contract (α_c^*, β_c^*) by utilizing two threshold discount rates conditional on the task complexity parameter θ: $r_c(\theta)$ and $\widehat{r}_c(\theta)$. For parsimony, the threshold discount rates for this and subsequent propositions are characterized in the respective proofs in the Appendix.

Proposition 1 *If the agent's performance is directly evaluated by the principal (centralization), the optimal base wage is $\alpha_c^{**} = 0$. The optimal incentive bonus β_c^* is characterized as follows:*

(i) *If the discount rate r is sufficiently low (i.e., $r \leq r_c(\theta)$), the principal provides the agent with the efficient bonus $\beta_c^{**}(e^*, \theta)$, where e^* solves $\Delta V \rho'(e) = B'(e)$.*

(ii) *For intermediate discount rates (i.e., $r_c(\theta) < r \leq \widehat{r}_c(\theta)$), the optimal bonus $\beta_c^*(r, \theta)$ is below the efficient level (i.e., $\beta_c^*(r, \theta) < \beta_c^{**}(e^*, \theta)$) and decreasing in r.*

(iii) *If the discount rate r is sufficiently high (i.e., $r > \widehat{r}_c(\theta)$), the optimal bonus is $\beta_c^*(r, \theta) = 0$.*

Proof All proofs are given in the Appendix.

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[12]It might be useful for the subsequent analysis to keep the following simple specification in mind: $\rho(e) = e$ and $c(e) = \gamma e^2/2$, where γ is sufficiently large such that for the second-best effort level e^* it holds that $e^* < 1$, and thus, $\rho(e^*) < 1$. Then, (7) becomes $\beta_c(e, \theta) = \gamma e/\theta$, which is equivalent to $e(\beta_c, \theta) = \theta\beta_c/\gamma$.

[13]It can be shown that assuming $c'''(e) \geq 0$ suffices to ensure that $B(e)$ is convex.
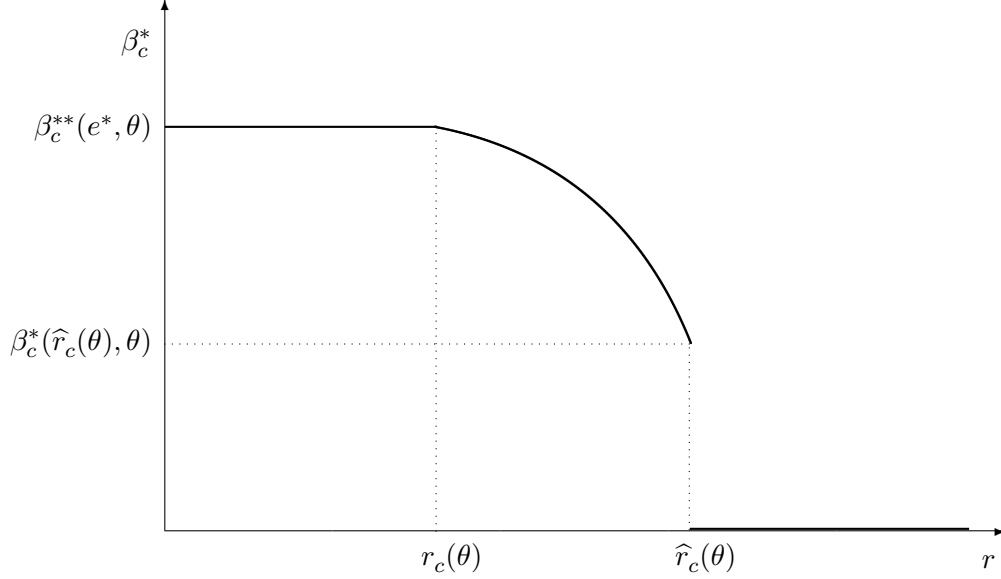
Figure 1: Centralization and the Provision of Incentives

Figure 1 illustrates the fundamental insights from Proposition 1. Clearly, the principal's promise to pay the efficient incentive bonus $\beta_c^{**}(e^*, \theta)$ is reliable as long as the discount rate r is sufficiently low. In this case, the value of a sustained employment relationship eliminates the principal's reneging temptation, and the incentive contract $(\alpha_c^{**}, \beta_c^{**}(e^*, \theta))$ is thus self-enforcing. The agent anticipates that the principal will deliver on her promise to pay $\beta_c^{**}(e^*, \theta)$, and is therefore motivated to implement the efficient (second-best) effort level e^*. For intermediate discount rates, however, the present value of a sustained employment relationship is too low to deter the principal from breaching the promise to pay $\beta_c^{**}(e^*, \theta)$. She is therefore compelled to reduce the agent's bonus payment below its efficient level in order to ensure its reliability. More specifically, the principal chooses the highest feasible bonus $\beta_c^*(r, \theta)$ such that the self-enforcement condition (6) becomes binding. Finally, if the discount rate is too high, the principal is tempted to bilk the agent of every strictly positive bonus β_c. Put another way, she cannot find a bonus $\beta_c > 0$ which satisfies the self-enforcement condition (6). Since any incentive payment is not trustworthy from the agent's perspective, the principal sets $\beta_c^*(r, \theta) = 0$, which in turn implies that the agent refuses to implement effort.

3.2 Delegating the Subjective Performance Evaluation

As shown in the preceding section, the agent cannot be motivated to implement the efficient (second-best) effort level e^* if the principal's promise to pay the efficient bonus $\beta_c^{**}(e^*, \theta)$ is not reliable. Instead of directly evaluating the agent's performance (centralization), the principal can delegate this task to a supervisor. The supervisor's expertise—which enables him to fully recognize the agent's contribution—clearly constitutes an argument for delegation. However, as discussed in the Introduction, delegating the performance evaluation to a third party potentially initiates vertical side-contracting. Whether the principal or the agent might be tempted to collude with the supervisor is eventually determined by the agent's actual contribution to firm value V. If the agent's contribution is low ($V = V_L$), the agent could secure the bonus β_d by bribing the supervisor into spuriously affirming a high contribution V_H. In contrast, if the agent's actual contribution is high ($V = V_H$), the principal could be tempted to bribe the supervisor into asserting a low contribution V_L in order to avoid the payment of β_d. To simplify the distinction between both types of collusion, we henceforth refer to side-contracting between the supervisor and agent as *collusion-down*, and between the supervisor and principal as *collusion-up*.

Clearly, potential collusion constitutes a serious threat to the efficiency of any incentive payments offered to the agent. It is therefore crucial for the principal to offer employment contracts which do not trigger side-contracting. To derive the necessary collusion-proofness conditions, we need to elaborate on the immediate consequences of collusion-down and collusion-up. To do so, consider first the principal's temptation to collude with the supervisor (collusion-up). The agent knows that collusion-up must have occurred whenever the actual contribution to firm value deviates from the one attested by the supervisor. Due to the agent's grim trigger strategy, the principal's fallback position after colluding with the supervisor is the application of a spot contract as considered in section 3.1. The principal, in contrast, can only detect collusion between the supervisor and agent (collusion-down) if she in fact observes the agent's actual contribution to firm value, which occurs with probability θ. If the principal discovers collusion-down, we assume that she replaces both colluding parties by employing a new agent and supervisor from the labor market.

We can now derive a condition which ensures that collusion between the supervisor and principal (collusion-up) does not take place. For this purpose, suppose for a moment that the agent's actual contribution to firm value is high ($V = V_H$). Furthermore, let $\bar{T}^P$ denote the maximum bribe the principal is willing to offer the supervisor in exchange for asserting a low contribution V_L, which is targeted at avoiding paying the bonus β_d. The maximum bribe $\bar{T}^P$ equals the principal's one-time gain β_d minus the discounted loss of expected profits after she has colluded with the supervisor and thus forfeited her reputation in the labor market:

$$\bar{T}^P(r) = \beta_d - \frac{\Pi^d - \bar{\Pi}}{r}. \tag{9}$$

If the supervisor accepts any bribe offered by the principal, we assume that the supervisor does not deviate from the stipulated behavior and affirms a low contribution to firm value.[14] For simplicity, we also assume that the supervisor colludes with the principal only if the offered bribe makes the supervisor *strictly* better off. Therefore, collusion-up would never occur if

$$\bar{T}^P(r) \leq \frac{1}{r} w^S, \tag{10}$$

because even the maximum bribe $\bar{T}^P(r)$ does not compensate the supervisor for the loss of prospective income.

Likewise, we can derive a condition which guarantees that collusion between the supervisor and agent (collusion-down) does not occur. To do so, suppose for a moment that the agent's actual contribution to firm value is low ($V = V_L$). Moreover, let $\bar{T}^A$ denote the maximum bribe the agent is willing to pay the supervisor in exchange for spuriously affirming a high contribution V_H, which clearly aims at securing the bonus β_d. The maximum bribe $\bar{T}^A$ equals the agent's one-time gain β_d minus the discounted loss of expected utility once collusion-down has been detected by the principal:

$$\bar{T}^A(r, \theta) = \beta_d - \frac{\theta}{r} \left[\alpha_d + \beta_d \rho(e) - c(e) \right]. \tag{11}$$

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[14]There exists experimental evidence that promises are honored among agents; see Dawes and Thaler [1988] for a survey. Alternatively, one could relax this assumption and consider reputational equilibria in repeated games which ensure that the supervisor does not deviate. Then, as becomes clear from our subsequent analysis, impeding collusion becomes less costly for the principal. This in turn implies that delegation becomes more often the optimal organizational design, which clearly reinforces our main implication.

The supervisor, however, will always refuse to collude with the agent whenever the maximum bribe $\bar{T}^A(r,\theta)$ does not compensate for the expected loss of future income:

$$\bar{T}^A(r,\theta) \leq \frac{\theta}{r} w^S. \tag{12}$$

After deriving the collusion-proofness conditions, we can now turn to the principal's problem. The principal's objective is to find collusion-proof employment contracts (α_d^*, β_d^*) and w^{S*} which maximize the expected profit, while ensuring the participation of both the agent and the supervisor. The optimal contracts thus solve

$$\max_{\alpha_d, \beta_d, e, w^S} \Pi^d = V_L + \Delta V \rho(e) - \alpha_d - \rho(e)\beta_d - w^S \tag{13}$$

s.t.

(5)

$$\alpha_d + \rho(e)\beta_d - c(e) \geq 0 \tag{14}$$

$$e \in \arg\max_{\tilde{e}} \alpha_d + \rho(\tilde{e})\beta_d - c(\tilde{e}) \tag{15}$$

$$w^S \geq 0 \tag{16}$$

$$\bar{T}^A(r,\theta) \leq \theta w^S / r \tag{17}$$

$$\bar{T}^P(r) \leq w^S / r. \tag{18}$$

This maximization problem differs from the one considered in section 3.1 (centralization) in three aspects. First, the probability for the agent to obtain the bonus β_d is now $\rho(e)$, and thus independent of the task complexity measure θ. This can be observed because the supervisor's expertise ensures that the bonus β_d is paid whenever the agent's contribution to firm value is high (i.e., $V = V_H$). Second, the supervisor's affirmation of the agent's actual contribution V renders the self-enforcement condition (6) unnecessary. Finally, the present maximization problem also takes into account the supervisor's participation constraint (16) as well as the two previously derived collusion-proofness conditions (17) and (18).

To shed light on the optimal employment contracts under delegation, we first identify the efficient contracts $(\alpha_d^{**}, \beta_d^{**})$ and w^{S**} in the absence of potential collusion. In addition to characterizing these efficient contracts, the next proposition exposes a collusion-proofness condition

by utilizing two threshold discount rates r_d^P and $r_d^A(\theta)$. More specifically, the threshold discount rate r_d^P refers to the principal's temptation to collude with the supervisor (collusion-up), while $r_d^A(\theta)$ refers to the agent's temptation (collusion-down).

Proposition 2 *If the agent's performance is evaluated by the supervisor (delegation), then*

(i)   *the efficient base wage for the agent is $\alpha_d^{**} = 0$, and the efficient incentive bonus is*
       $$\beta_d^{**}(e^*) = c'(e^*)/\rho'(e^*), \text{ where } e^* \text{ solves } \Delta V \rho'(e) = B'(e);$$

(ii) *the efficient wage for the supervisor is $w^{S**} = 0$.*

The efficient employment contracts $(\alpha_d^{**}, \beta_d^{**}(e^*))$ and w^{S**} do not induce collusion if the discount rate r is sufficiently low (i.e., $r \leq r_d(\theta) \equiv \min\{r_d^A(\theta), r_d^P\}$).

Proposition 2 provides two important insights. First, if all involved parties are sufficiently patient (i.e., $r \leq r_d(\theta)$), the efficient employment contracts $(\alpha_d^{**}, \beta_d^{**}(e^*))$ and w^{S**} trigger neither collusion-up nor collusion-down. In this case, every party clearly gains more from a sustained employment relationship based on the supervisor's performance appraisal than from side-contracting. The second important insight refers to the agent's efficient incentive bonus $\beta_d^{**}(e^*)$. In contrast to the case where the agent's performance is directly evaluated by the principal (centralization), the complexity of the agent's task—measured by θ—does not affect the optimal incentive provision. This observation is clearly rooted in the supervisor's expertise, which eventually allows to reward the agent whenever the actual contribution to firm value is high.

However, if the involved parties are not sufficiently patient (i.e., $r > r_d(\theta)$), the efficient employment contracts $(\alpha_d^{**}, \beta_d^{**}(e^*))$ and w^{S**} will trigger either collusion-up or collusion-down. Technically, the efficient contracts violate at least one of the collusion-proofness conditions (17) and (18). The next lemma exposes a condition which allows us to identify when the efficient contracts initiate collusion-down but not collusion-up, and vice versa.

Lemma 2 *There exists a threshold of the task complexity measure $\widehat{\theta}(\Delta V) \in (0, 1]$ such that for some discount rates, the efficient contracts $(\alpha_d^{**}, \beta_d^{**}(e^*))$ and w^{S**} are only prone to collusion-down if $\theta < \widehat{\theta}(\Delta V)$ (i.e., $r_d^A(\theta) < r_d^P$), and to collusion-up otherwise (i.e., $r_d^A(\theta) \geq r_d^P$). The threshold $\widehat{\theta}(\Delta V)$ is increasing in the agent's potential contribution to firm value ΔV.*

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According to Lemma 2, the complexity of the agent's task (measured by θ) eventually determines whether the efficient contracts will trigger only collusion-down or only collusion-up. More specifically, if the agent's task is sufficiently complex, the efficient contracts are more prone to collusion-down because the principal—as a result of her limited expertise—is less likely to detect collusion between the supervisor and agent. This in turn alleviates the expected penalty for side-contracting, and thus makes collusion-down more attractive. We can also infer from Lemma 2 that the effectiveness of the agent's incentive contract is more likely to be put in jeopardy by collusion-up whenever the agent's potential contribution to firm value ΔV is sufficiently low. Clearly, a low potential contribution decreases the principal's benefit from a sustained employment relationship, and thus makes collusion-up more attractive.

If the efficient employment contracts initiate either collusion-down or collusion-up, the principal is forced to adjust these contracts in order to safeguard their effectiveness against harmful side-contracting. To ease the derivation of the optimal collusion-proof employment contracts, we first illustrate the contract adjustments required to impede collusion-down.

Proposition 3 (Collusion-down) *If the discount rate r is sufficiently high (i.e., $r > r_d^A(\theta)$), preventing collusion-down requires the following contract adjustments:*

(i) *The agent's and supervisor's optimal fixed payments $\alpha_{d \cdot cd}^*(r, \theta)$ and $w_{cd}^{S*}(r, \theta)$ are set above their efficient levels (i.e., $\alpha_{d \cdot cd}^*(r, \theta) \geq \alpha_d^{**}$ and $w_{cd}^{S*}(r, \theta) \geq w^{S**}$). The optimal fixed payments $\alpha_{d \cdot cd}^*(r, \theta)$ and $w_{cd}^{S*}(r, \theta)$ are increasing in the discount rate r and decreasing in the task complexity measure θ.*

(ii) *The agent's optimal bonus $\beta_{d \cdot cd}^*(r, \theta)$ is below its efficient level (i.e., $\beta_{d \cdot cd}^*(r, \theta) < \beta_d^{**}(e^*)$), and is decreasing in the discount rate r and increasing in the task complexity measure θ.*

Proposition 3 provides three important insights. First, impeding side-contracting between the supervisor and agent requires enhancing their wages above their efficient levels. This in turn provides both parties with higher economic rents, which are essential to deter them from side-contracting. The second important observation refers to the agent's optimal incentive payment $\beta_{d \cdot cd}^*(r, \theta)$. According to Proposition 3, the principal is compelled to provide the agent with too low-powered incentives. Reducing the agent's incentive payment below its efficient level

clearly degrades the agent's one-time gain from collusion, and thus curbs his temptation to bribe the supervisor into spuriously affirming a high contribution to firm value V_H. Finally, Proposition 3 points out that the required contract adjustments are sensitive to the complexity of the agent's task, which is measured by θ. More specifically, if the agent's task is highly complex (i.e., θ is low), preventing collusion-down necessitates higher wages for both the agent and the supervisor, and lower-powered effort incentives for the agent. This can be deduced because a higher task complexity hampers the principal to detect side-contracting between the supervisor and agent.

We can now turn to the contract adjustments which are required to prevent collusion between the supervisor and principal (collusion-up).

Proposition 4 (Collusion-up) *If the discount rate r is sufficiently high (i.e., $r > r_d^P$), preventing collusion-up only requires adjusting the agent's incentive bonus β_d^* as follows:*

(i) *For intermediate discount rates r (i.e., $r^P < r \leq \widehat{r}_d^P$), the optimal bonus $\beta_{d \cdot cu}^*(r)$ is below its efficient level (i.e., $\beta_{d \cdot cu}^*(r) < \beta_d^{**}(e^*)$) and is decreasing in the discount rate r.*

(ii) *If the discount rate r is sufficiently high (i.e., $r > \widehat{r}_d^P$), the optimal bonus is $\beta_{d \cdot cu}^*(r) = 0$.*

To credibly commit herself not to collude with the supervisor (collusion-up), the principal is compelled to reduce the agent's incentive payment below its efficient level. Put differently, providing low-powered incentives is clearly targeted at curbing the principal's one-time gain from side-contracting, and thus strengthening the reliability of incentive payments based on the supervisor's appraisal. However, if the discount rate is sufficiently high, every strictly positive incentive payment for the agent will prompt the principal to collude with the supervisor. To ensure collusion-proofness, the principal is therefore forced to refrain from offering the agent an incentive payment. Furthermore, Proposition 4 points out that the prevention of collusion-up—in contrast to collusion-down—does not necessitate setting the agent's and supervisor's wages above their efficient levels. As becomes clear from the Proof of Proposition 4 (see Appendix), setting the agent's base wage α_d above its efficient level ($\alpha_d^{**} = 0$) actually encourages collusion-up. Enhancing the supervisor's wage w^S, however, does not support the prevention of
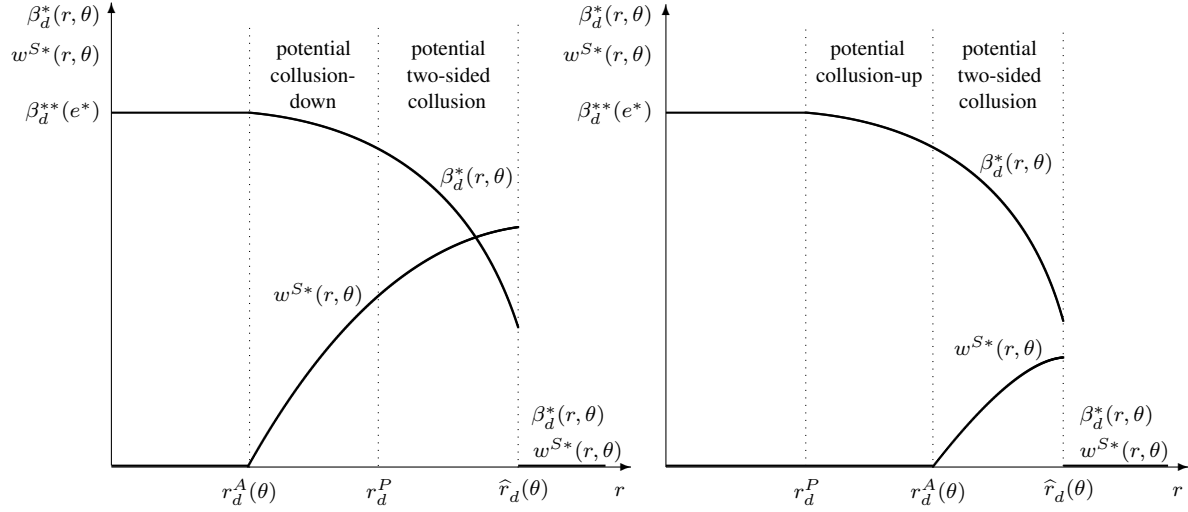
Figure 2: Delegation and Employment Contracts

collusion-up. It is therefore optimal for the principal to set the agent's and supervisor's wages at their respective efficient levels.

By drawing on the results from Propositions 2, 3, and 4, we can finally characterize the optimal employment contracts for delegation.

Proposition 5 *If the agent's performance is evaluated by the supervisor (delegation), the agent's and supervisor's optimal employment contracts are characterized as follows:*

(i) *The agent's optimal base wage $\alpha_d^*(r,\theta)$ is identical to its efficient level for all discount rates r (i.e., $\alpha_d^*(r,\theta) = \alpha_d^{**}$).*

(ii) *For sufficiently low discount rates (i.e., $r \leq r_d$), the agent's optimal incentive bonus $\beta_d^*(r,\theta)$ is identical to its efficient level (i.e., $\beta_d^*(r,\theta) = \beta_d^{**}(e^*)$), and below otherwise (i.e., $\beta_d^*(r,\theta) = \min\{\beta_{d \cdot cd}^*(r,\theta), \beta_{d \cdot cu}^*(r,\theta)\} < \beta_d^{**}(e^*)$).*

(iii) *For sufficiently low discount rates (i.e., $r \leq r_d^A(\theta)$), the supervisor's optimal wage $w^{S*}(r,\theta)$ is identical to its efficient level (i.e., $w^{S*}(r,\theta) = w^{S**}$), and above for intermediate discount rates (i.e., $w^{S*}(r,\theta) > w^{S**}$ for $r_d^A(\theta) < r \leq \widehat{r}_d(\theta)$).*

If the discount rate r is sufficiently high (i.e., $r > \widehat{r}_d(\theta)$), the optimal employment contracts are characterized by $\alpha_d^*(r,\theta) = \beta_d^*(r,\theta) = 0$ and $w^{S*}(r,\theta) = 0$.

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Figure 2 illustrates the fundamental insights from Proposition 5. Notice that the left graph visualizes the contract adjustments for a low complexity level of the agent's task (i.e., $\theta < \widehat{\theta}(\Delta V)$ such that $r_d^A(\theta) < r_d^P$), and the right graph for a high complexity level (i.e., $\theta > \widehat{\theta}(\Delta V)$ such that $r_d^P < r_d^A(\theta)$). Clearly, a sufficiently low discount rate r allows the principal to utilize the efficient employment contracts $(\alpha_d^{**}, \beta_d^{**}(e^*))$ and w^{S**} without compromising the supervisor's neutrality in the evaluation process. Otherwise, the principal is forced to adjust these contracts in order to impede harmful side-contracting. As revealed by our previous analysis, the specific adjustments depend on whether the efficient employment contracts are prone to collusion-up, collusion-down, or both. In particular, offering the supervisor a compensation $w^{S*}(r, \theta)$ above its efficient level is essential whenever the supervisor is tempted to collude with the agent (collusion-down). Enhancing the supervisor's wage above its efficient level provides the supervisors with economic rents, which in turn are necessary to ensure an unbiased evaluation of the agent's performance. Furthermore, the principal is forced to provide the agent with too low-powered incentives whenever the efficient contracts are prone either to collusion-down or to collusion-up. As explained earlier, this approach aims at impairing the principal's (collusion-up) or the agent's (collusion-down) one-time gain from colluding with the supervisor, and is thus targeted at ensuring the supervisor's neutrality in the evaluation process.

Finally, for sufficiently high discount rates r, the agent's optimal employment contract does not comprise any incentive payments. The reason for this observation can be twofold. Firstly, for sufficiently high values of r, the principal cannot find a strictly positive bonus which eliminates her temptation to collude with the supervisor (collusion-up). Secondly, ensuring an unbiased evaluation process requires offering the supervisor a compensation $w^{S*}(r, \theta)$ which might eventually exceed the agent's expected contribution to firm value. In both situations, the principal is forced to desist from providing the agent with effort incentives.

4 The Optimal Organizational Design

After characterizing the optimal employment contracts for both alternatives, we are now well equipped to identify the superior organizational design when firms rely on subjective evalua-

tions to provide their employees with effort incentives. We begin our investigation by focusing on the relationship between the complexity of the agent's task (measured by θ) and the optimal firm structure. To shed light on this relationship, we first consider the extreme case in which the principal can fully observe the agent's contribution to firm value.

Lemma 3 *Suppose the agent's contribution to firm value V can completely be observed by the principal (i.e., $\theta = 1$). In this case, the principal does not benefit from delegating the responsibility for subjective performance evaluations to a supervisor.*

Lemma 3 provides an important insight into the efficient design of organizations. Accordingly, whenever the principal is able to perfectly observe the agent's contribution to firm value, there is no need to incorporate a third party—the supervisor—in the evaluation process. A subjective performance evaluation conducted by the principal yields at least the same contract efficiency as delegating this task to a supervisor. At first glance, this result is surprising because a direct evaluation (centralization) necessitates sufficient trust to be effective, which—according to our previous analysis—can only be achieved in some situations by curbing effort incentives for the agent. By contrast, delegating performance appraisals to a supervisor renders trust unnecessary as associated incentive payments can be enforced by court. As shown, however, ensuring the supervisor's neutrality in the evaluation process potentially imposes additional costs, which are rooted in the supervisor's high wage, and in the low-powered incentives for the agent. We can infer from Lemma 3 that the costs associated with delegation—at least weakly—outweigh the costs associated with centralization.

We now investigate the optimal firm structure for the more realistic case in which the agent's contribution to firm value V is complex, and therefore, cannot fully be recognized by the principal (i.e., $\theta < 1$). By utilizing a new threshold discount rate $\widehat{r}(\theta)$, the next proposition identifies the superior organizational design when the principal relies on subjective evaluations to provide the agent with effort incentives.

Proposition 6 *Suppose the principal cannot fully comprehend the agent's contribution to firm value V (i.e., $\theta < 1$). The optimal organizational design is then characterized as follows:*
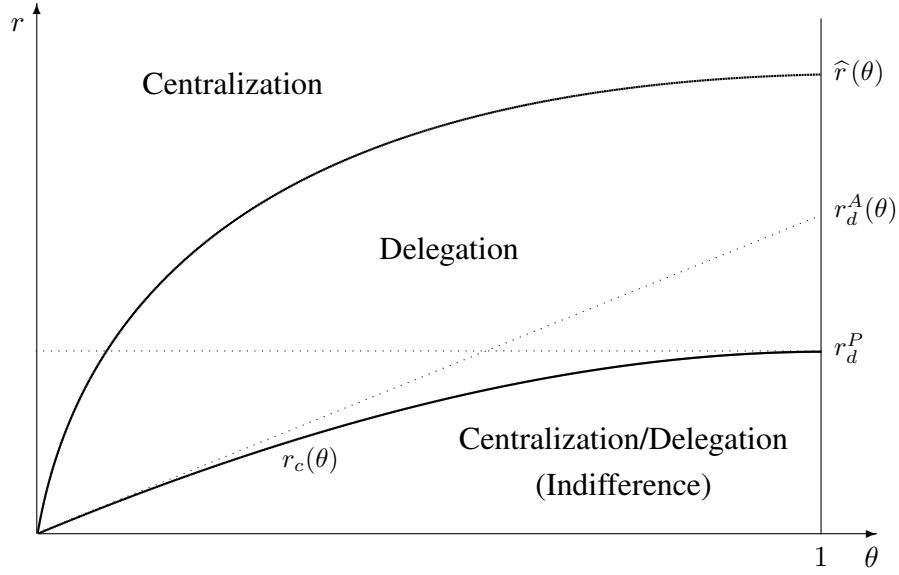
Figure 3: Task Complexity and the Optimal Organizational Choice

(i) *If the discount rate r is sufficiently low (i.e., $r \leq \min\{r_c(\theta), r_d^A(\theta)\}$), the principal is indifferent between centralization and delegation.*

(ii) *For intermediate discount rates (i.e., $r_c(\theta) < r < \widehat{r}(\theta)$), the principal strictly prefers delegation.*

(iii) *For some intermediate discount rates (i.e., $r_d^A(\theta) < r \leq r_c(\theta)$ if $r_d^A(\theta) < r_c(\theta)$), and for sufficiently high discount rates (i.e., $r \geq \widehat{r}(\theta)$), the principal prefers centralization.*

Proposition 6 points out that the optimal firm structure is determined by the mutually shared discount rate r, which—as revealed by our previous analysis—defines the respective employment contracts for both alternatives. Less obvious but at least as crucial for the optimal organizational design, however, is the complexity of the agent's task, measured by θ. This follows from the fact that various threshold discount rates—which eventually determine the optimal firm structure—are affected by the task complexity measure θ. Figure 3 illustrates the superior firm structure for different discount rates r (vertical axis) and task complexity measures θ (horizontal axis) as emphasized by Proposition 6.[15]

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[15]We demonstrate in Proof of Proposition 6 that $\widehat{r}(\theta) = \min\{\widehat{r}_{d \cdot cd}(\theta), \widehat{r}_d^P\}$, where $\widehat{r}_{d \cdot cd}(\theta)$ is a new threshold discount rate. We implicitly assumed for Figure 3 that $\widehat{r}_d^P > \widehat{r}_{d \cdot cd}(\theta)$ for all $\theta < 1$, so that $\widehat{r}(\theta)$ is strictly increasing in θ, and $r_c(\theta) < r_d^A(\theta)$ for all $\theta > 0$.

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Clearly, for sufficiently low discount rates, both centralization and delegation are equally profitable for the principal. The reason is as follows. For centralization, the principal's promise to pay the efficient bonus $\beta_c^{**}(e^*, \theta)$ is reliable from the agent's perspective. For delegation, the efficient contracts $(\alpha_d^{**}, \beta_d^{**}(e^*))$ and w^{S**} are prone neither to collusion-up nor to collusion-down. At first glance, however, it appears to be surprising that—despite her limited expertise—the principal conducting the performance evaluation (centralization) is as profitable as delegating this task to a supervisor. Specifically, for centralization, Lemma 1 pointed out that a more complex task necessitates offering the agent a higher incentive bonus β_c in order to induce the same effort level. At the same time, however, the agent is less likely to obtain the bonus. One can easily verify that the net effect on the expected bonus $B(e)$—and thus on the principal's expected profit—is zero for $r \leq r_c(\theta)$.[16] Consequently, centralization and delegation are equally profitable for sufficiently low discount rates, irrespective of the agent's task complexity. Note, however, that this conclusion rests on the assumption that the supervisor's reservation utility is zero. With a strictly positive reservation utility—which would imply that the supervisor's wage w^{S**} is strictly positive—the principal would then have a clear preference for direct performance evaluations (centralization).[17]

The most important implication from Proposition 6, however, is that delegating the responsibility for subjective evaluations to a supervisor (delegation) can be optimal. More specifically, delegation constitutes the superior organizational design for intermediate discount rates when the agent's contribution to firm value is complex, and therefore cannot completely be observed by the principal (i.e., $\theta < 1$). This can be observed despite ensuring the impartiality of the supervisor in the evaluation process is costly. More precisely, to deter the involved parties from harmful side-contracting, the corresponding employment contracts comprise an inefficiently high wage for the supervisor, and too low-powered incentives for the agent. Clearly, in the event that delegation constitutes the superior organizational design, these costs must be outweighed by the supervisor's expertise, which allows the firm to reward the agent whenever his

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[16]See Proof of Proposition 6 in the Appendix for a formal derivation.

[17]However, incorporating a strictly positive reservation utility for the supervisor would add more complexity to our model without providing additional insights.

performance is high. Otherwise, if impeding side-contracting becomes too costly, the principal prefers to directly evaluate the agent's performance (centralization).

For delegation, our analysis in section 3.2 revealed that the costs of ensuring unbiased performance evaluations crucially hinge on whether the principal (collusion-up) or the agent (collusion-down) is tempted to collude with the supervisor. Moreover, Lemma 2 implies that the agent's potential contribution to firm value ΔV implicitly determines whether the efficient contracts are prone to collusion-up or to collusion-down. To gain more insights, we now investigate the relationship between the agent's potential contribution ΔV and the optimal organizational design. The next lemma elaborates on this relationship.

Lemma 4 *Delegation is more likely to constitute the optimal organizational design if the agent's potential contribution to firm value ΔV is low.*

Lemma 4 implies that the optimal firm structure—in addition to the discount rate r and the complexity of the agent's task θ—is determined by the agent's potential added value ΔV. The reason for this observation is as follows. According to Lemma 2, the efficient contracts for delegation are more likely to be only prone to collusion-up if the agent's potential contribution ΔV is low. We demonstrate in the Appendix (see Proof of Proposition 6) that—in the absence of collusion-down—delegation is always superior to centralization for intermediate discount rates (i.e., $r_c(\theta) < r \leq \widehat{r}_d^P$). Moreover, Propositions 3 and 4 imply that providing the supervisor with a wage $w^{S*}(r, \theta)$ above its efficient level is essential to prevent collusion-down, but not to impede collusion-up. Consequently, if the efficient contracts are less likely to initiate collusion-down, ensuring the supervisor's neutrality in the evaluation process becomes less costly for the principal. This in turn implies that delegation more often constitutes the superior firm structure.

5 Organizational Design and Employment Contracts

In addition to identifying the optimal firm structure, it is useful to shed light on the properties of associated employment contracts. Figure 4 visualizes the previously discussed contract ad-
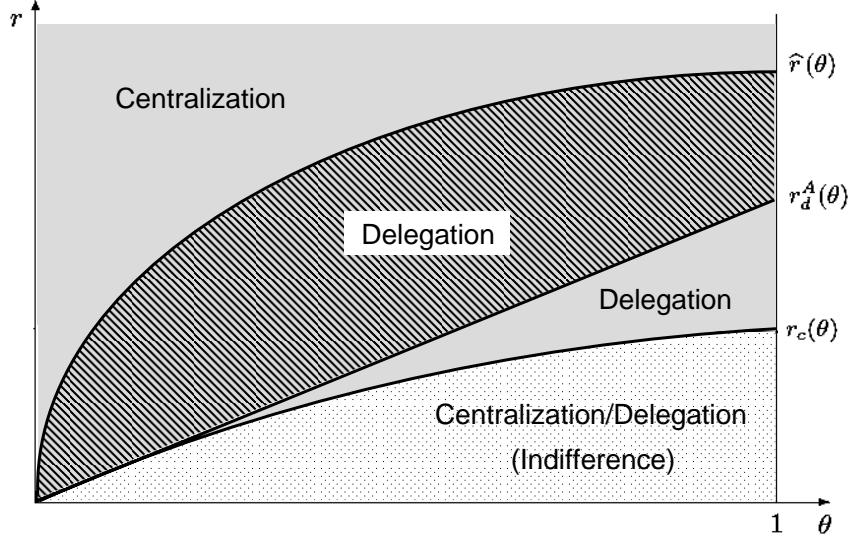
Figure 4: Organizational Choice and Properties of Employment Contracts

justments for both alternatives—centralization and delegation—by accounting for the optimal organizational design as emphasized by Proposition 6.

Consider first the dotted area in Figure 4, where the principal is indifferent between centralization and delegation (i.e., $r \leq \min\{r_c(\theta), r_d^A(\theta)\}$). Clearly, the principal can utilize the respective efficient employment contracts for centralization (α_c^{**}, $\beta_c^{**}(e^*, \theta)$) and for delegation ($\alpha_d^{**}$, $\beta_d^{**}(e^*)$, w^{S**}). Put differently, irrespective of the chosen firm structure, the principal can provide the agent with the efficient incentive bonus, which in turn motivates the agent to implement the efficient (second-best) effort level e^*. Furthermore, in the event that the principal chooses delegation, she can offer the supervisor the efficient wage w^{S**} which ensures the supervisor's participation in this employment relationship, but does not provide him with economic rents.

Next, consider the gray area in Figure 4 (i.e., where $r > r_c(\theta)$). In this area, the principal is forced to curb the agent's effort incentives, which in turn induces only a suboptimal effort level. The particular rationale for this observation, however, is rooted in the chosen firm structure. First, if delegation is the superior firm structure, low-powered incentives are indispensable to ensure the neutrality of the supervisor; otherwise incentive payments based on the supervisor's appraisals will be ineffective. Second, for centralization, the provision of low-powered

incentives is essential to eliminate the principal's temptation to renege, and thus to ensure the effectiveness of incentive payments based on the principal's assessments. In sum, irrespective of the chosen firm structure, effort incentives are low-powered for intermediate and high discount rates.

Finally, consider the dashed area in Figure 4 (i.e., where $r_d^A(\theta) < r < \widehat{r}(\theta)$). Here, delegation constitutes the superior organizational design, but the efficient employment contracts are vulnerable to collusion between the supervisor and the agent (collusion-down). We can thus infer from Proposition 5 that—in this area—the principal is forced to offer the supervisor a wage $w^{S*}(r, \theta)$, which not only ensures the supervisor's participation, but also provides him with an economic rent. As revealed by our previous analysis, enhancing the supervisor's wage above its efficient level is indispensable in this context to ensure the supervisor's impartiality in the evaluation process.

6 Managerial and Empirical Implications

We now discuss some managerial and empirical implications which can be derived from our framework. Specifically, we critically assess in the next section the recent trend towards flattening the hierarchical structure of firms from an incentive perspective. We then utilize our framework to shed more light on how employment contracts, which rely on subjective appraisals, as well as management compensations generally respond to inefficiently high (fixed) wages for workers enforced by unions.

6.1 The Effect of Flattening Firms

Several scholars have emphasized that intermediate positions in corporate hierarchies have been eliminated, primarily due to cost considerations (see, e.g., Dopson and Stewart [1990] and Rajan and Wulf [2006]). While it is clearly beyond the scope of this paper to provide an in-depth evaluation of such reorganizations, we can nonetheless stress some emerging challenges for the design of incentive schemes within these firms. As highlighted earlier, firms frequently rely

on subjective evaluations to provide their employees with goal-oriented incentives. Without a deep-layered firm structure, however, middle managers are generally responsible for more employees, and therefore in charge of evaluating subordinates who perform more diverse tasks. In this situation, our study accentuates that firms face a drastic challenge: since the performance of many employees cannot be adequately assessed and thus rewarded, incentive schemes within these firms become considerably weaker. Formally, suppose that after eliminating intermediate positions, a middle manager can only observe the actual contributions of newly assigned subordinates with probability θ_S, where $\theta_S > \theta$. Without adequate adjustments of their employment contracts, we can infer from Lemma 1 that these employees will implement lower effort levels, which in turn impairs their expected contributions to firm value. It is therefore predictable that the flattening of firms has a detrimental effect on the productivity of employees whose contributions to firm value are highly complex and thus not captured by comprehensive and contractible performance measures.

6.2   Unionization and Employment Contracts

In this section, we draw on our framework to briefly discuss how employment contracts respond to wage bargaining when incentive schemes within firms rest upon subjective evaluations. Clearly, industries can in parts vary substantially in their rates of unionization. For instance, while the automobile industry in the U.S. is well known for being heavily unionized, the opposite can be said about the software industry.

To shed light on how wage bargaining can affect employment contracts, suppose that a firm is forced to increase the base salary for its knowledge workers, which is synonymous with an increase of the base wage α in our model. Our framework suggests that an (exogenous) increase of α has the following two effects. First, *ceteris paribus*, collusion between the supervisor and the principal becomes more likely to occur, while, at the same time, a higher α deters side-contracting between the supervisor and the agent (see Proposition 3 and Proof of Proposition 4 in the Appendix). Second, in response, the principal is forced to reduce the agent's incentive payment β to credibly commit herself not to collude with the supervisor, and thus, to ensure

an unbiased evaluation of the agent's performance. Clearly, reducing effort incentives has a detrimental effect on the productivity of the firm, which constitutes an indirect cost of raising employees' base salaries. More interesting, however, is the observation that lower effort incentives for knowledge workers makes collusion-down less likely, which in turn allows the firm to reduce the compensation for managers. Put differently, a strong unionization, leading to enhanced wages for knowledge workers, has an indirect and negative effect on the compensations for managers, and hence, curbs their extraction of economics rents. In concluding, our model predicts lower wage differentials across corporate hierarchies, and lower-powered incentives for knowledge workers in more heavily unionized industries.

7 Conclusion

Many scholars have emphasized that subjective performance evaluations are prevalent components of incentive schemes in firms. This study contributes to economic and management literature by investigating when delegating the responsibility for subjective evaluations to middle managers is optimal. Our study therefore aims to explain why in business practise, middle managers, and not firm owners, assess the performance of employees as basis for incentive payments.

This study delivers novel insights into the efficient design of organizations when goal-oriented incentive schemes rely on subjective performance evaluations. Specifically, we demonstrate that a decentralized evaluation of employees' performance (delegation) can be optimal even though it is prone to biased appraisals. Moreover, the analysis in this paper reveals that delegation is accompanied by high compensations for middle managers, which in turn lead to high economic rents, and by low-powered incentives for their subordinates. According to our study, this constitutes an important safeguard against biased internal performance evaluations, which would clearly jeopardize the effectiveness of associated incentive payments.

Clearly, we have pursued a narrow view of middle management in order to explain several phenomena from business practise. Specifically, we focused on the integration of middle management in corporate hierarchies as a device for firm owners to augment the accuracy and cred-

ibility of subjective evaluations, which in turn form crucial components of incentive schemes within firms. Despite neglecting other important dimensions of middle management's responsibilities, our model explains several prevailing phenomena, such as the existence of hierarchical firms, significant wage differentials within these firms, and high management compensations. Investigating the effect of other important managerial tasks on the optimal design of organizations is another promising avenue for future research.

Appendix

Proof of Proposition 1.

Assume for a moment that (6) is satisfied for the optimal bonus contract. Let λ and ξ denote Lagrange multipliers. Then, the Lagrangian is

$$\mathcal{L}(\alpha_c, e) = V_L + \Delta V \rho(e) - \alpha_c - B(e) + \lambda \left[\alpha_c + B(e) - c(e)\right] + \xi \alpha_c. \tag{19}$$

The first-order conditions with respect to α_c and e are

$$-1 + \lambda + \xi = 0, \tag{20}$$

$$\Delta V \rho'(e) - B'(e) + \lambda \left[B'(e) - c'(e)\right] = 0. \tag{21}$$

Suppose $\lambda > 0$. Then, $\alpha_c + B(e) - c(e) = 0$ due to complementary slackness. Since $\alpha_c \geq 0$, this would imply that $B(e) \leq c(e)$, and hence $e^* = 0$. Thus, $\lambda > 0$ cannot be a solution of this problem. Therefore, $\lambda = 0$. We can then infer from (20) that $\xi = 1$. Consequently, $\alpha_c^{**} = 0$ due to complementary slackness. Because $\lambda = 0$, it follows from (21) that the optimal effort level e^* solves $\Delta V \rho'(e) = B'(e)$. Concavity of $\rho(e)$ and convexity of $B(e)$ ensure that the first-order condition to identify the optimal effort level is also sufficient. By using (7), it follows that the optimal bonus is $\beta_c^{**}(e^*, \theta) = c'(e^*)/(\rho'(e^*)\theta)$. Substituting $\alpha_c^{**} = 0$ and $B(e^*)$ in the principal's objective function leads to $\Pi^c(e^*) = V_L + \Delta V \rho(e^*) - B(e^*)$. Moreover, substituting $\Pi^c(e^*)$ with $B(e^*) = \rho(e^*)\theta\beta_c^{**}(e^*, \theta)$ and $\bar{\Pi} = V_L$ in (6) yields

$$r \leq \left[\frac{\rho'(e^*)}{c'(e^*)}\Delta V - 1\right]\theta\rho(e^*) \equiv r_c(\theta). \tag{22}$$

If $r > r_c(\theta)$, the efficient bonus $\beta_c^{**}(e^*, \theta)$ would violate (6). In this case, the principal chooses the highest feasible bonus β_c such that (6) binds:

$$\underbrace{\Delta V \rho(e(\beta_c, \theta)) - \rho(e(\beta_c, \theta))\theta\beta_c}_{=\Pi^c(\beta_c, \theta) - V_L} = r\beta_c. \tag{23}$$

Figure 5 illustrates the feasible bonus payments for different discount rates, where the straight lines $r\beta_c$ represent the rhs of the self-enforcement condition (6). Observe that the lhs of (23) is concave increasing in β_c for $\beta_c < \beta_c^{**}(e^*, \theta)$, whereas the rhs is linear increasing with slope r
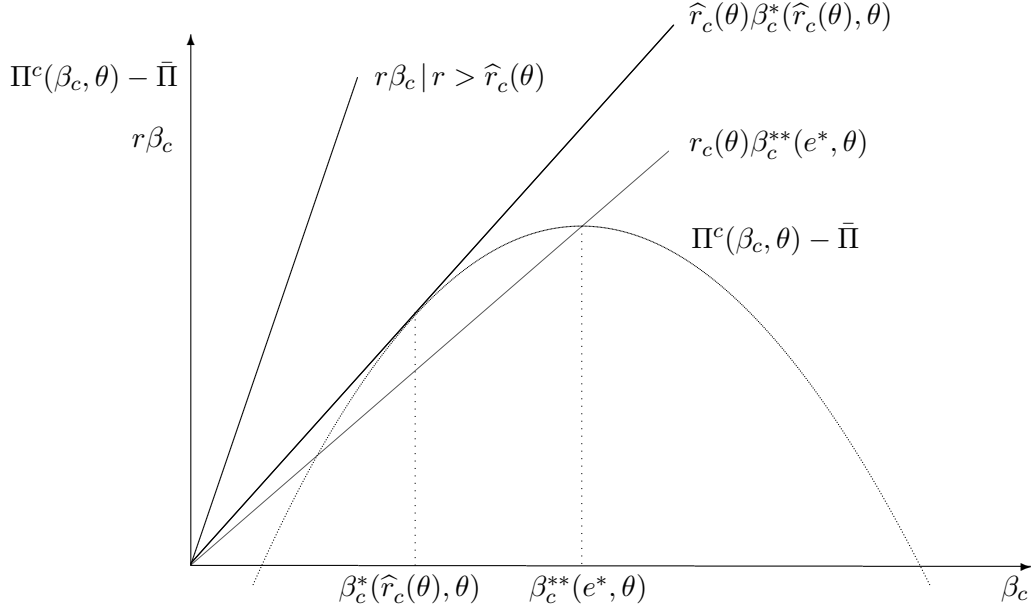
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Figure 5: Feasible Bonus Payments for Different Discount Rates

(see also Figure 5). Thus, depending on r, there exist potentially two values of β_c which solve (23). To maximize the expected profit, the principal chooses the maximum value of β_c solving (23), which is denoted by $\beta_c^*(r, \theta)$. Moreover, implicit differentiating (23) gives

$$\frac{d\beta_c^*(r, \theta)}{dr} = \frac{\beta_c}{\left.\frac{d\Pi^c(\beta_c, \theta)}{d\beta_c}\right|_{\beta_c = \beta_c^*(r, \theta)} - r}. \tag{24}$$

We can infer from Figure 5 that $d\Pi^c(\beta_c, \theta)/d\beta_c|_{\beta_c = \beta_c^*(r, \theta)} < r$ for $r_c(\theta) < r \leq \widehat{r}_c(\theta)$, where the threshold $\widehat{r}_c(\theta)$ is characterized below. Hence, $d\beta_c^*(r, \theta)/dr < 0$ for $r_c(\theta) < r \leq \widehat{r}_c(\theta)$. Finally, one can deduce from Figure 5 that there exists a threshold $\widehat{r}_c(\theta)$ such that every $\beta_c > 0$ would violate (23) for $r > \widehat{r}_c(\theta)$. Consequently, $\beta_c^*(r, \theta) = 0$ for $r > \widehat{r}_c(\theta)$, where $\widehat{r}_c(\theta)$ is characterized by the tangency condition $r = d\Pi^c(\beta_c, \theta)/d\beta_c|_{\beta_c = \beta_c^*(\widehat{r}_c(\theta), \theta)}$. $\qquad\qquad\square$

Proof of Proposition 2.

Suppose for moment that the efficient contracts $(\alpha_d^{**}, \beta_d^{**})$ and w^{S**} are collusion-proof such that (17) and (18) are satisfied. Then, the principal's maximization problem for delegation is identical to the one for centralization with $\theta = 1$. Hence, we can infer from Proposition 1 that $\alpha_d^{**} = 0$ and $\beta_d^{**}(e^*) = c'(e^*)/\rho'(e^*)$, where e^* solves $\Delta V \rho'(e) = B'(e)$. Moreover, cost

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minimization requires to set $w^{S**} = 0$. Consequently, $\Pi^d(e^*) = V_L + \Delta V \rho(e^*) - \rho(e^*)\beta_d^{**}(e^*)$. Finally, we need to derive a condition which ensures that (17) and (18) are satisfied for the efficient contracts $(\alpha_d^{**}, \beta_d^{**}(e^*))$ and w^{S**}. Substituting $w^{S**} = 0$, $\alpha_d^{**} = 0$, and $\beta_d^{**}(e^*) = c'(e^*)/\rho'(e^*)$ in (17) yields the condition which guarantees that collusion-down does not occur:

$$r \le \theta \left[\rho(e^*) - \frac{\rho'(e^*)c(e^*)}{c'(e^*)} \right] \equiv r_d^A(\theta). \tag{25}$$

Likewise, substituting $\Pi^d(e^*)$, $\beta_d^{**}(e^*)$, and $\bar{\Pi} = V_L$ in (18) yields the condition which ensures that collusion-up does not take place:

$$r \le \frac{\rho'(e^*)}{c'(e^*)} \Delta V \rho(e^*) - \rho(e^*) \equiv r_d^P. \tag{26}$$

Thus, $(\alpha_d^{**}, \beta_d^{**}(e^*))$ and w^{S**} are collusion-proof if $r \le r_d(\theta) \equiv \min\{r_d^A(\theta), r_d^P\}$. $\qquad\square$

Proof of Lemma 2.

Note that the efficient contracts $(\alpha_d^{**}, \beta_d^{**}(e^*))$ and w^{S**} would trigger collusion-down but not collusion-up if $r_d^A(\theta) < r \le r_d^P$. Clearly, this requires that $r_d^A(\theta) < r_d^P$. We can infer from the collusion-proofness conditions (17) and (18) that $r_d^A(\theta) < r_d^P$ is equivalent to

$$\theta U^A(e^*) < \Pi^d(e^*) - \bar{\Pi}, \tag{27}$$

where $U^A(e^*)$ denotes the agent's expected utility. Observe that the lhs of (27) is increasing in θ, and is zero if $\theta \to 0$. Moreover, the rhs of (27) is strictly positive and independent of θ. Clearly, even for $\theta = 1$, the lhs of (27) can be strictly smaller than the rhs. Hence, there exists a threshold $\widehat{\theta} \in (0, 1]$ such that $r_d^A(\theta) < r_d^P$ for $\theta \le \widehat{\theta}$. Furthermore, we can infer from (27) that the threshold $\widehat{\theta}$ is affected by ΔV. By applying the Envelope Theorem, implicit differentiating $\widehat{\theta}$ with respect to ΔV yields

$$\frac{d\widehat{\theta}(\Delta V)}{d\Delta V} = \frac{\frac{d\Pi^d(e^*)}{d\Delta V} - \widehat{\theta}\frac{dU^A(e^*)}{d\Delta V}}{U^A(e^*)} = \frac{\rho(e^*) - \widehat{\theta}\left[\rho(e^*)\frac{d\beta_d^{**}(e^*)}{d\Delta V}\right]}{U^A(e^*)}. \tag{28}$$

Since the agent's participation constraint (14) is not binding for $\beta_d^{**}(e^*) > 0$, it follows that $U^A(e^*) > 0$. Hence, $d\widehat{\theta}(\Delta V)/d\Delta V > 0$ if $1 > \widehat{\theta} d\beta_d^{**}(e^*)/d\Delta V$. Note that profit maximization requires $d\beta_d^{**}(e^*)/d\Delta V < 1$. Consequently, by accounting for the fact that $\widehat{\theta}(\Delta V) \in (0, 1]$, we

have $d\widehat{\theta}(\Delta V)/d\Delta V \geq 0$. $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\square$

Proof of Proposition 3.

If $r > r_d^A(\theta)$, the efficient contracts $(\alpha_d^{**}, \beta_d^{**}(e^*))$ and w^{S**} would violate the collusion-proofness condition (17) (collusion-down). Note that (17) is equivalent to

$$\alpha_d + w^S \geq \beta_d \left[\frac{r}{\theta} - \rho(e(\beta_d))\right] + c(e(\beta_d)). \tag{29}$$

To minimize costs, the principal sets α_d and w^S such that (29) binds, given that α_d, $w^S \geq 0$. Substituting (29) in the principal's objective function yields the simplified problem for $r > r_d^A(\theta)$:

$$\max_{\beta_{d \cdot cd}} \Pi^d = V_L + \Delta V \rho(e(\beta_{d \cdot cd})) - \frac{r}{\theta}\beta_{d \cdot cd} - c(e(\beta_{d \cdot cd})), \tag{30}$$

where $\beta_{d \cdot cd}$ denotes the bonus payment which does not induce collusion-down. From the first-order condition, the optimal bonus $\beta_{d \cdot cd}^*(r, \theta)$ is implicitly characterized by

$$r = \theta \left[\Delta V \rho'(e(\beta_{d \cdot cd})) - c'(e(\beta_{d \cdot cd}))\right] \frac{de}{d\beta_{d \cdot cd}}. \tag{31}$$

Implicit differentiating (31) with respect to r gives

$$\frac{d\beta_{d \cdot cd}^*(r, \theta)}{dr} = \frac{1}{\frac{d}{d\beta_{d \cdot cd}} \left[\theta \left[\Delta V \rho'(e(\beta_{d \cdot cd})) - c'(e(\beta_{d \cdot cd}))\right] \frac{de}{d\beta_{d \cdot cd}}\right]}, \tag{32}$$

where the denominator is strictly negative because of the second-order condition. Hence, $d\beta_{d \cdot cd}^*(r, \theta)/dr < 0$. Moreover, implicit differentiating (31) with respect to θ yields

$$\frac{d\beta_{d \cdot cd}^*(r, \theta)}{d\theta} = -\frac{\left[\Delta V \rho'(e(\beta_{d \cdot cd})) - c'(e(\beta_{d \cdot cd}))\right] \frac{de}{d\beta_{d \cdot cd}}}{\frac{d}{d\beta_{d \cdot cd}} \left[\theta \left[\Delta V \rho'(e(\beta_{d \cdot cd})) - c'(e(\beta_{d \cdot cd}))\right] \frac{de}{d\beta_{d \cdot cd}}\right]}. \tag{33}$$

We can infer from the first-order condition (31) that the numerator is strictly positive for $\theta > 0$. Again, the denominator is strictly negative due to the second-order condition. Hence, $d\beta_{d \cdot cd}^*(r, \theta)/d\theta > 0$.

Finally, note that $d\Pi^d(\cdot)/dr < 0$ for $r > r_d^A(\theta)$ since $d\beta_{d \cdot cd}^*(\cdot)/dr < 0$. Taking the first derivative of $\Pi^d(\cdot)$ with respect to r yields

$$\frac{d\Pi^d(\cdot)}{dr} = \left.\frac{\partial \Pi^d(\cdot)}{\partial \beta_{d \cdot cd}}\right|_{\beta_{d \cdot cd} = \beta_{d \cdot cd}^*(\cdot)} \cdot \frac{d\beta_{d \cdot cd}^*(\cdot)}{dr} - \frac{d(\alpha_{d \cdot cd}^*(\cdot) + w_{cd}^{S*}(\cdot))}{dr}. \tag{34}$$

Observe that $\partial \Pi^d(\cdot)/\partial\beta_{d\cdot cd}|_{\beta_{d\cdot cd}=\beta^*_{d\cdot cd}(\cdot)} \to 0$ if $r > r_d^A(\theta)$ and $r \to r_d^A(\theta)$. Thus, it must hold that $d(\alpha^*_{d\cdot cd}(\cdot) + w^{S*}_{cd}(\cdot))/dr > 0$. If this is true for $r \to r_d^A(\theta)$, it must also be true for every $r > r_d^A(\theta)$ because of the concavity of $\Pi^d(\cdot)$ in $\beta_{d\cdot cd}$, and linearity of $\Pi^d(\cdot)$ in $\alpha_d + w^S$. Hence, $\alpha^*_{d\cdot cd}(r,\theta) + w^{S*}_{cd}(r,\theta) > \alpha^{**}_d + w^{S**} = 0$ for $r > r_d^A(\theta)$, where $\alpha^*_{d\cdot cd}(r,\theta) + w^{S*}_{cd}(r,\theta)$ is increasing in r. Similarly, one can show that $\alpha^*_{d\cdot cd}(r,\theta) + w^{S*}_{cd}(r,\theta)$ is decreasing in θ for all $r > r_d^A(\theta)$.
□

Proof of Proposition 4.

If $r > r_d^P$, the efficient contracts $(\alpha^{**}_d, \beta^{**}_d(e^*))$ and w^{S**} would violate the collusion-proofness condition (18) (collusion-up). We can infer from (18) that enhancing α_d would reduce $\Pi^d(\cdot)$, and thus raise $\bar{T}^P(r)$. Consequently, to minimize costs, the principal sets $\alpha^*_d = 0$. Moreover, the marginal effect of increasing w^S on both sides of the collusion-proofness condition (18) is $1/r$. Therefore, enhancing w^S does not prevent collusion-up. Thus, cost minimization requires the principal to set $w^{S*} = 0$. Let $\beta_{d\cdot cu}$ denote the bonus payment which does not trigger collusion-up. The principal chooses the highest feasible $\beta_{d\cdot cu}$ such that (18) binds:

$$\underbrace{\Delta V \rho(e(\beta_{d\cdot cu})) - \beta_{d\cdot cu}\rho(e(\beta_{d\cdot cu}))}_{=\Pi^d(\beta_{d\cdot cu})-V_L} = r\beta_{d\cdot cu}. \tag{35}$$

Note that the lhs of (35) is concave increasing in $\beta_{d\cdot cu}$ for $\beta_{d\cdot cu} < \beta^{**}_d(e^*)$, whereas the rhs is linear increasing with slope r. Therefore, depending on r, there are potentially two values of $\beta_{d\cdot cu}$ which solve (35). Profit maximization requires to chooses the maximum value of $\beta_{d\cdot cu}$ solving (35), which is denoted by $\beta^*_{d\cdot cu}(r)$. Implicit differentiating (35) yields

$$\frac{d\beta^*_{d\cdot cu}(r)}{dr} = \frac{\beta_d}{\left.\frac{d\Pi^d(\beta_{d\cdot cu})}{d\beta_{d\cdot cu}}\right|_{\beta_{d\cdot cu}=\beta^*_{d\cdot cu}(r)} - r}. \tag{36}$$

We can infer from Figure 5 (see Proof of Proposition 1) that $d\Pi^d(\beta_{d\cdot cu})/d\beta_{d\cdot cu}|_{\beta_{d\cdot cu}=\beta^*_{d\cdot cu}(r)} < r$ for $r_d^P < r \le \hat{r}_d^P$, where $\hat{r}_d^P$ is characterized below. Hence, $d\beta^*_{d\cdot cu}(r)/dr < 0$ for $r^P < r \le \hat{r}_d^P$. Finally, we can deduce from Figure 5 that there exists a threshold $\hat{r}_d^P$ such that every $\beta_{d\cdot cu} > 0$ would violate (35) for $r > \hat{r}_d^P$. Hence, $\beta^*_{d\cdot cu}(r) = 0$ for $r > \hat{r}_d^P$, where $\hat{r}_d^P$ is characterized by the tangency condition $r = d\Pi^d(\beta_{d\cdot cu})/d\beta_{d\cdot cu}|_{\beta_{d\cdot cu}=\beta^*_{d\cdot cu}(\hat{r}_d^P)}$. □

Proof of Proposition 5.

For $r \leq r_d(\theta) = \min\{r_d^A(\theta), r_d^P\}$, Proposition 2 implies that the optimal contracts are charac-terized by $\alpha_d^{**} = 0$, $\beta_d^{**}(e^*) = c'(e^*)/\rho'(e^*)$, and $w^{S**} = 0$. For $r > r_d(\theta)$, collusion-proofness requires to choose the lowest of the two derived bonus payments $\beta_{d\cdot cd}^*(r, \theta)$ and $\beta_{d\cdot cu}^*(r)$, i.e., $\beta_d^*(r, \theta) \equiv \min\{\beta_{d\cdot cd}^*(r, \theta), \beta_{d\cdot cu}^*(r)\} < \beta_d^{**}(e^*)$. Moreover, to prevent collusion-down for $r > r_d^A(\theta)$, the principal needs to set $\alpha_d^*(r, \theta) + w^{S*}(r, \theta) > \alpha_d^{**} + w^{S**} = 0$, see Proof of Propo-sition 3. However, recall from Proof of Proposition 4 that preventing collusion-up requires to set $\alpha_d^* = 0$. Hence, $w^{S*}(r, \theta) > w^{S**} = 0$ and $\alpha_d^*(r, \theta) = \alpha_d^{**} = 0$ for $r > r_d^A(\theta)$. Finally, recall from Proposition 3 that the principal can always find a strictly positive bonus β_d which satisfies the collusion-proofness condition (31) for $r > r_d^A(\theta)$ (collusion-down). In contrast, Proposition 4 implies that there exists a threshold $\widehat{r}_d^P$ such that for $r > \widehat{r}_d^P$, every $\beta_d > 0$ would violate the collusion-proofness condition (35) (collusion-up). Thus, $\beta_d^*(r, \theta) = 0$ for all $r > \widehat{r}_d^P$. Moreover, recall that $w^{S*}(r, \theta) > w^{S**} = 0$ for $r > r_d^A(\theta)$, where $w^{S*}(r, \theta)$ is increasing in r, see Proposition 3. Hence, there exists a threshold $\widehat{r}_d^A(\theta)$ satisfying $\Pi^d(\widehat{r}_d^A(\theta), \theta) = \bar{\Pi}$. Conse-quently, if $r > \widehat{r}_d(\theta) \equiv \min\{\widehat{r}_d^P, \widehat{r}_d^A(\theta)\}$, the principal sets α_d^*, $\beta_d^*(r, \theta) = 0$, and $w^{S*} = 0$. □

Proof of Lemma 3.

If $\theta = 1$, we can infer from Proposition 1 that the agent's optimal contract for centralization is characterized by $\alpha_c^{**} = 0$ and $\beta_c^{**}(e^*, 1) = c'(e^*)/\rho'(e^*)$ as long as $r \leq r_c(1)$. For delega-tion, Proposition 2 implies that the optimal employment contracts are characterized by $\alpha_d^{**} = 0$, $\beta_d^{**}(e^*) = c'(e^*)/\rho'(e^*)$, and $w^{S**} = 0$ as long as $r \leq r_d(1)$. Because of identical incentive con-tracts for the agent and $w^{S**} = 0$, it follows that $\Pi^c(e^*, 1) = \Pi^d(e^*)$ for $r \leq \min\{r_c(1), r_d(1)\}$. Next, recall that $r_d(1) = \min\{r_d^A(1), r_d^P\}$. We can infer from Proof of Proposition 1 and Proof of Proposition 2 that $r_c(1) = r_d^P$, and additionally from Proof of Proposition 4 that $\widehat{r}_c(1) = \widehat{r}_d^P$. To simplify the subsequent proof, ignore for a moment the possibility of collusion-down, and thus the threshold discount rate $r_d^A(1)$. As demonstrated for centralization as well as for delegation, the principal is forced to adjust the respective incentive bonuses $\beta_c^*(r, 1)$ and $\beta_d^*(r)$ whenever $r > r_c(1) = r_d^P$. As (24) in connection with (23), and (36) in connection with (35) indicate, the respective bonuses $\beta_c^*(r, 1)$ and $\beta_d^*(r)$ are decreasing in r with the same rate. Thus,

$\Pi^c(\cdot)$ is decreasing in r with the same rate as $\Pi^d(\cdot)$ for $r_c(1) < r \leq \widehat{r}_c(1)$. Hence, $\Pi^c(\cdot) = \Pi^d(\cdot)$ as long as $r \leq r_d^A(1)$. Now suppose that $r > r_d^A(1)$. To prevent collusion-down, the principal is forced to pay the supervisor a wage $w^{S*}(r,\theta)$ above its efficient level (i.e., $w^{S*}(r,\theta) > w^{S**}$), see Proposition 5. Thus, $\Pi^c(\cdot) > \Pi^d(\cdot)$ for $r > r_d^A(1)$.

Finally, recall that $\widehat{r}_c(1) = \widehat{r}_d^P$. Therefore, for $r > \widehat{r}_c(1) = \widehat{r}_d^P$, any strictly positive incentive bonus β would neither be credible under centralization nor collusion-proof under delegation. Propositions 1 and 5 thus imply that $\Pi^c(\cdot) = \Pi^d(\cdot) = V_L$ for $r > \widehat{r}_c(1) = \widehat{r}_d^P$. In sum, if $\theta = 1$, delegation does not yield a strictly higher expected profit than centralization for all discount rates r. □

Proof of Proposition 6.

First, recall from Proposition 1 that the efficient incentive contract $(\alpha_c^{**}, \beta_c^{**}(e^*, \theta))$ is credible as long as $r \leq r_c(\theta)$. Moreover, we know from Lemma 3 that $\theta = 1$ implies $\Pi^c(e^*, 1) = \Pi^d(e^*)$ as long as $r \leq \min\{r_c(1), r_d(1)\}$. Recall that the expected bonus $B(e) = \rho(e)c'(e)/\rho'(e)$ for centralization is independent of the task complexity measure θ, see section 3.1. Hence, by applying the Envelope Theorem one get $d\Pi^c(\cdot)/d\theta = 0$ for $r \leq r_c(\theta)$. Furthermore, we can infer from Proof of Proposition 1 and Proof of Proposition 4 that $r_c(\theta) < r^P$ for $\theta < 1$. Consequently, $\Pi^c(\cdot) = \Pi^d(\cdot)$ as long as $r \leq \min\{r_c(\theta), r_d^A(\theta)\}$.

To simplify the subsequent proof, ignore for a moment the collusion-proofness condition (17) (collusion-down), and thus the threshold discount rate $r_d^A(\theta)$. We can then infer from (24) in connection with (23), and (36) in connection with (35) that $d\beta_c^*(r,\theta)/dr < d\beta_d^*(r)/dr$. Hence, as long as the collusion-proofness condition (17) is satisfied, it follows that $\Pi^d(\cdot) > \Pi^c(\cdot)$ for $\theta < 1$ and $r_c(\theta) < r \leq \widehat{r}_d^P$.

Finally, suppose that the collusion-proofness condition (17) (collusion-down) is violated, i.e., $r > r_d^A(\theta)$. We know from Proposition 5 that preventing collusion-down then requires to pay the supervisor a wage $w^{S*}(r,\theta)$ above its efficient level (i.e., $w^{S*}(r,\theta) > w^{S**}$), which is increasing in r. Moreover, the principal is potentially forced to reduce the agent's incentive bonus even more in order to impede collusion-down, see Proposition 5. Thus, if $r_d^A(\theta) < r_c(\theta)$, the principal strictly prefers centralization for $r_d^A(\theta) < r \leq r_c(\theta)$. For $r > r_c(\theta)$, there exists a threshold

$\widehat{r}_{d \cdot cd}(\theta)$, with $\widehat{r}_{d \cdot cd}(\theta) \leq \widehat{r}_d^A(\theta)$, such that $\Pi^c(\cdot) \geq \Pi^d(\cdot)$ for $r \geq \widehat{r}_{d \cdot cd}(\theta)$. Furthermore, recall from Proposition 4 that $\Pi^d(\cdot) = \bar{\Pi} = V_L$ for $r > \widehat{r}_d^P$. Hence, by combining previous observations, it follows that $\Pi^d(\cdot) > \Pi^c(\cdot)$ for $r_c(\theta) < r < \widehat{r}(\theta)$, with $\widehat{r}(\theta) \equiv \min\{\widehat{r}_{d \cdot cd}(\theta), \widehat{r}_d^P\}$. Moreover, for $r \geq \widehat{r}(\theta)$, it follows that $\Pi^c(\cdot) \geq \Pi^d(\cdot)$. $\qquad \square$

Proof of Lemma 4.

First, recall from Lemma 2 that for some discount rates r, the efficient contracts $(\alpha_d^{**}, \beta_d^{**}(e^*))$ and w^{S**} can induce collusion-up but not collusion-down if ΔV is sufficiently low. In the absence of potential collusion-down, we know that $\Pi^d(\cdot) > \Pi^c(\cdot)$ for $r_c(\theta) < r \leq \widehat{r}_d^P$, see Proof of Proposition 6. Furthermore, Propositions 3 and 5 imply that impeding collusion-down requires to pay the supervisor a wage $w^{S*}(r, \theta)$ above its efficient level (i.e., $w^{S*}(r, \theta) > w^{S**}$), in addition to reducing the agent's incentive bonus $\beta_d^*(r, \theta)$. In contrast, recall from Proposition 4 that paying the supervisor a wage $w^{S*}(r, \theta) > w^{S**}$ is not required to prevent collusion-up. Because of the additional costs associated with impeding collusion-down, centralization is optimal for $r > \widehat{r}(\theta)$, see Proof of Proposition 6. By combing the previous observations with the implication of Lemma 2, it follows that for some discount rates r, $\Pi^d(\cdot) > \Pi^c(\cdot)$ if ΔV is sufficiently low, and $\Pi^c(\cdot) \geq \Pi^d(\cdot)$ otherwise. $\qquad \square$

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