Incentives and the Delegation of Task Assignment[†]

Anna Rohlfing-Bastian[‡] and Anja Schöttner[*]

April 4, 2017

Abstract

We analyze the optimal interaction between monetary incentives and decision-making authority with respect to task assignment in a production process with two agents, each exerting non-observable effort in their main task. A further task needs to be performed and one agent is privately informed about his costs for this task. The principal can either assign the task herself or delegate the decision-making authority to the informed agent. We find that, if the principal can employ a congruent performance measure to provide the agents with effort incentives, delegation of task assignment and monetary incentives are complements. However, with an incongruent performance measure introducing the problem of effort misallocation across tasks, the relation between the two instruments is not univocal. We thus contribute to explaining the mixed empirical evidence on the relation between incentives and the delegation of decision rights.

Keywords: *Delegation, Decision Rights, Incentive Contracts, Performance Measurement, Task Assignment*

1 Introduction

The organizational design of firms requires to balance a three-legged stool: the assignment of decision rights, the methods of rewarding employees, and the measurement of performance (Brickley, Smith, and Zimmerman 2009). Economic theory confirms a general interaction between the three components (Athey and Roberts 2001; Holmström and Milgrom 1994), and examples from corporate practice illustrate that changes in a firm's organizational architecture and the associated reallocation of decision rights are often accompanied by an adjustment of the firm's performance evaluation and incentive schemes.[1] An appropriate assignment of tasks can be used to stabilize the three-legged stool because it can influence the effectiveness of performance measurement and is thus an important means to control incentives (e.g., Holmström and Milgrom 1991; Itoh 1994; Hemmer 1995; Schmitz 2005; Ratto and Schnedler 2008; Schöttner 2008; Kragl and Schöttner 2014). The delegation of decision-making authority on task assignment, however, has hardly been studied even though it is commonplace in practice.[2] This paper aims to fill this gap by analyzing the optimal delegation of task assignment and its interaction with performance-related pay against the background of performance measure quality.

We employ the modeling approach proposed by Feltham and Xie (1994) and Baker (2002) to analyze a multitasking problem with potentially imperfect performance measurement in the spirit of Holmström and Milgrom (1991). In our model, we focus on a short-term task allocation problem. Two agents (workers or managers) perform specialized main tasks that match their abilities, training, or professional experience. An additional task needs to be assigned to one of the agents, but the principal (firm owner) is not perfectly informed about the agents' effort costs for this task. One agent, however, privately observes whether he has lower or higher costs for the third task relative to his colleague. The principal can either assign the third task herself (centralization), running the risk of an inefficient task assignment, or grant the authority to assign the task to the informed agent (delegation). Delegation leads to a superior task allocation relative to centralization if the informed agent chooses to perform the third task herself whenever he has lower costs than his colleague. The three tasks jointly affect an aggregate performance measure that may or may

---

[1] *Citibank* changed their organizational structure from a regional focus to a customer focus and adjusted corporate incentives accordingly (Baron and Besanko 2001). Massive changes in the industry environment forced the *RoyalDutch/Shell Group* to change their organizational structure, which was accompanied by a redesign of incentive systems (Grant 2007). *GlaxoSmithKline* restructured their R&D department for efficiency reasons and tailored their performance measurement and incentives to this new structure (Garnier 2008).

[2] Managers, supervisors, or team leaders are often responsible for assigning tasks to their subordinates. At *Apple*, for example, large tasks are allocated to a "DRI", a directly responsible individual, who can delegate sub-tasks to other employees (Lashinsky 2011).

not perfectly reflect the tasks' true contribution to firm value. In the former case, performance measurement is accurate and we say that the performance measure is congruent. The latter case reflects the practically more relevant situation of inaccurate performance measurement, where the performance measure is incongruent. The agents' compensation contracts can condition on the realization of the performance measure, but not on the task assignment.[3] Such task assignment problems frequently arise in practice. We can think of the agents as differently specialized employees of the same business unit whose compensation depends on the unit's performance. In addition to his main task, one of the employees might need to, e.g., answer a request from another unit, a contractor, or a customer, instruct a new colleague, or step in temporarily for an absent colleague.[4]

Our main result demonstrates that performance measure quality has a crucial impact on the optimal interplay of decision-making authority on task assignment and monetary incentives. When performance measurement is accurate, delegation of task assignment and monetary incentives are always complements, but they may be substitutes when the performance measure is incongruent. We further show that, under accurate performance measurement, the delegation of task assignment may induce the first-best allocation, which can never be attained under centralization. Moreover, an optimal organizational change from centralization to delegation can involve a distortion of incentives such that the agent with decision-making authority works harder than in the first best, whereas his colleague works inefficiently little.

The intuition behind our results is the following. Delegation allows to use the informed agent's private knowledge but also entails two potential problems from the principal's point of view. First, the agent may abuse his decision-making authority and, in order to keep his own effort costs low, assign the task to his colleague even though he knows that the colleague has a comparative disadvantage at the task. Second, delegation introduces uncertainty on the final task assignment at the time of contracting because it makes the task assignment dependent on the future realization of effort costs. This means that the principal has to stipulate the agents' bonuses without knowing who of them will perform the additional task.

The second problem, however, is not relevant when the performance measure is congruent because then the bonuses that provide efficient effort incentives do not depend on the task assignment.

---

[3]We thus follow an incomplete contracting approach, reflecting that real-world employment contracts usually do not cover all parts of an employment relationship, e.g., because certain parts are non-verifiable by third parties or the contracting parties are unable to foresee and plan for all possible contingencies (Milgrom and Roberts 1992).

[4]In our basic model, the additional task arises exactly once in the contracting period. However, as we discuss in Section 6, the model can be easily extended to a situation where the additional task may arise several times and the agents' relative costs may vary in each instance.

Moreover, the bonuses that are efficient from the perspective of effort incentives may also induce the informed agent to choose the efficient task allocation, implying that the first problem is not relevant either. In this situation, delegation leads to the first-best allocation and hence always dominates centralization. That situation particularly arises when the informed agent's comparative cost advantage relative to his colleague is large because then his interests to allocate tasks do not differ substantially from those of the principal. Otherwise, the principal needs to provide the informed agent with extra incentives to align their objectives regarding the task assignment. The informed agent's bonus has to increase relative to the level that is efficient from a pure effort-incentive perspective, while his colleague's bonus decreases. The informed agent then anticipates that he has considerably stronger incentives to work hard than his colleague and therefore decides to perform the task himself when his costs are low. Hence, monetary incentives and delegation complement each other.

With an incongruent performance measure, efficient effort incentives need to mitigate the problem of effort misallocation across tasks and thus depend on the task allocation. This holds true for both centralization and delegation of task assignment. However, delegation can aggravate multitasking problems because, unlike centralization, it introduces uncertainty about the task allocation. As a consequence, delegation might be less often optimal when the performance measure is incongruent. In addition, the relationship between delegation and incentives is no longer univocal. Assume that, under centralization, the informed agent only performs his specialized task. Under delegation, he would perform the additional task with some positive probability. When the performance measure overemphasizes this task relative to its actual productivity, the agent's bonus under delegation can be smaller than under centralization in order to optimally balance the agent's effort incentives across tasks. Hence, delegation and incentives can be substitutes.

Our results are in line with the mixed empirical evidence on the relation between monetary incentives and the delegation of decision rights. Employing different measures of decision-making authority, the first empirical studies on the interaction of decision rights and incentives find a complementary relation between the two instruments (e.g., Nagar 2002; Wulf 2007; DeVaro and Kurtulus 2010). The typical rationale is that performance-based pay is needed to align employees' decisions with the firm's objectives, and the more decision rights an employee holds the more performance-based pay is needed. However, the recent papers by De Varo and Prasad (2015) and Jia and van Veen-Dirks (2015) indicate that the interaction between decision rights and incentives is not univocal. Jia and van Veen-Dirks (2015) find that production managers' discretion to make

operational decisions is negatively associated with incentive pay. De Varo and Prasad (2015) analyze data on non-managerial occupations and demonstrate that the relationship between incentives and employees' influence about the range of tasks they perform is positive for simple jobs but negative for complex jobs.[5] Both papers suggest that the nature of the relationship depends on the quality of the available performance measure, which is also a main determinant in our model.

Our model provides a theoretical explanation for decision-making authority and effort incentives being complements or substitutes depending on some underlying parameters of the model. To our knowledge, De Varo and Prasad (2015) is the only other paper that derives a similar result.[6] They show that a negative relation between delegation and incentives can emerge if a risk-averse agent is assigned the right to choose between tasks that have a positive risk-return trade-off for the principal, and there is only one performance measure to affect task selection and effort. In such a situation, combining delegation with high-powered incentives may not be optimal because it can induce the agent to excessively choose low risk-return tasks (see also Lando (2004) for a similar construction). The authors argue that the crucial features of their model are specific to complex jobs, which explains their empirical findings on a negative relationship between delegation and incentives for complex jobs but not for simple jobs. We consider a different setup and our results are independent of risk considerations. However, presuming that congruent performance measures are less likely to exist for complex than for simple jobs, our model also predicts that a negative relationship between delegation and incentives should be observed more often for complex jobs.

The remainder of the paper is structured as follows. Section 2 discusses the related theoretical literature and Section 3 introduces the model. Section 4 derives preliminary results on optimal incentive contracting given that the principal either centralizes or delegates the task assignment. Section 5 analyzes the optimal organizational design against the background of performance measure quality. Section 6 discusses the robustness of the results and Section 7 concludes. All proofs are relegated to the Appendix.

---

[5]De Varo and Prasad (2015, pp. 284-285) categorize professional, technical, and scientific occupations as complex jobs, whereas simple jobs belong to one of the following groups: 'clerical and secretarial occupations', 'craft and skilled manual occupations', 'personal service occupations', 'sales occupations', 'operative and assembly manual occupations', 'routine unskilled manual occupations'.

[6]Hong, Kueng, and Yang (2015) also introduce a model where performance pay and delegation can be substitutes or complements. However, the absence or existence of performance pay is exogenously given, and they discuss whether there is more or less delegation under performance pay. De Varo and Prasad (2015) and the present paper simultaneously determine optimal performance pay and allocation of authority.

2 Related Theoretical Literature

Most theoretical studies on the optimal interaction of delegation and incentives predict a univocal relation. Holmström and Milgrom (1991) and Prendergast (2002) find a positive relationship. They assume that the principal chooses the set of activities that the agent is allowed to engage in, and the agent prefers some activities to others because they entail a larger private benefit. In Holmström and Milgrom (1991), the principal increases performance pay when she permits more activities that yield a benefit to the agent but are unproductive for the principal in order to make the agent direct more attention to the productive task.[7] In Prendergast (2002), performance pay is the principal's only means to control the agent under the delegation of task selection, which may be optimal due to the agent's superior knowledge on each task's value for the firm. If the principal does not delegate, she prefers to monitor effort and hence refrains from performance pay. Bester and Krähmer (2008) analyze a standard principal-agent moral hazard model preceded by a stage where the project the agent will work on has to be chosen. Principal and agent differ in their preferences over projects. They show that, relative to the benchmark where effort is contractible, the principal delegates project choice less often when she has to provide effort incentives and hence there is a negative relation between incentives and delegation.

Several authors have shown that incentives problems in multitasking settings can be mitigated by appropriate job design (e.g., Holmström and Milgrom 1991; Itoh 1994; Hemmer 1995; Schmitz 2005; Ratto and Schnedler 2008; Schöttner 2008; Kragl and Schöttner 2014). We depart from this literature by studying a situation where the principal may benefit from delegating the task assignment to an agent who possesses relevant effort cost information. In accordance with previous studies on the decentralization of decision-making authority (e.g., Dessein 2002; Mookherjee 2006), delegating the task assignment involves a loss of control for the principal but entails more efficient use of specific knowledge. While it is well established that decentralization can also enhance employee motivation (e.g., Aghion and Tirole 1997; Baker, Gibbons, and Murphy 1999; Shin and Strausz 2014), this is not a key advantage of delegation in our model, were agents are motivated by performance-contingent contracts, whose effectiveness is however interlinked with the allocation of authority. The principal always retains the right to design the agents' contracts, which is in contrast to the literature on delegated contracting (e.g., Melumad, Mookherjee, and Reichel-

---

[7]Within another context, Holmström and Milgrom (1991) also provide informal arguments for incentives and delegation being substitutes. An agent who performs more productive tasks may receive less performance pay if increased multitasking makes performance measurement more difficult.

stein 1992, 1995; Macho-Stadler and Pèrez-Castrillo 1998; Rajan and Reichelstein 2004; Feltham and Hofmann 2007; Feltham, Hofmann, and Indjejikian 2016), where an agent with contracting authority typically obtains more incentive pay.

Closest to our paper is Reichmann and Rohlfing-Bastian (2014), who also analyze a setting where a task needs to be allocated to one of two agents who differ in their effort costs for the task. In contrast to our paper, they assume that effort costs are observable and the principal cannot allocate the task herself due to exogenous reasons. We introduce private information on effort costs, which allows us to endogenously derive the optimal organizational form and the corresponding optimal interaction of decision-making authority and incentives. Unlike us, Reichmann and Rohlfing-Bastian (2014) focus their analysis on which of the two agents the principal should make responsible for the task assignment[8] and whether this agent performs the allocatable task himself. They show that delegation has an impact on both agents' incentives, however, they do not further analyze the specific direction of this effect.

3 Model

We consider a single-period setting in which a principal (firm owner) contracts with two agents (workers or managers) indexed by $i = 1, 2$ to provide unobservable effort $e_\ell \geq 0$ in three productive tasks indexed by $\ell = 1, 2, 3$. Each agent is specialized in one task, e.g., due to ability, professional experience, or task-specific training. Without loss of generality, we assume that Agent 1 is specialized in task 1 whereas Agent 2 is specialized in task 2, implying that only Agent 1 can perform task 1 and only Agent 2 can carry out task 2. The third task can be performed by either agent but cannot be split between the agents. When working on their specialized tasks, agents incur effort costs $\kappa(e_\ell) = 1/2 \cdot e_\ell^2$ for $\ell = 1, 2$. With respect to the third task, the two agents differ in their costs. Agent 2 incurs standard effort costs of $1/2 \cdot e_3^2$, whereas Agent 1's effort costs in task 3 are $1/2 \cdot ce_3^2$. Ex ante, c is a random variable with $c \in \{c_L, c_H\}$, $0 < c_L < 1 < c_H$, and $\Pr[c = c_L] = p \in (0, 1)$. Accordingly, Agent 1 can have higher or lower effort costs for performing task 3 than Agent 2. The parameter c is privately observed by Agent 1 after he has signed the contract and entered the firm but before choosing effort. He cannot communicate the information to others in the firm.[9]

---

[8]In the present paper, the principal can only benefit from delegating the job design to the informed agent. Delegation to the uninformed agent entails a control problem but does not lead to any advantages and is hence dominated by central task allocation.

[9]Baker (1992), Prendergast (2002), and Raith (2008) make similar assumptions on an agent's production technology.

The agents' joint contribution to firm value is $Y \in \{0,1\}$, with

$$\Pr[Y = 1|e_1, e_2, e_3] = \min\{f_1 e_1 + f_2 e_2 + f_3 e_3, 1\},$$

where $f_\ell > 0$ denotes the marginal productivity of effort in task ℓ for $\ell = 1, 2, 3$. Firm value Y is non-verifiable and thus cannot be part of an incentive contract. However, there is a verifiable, aggregate performance measure $P \in \{0,1\}$,

$$\Pr[P = 1|e_1, e_2, e_3] = \min\{g_1 e_1 + g_2 e_2 + g_3 e_3, 1\},$$

with performance measure sensitivities $g_\ell > 0$ for $\ell = 1, 2, 3$. The marginal productivity and performance measure sensitivity of task 3 are task-related and therefore do not vary with the agent performing the task. The performance measure is congruent if the ratio of productivity to performance measure sensitivity is identical for all three tasks, i.e., f_ℓ/g_ℓ is constant for all ℓ. Otherwise, the performance measure is incongruent (Feltham and Xie 1994; Baker 2002). An incongruent performance measure potentially entails an inefficient effort allocation of the multi-tasking agent, i.e., the agent who performs the third task in addition to his specialized task. We further assume that the functional forms are such that the above probabilities for the realizations of Y and P remain strictly below one at the first- and second-best solution. All parties are risk neutral and their reservation utilities are zero.[10]

The principal wants to maximize expected firm value net of wage costs. She chooses between a centralized or a decentralized organizational structure and stipulates the agents' incentive contracts. Under centralization, the principal determines who should carry out task 3 and fixes the task assignment ex ante. In practice, a fixed task assignment can be ensured by designing the workplace such that agents work separately and only the agent who is in charge of task 3 can perform this task because only he obtains access to the required material, equipment, or information, or any requests are to be directed towards him. Under decentralization (or delegation), the principal delegates the assignment of task 3 to Agent 1. After observing his effort costs, Agent 1 either carries out task 3 himself or assigns the task to Agent 2. A variable task assignment with a timely allocation procedure can be implemented in practice when the agents share a work space with joint access to the required tools. We assume that, if Agent 2 refuses to perform task 3 when it is assigned

---

[10]Note that the principal cannot solve the agency problem by selling the firm to Agent 1 because this would imply a double moral-hazard problem between Agent 1 (the new principal) and Agent 2 (Holmström 1982). Such type of problem does not occur in the current setting where the principal is a budget breaker of the team production process.
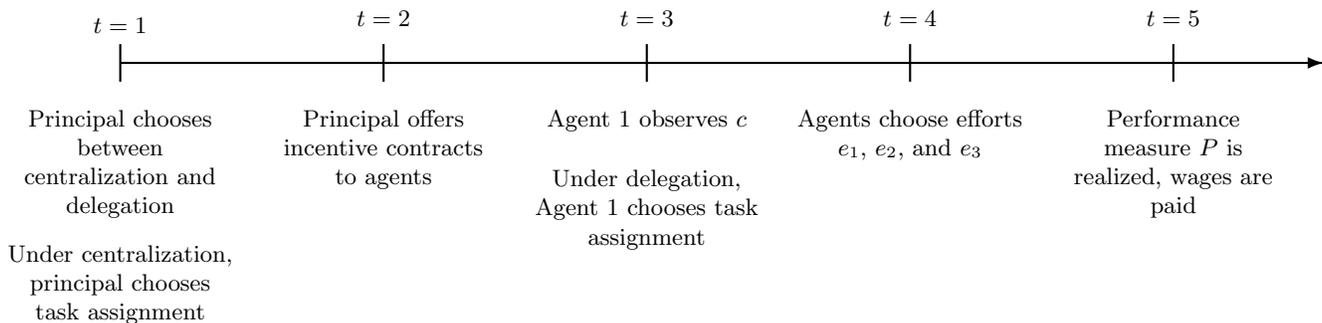
Principal chooses between centralization and delegation

Under centralization, principal chooses task assignment

Principal offers incentive contracts to agents

Agent 1 observes c

Under delegation, Agent 1 chooses task assignment

Agents choose efforts e_1, e_2, and e_3

Performance measure P is realized, wages are paid

Figure 1: Timing of the Model

to him, the opportunity to perform the task is foregone and hence the task has no impact on the performance measure P. Given our assumptions on P and the effort costs for task 3, this implies that Agent 2 is willing to perform the task if Agent 1 assigns it to him.

The incentive contract for Agent i specifies a fixed wage s_i and a bonus b_i to be paid when $P = 1$. Under delegation, the agents' payments cannot be conditioned on the task assignment because it cannot be verified who carried out task 3, e.g., due to a teamwork process in a joint work space that is necessary for delegation to be feasible. As a straightforward extension of our model, the production process could require task 3 to be carried out several times in the given period, where it would be too costly to monitor who performed the task in each instance.[11]

Figure 1 illustrates the timing of the model. At $t = 1$, the principal chooses between centralization or delegation. Under centralization, the principal decides who should perform task 3. At $t = 2$, the principal offers an incentive contract to each agent. Each agent observes the organizational structure and the contract of the other agent. At $t = 3$, given that the agents accepted the contracts, Agent 1 observes his effort cost parameter c. Under delegation, Agent 1 then decides on the assignment of task 3. At $t = 4$, the agents choose their efforts. Finally, at $t = 5$, the performance measure P is realized and wages are paid. The firm value Y might be realized simultaneously with P or afterwards.

In the first-best solution to our model, when effort choices and the cost parameter c are common knowledge, the agent with the lower costs for task 3 should perform this task. Accordingly, if $c = c_L$, Agent 1 performs task 3 and first-best effort levels are $e_1 = f_1$, $e_2 = f_2$, and $e_3 = f_3/c_L$. Otherwise, Agent 2 performs task 3 and the respective effort levels are $e_\ell = f_\ell$ for all ℓ. The principal

---

[11]We discuss this extension in more detail in Section 6.

compensates the agents for their effort costs and, consequently, his first-best profit is

$$\Pi^{FB} = \begin{cases} \frac{1}{2}\left(f_1^2 + f_2^2 + c_L^{-1}f_3^2\right) & \text{if } c = c_L \\ \frac{1}{2}\left(f_1^2 + f_2^2 + f_3^2\right) & \text{if } c = c_H \end{cases}.$$

If the performance measure is congruent (i.e., f_ℓ/g_ℓ is constant for all ℓ) and Agent 1 has no private information on effort costs (i.e., $p = 0$ or $p = 1$), the principal can induce the first-best solution by assigning the task to the agent with the lower costs, stipulating bonus payments $b_1 = b_2 = f_\ell/g_\ell$, and choosing the fixed wages s_i such that the agents obtain their reservation utility in expectation. The following sections explore the impact of an incongruent performance measure and private information regarding effort costs on the optimal organizational design. The impact of our main assumptions on the results is discussed in Section 6.

4 Optimal Contract Design under Centralization and Decentralization

4.1 Incentives and Profit under Centralization

We first discuss optimal incentive contracting under centralization, where the principal decides on the task assignment ex ante. Because she does not observe Agent 1's effort costs, the principal can base her decision only on expectations about the cost parameter c. In addition to cost considerations, she has to take into account potential congruity problems associated with the two possible task assignments. The following lemma characterizes the optimal contract and task assignment. All proofs are relegated to the Appendix.

Lemma 1 *Consider the case of centralization and define $\gamma := E\left[c^{-1}\right] = pc_L^{-1} + (1-p)c_H^{-1}$. If the principal assigns task 3 to Agent 1, the optimal bonuses and the principal's profit are given, respectively, by*

$$b_1^{C_1} = \frac{g_1^2}{g_1^2 + \gamma g_3^2}\frac{f_1}{g_1} + \frac{\gamma g_3^2}{g_1^2 + \gamma g_3^2}\frac{f_3}{g_3}, \quad b_2^{C_1} = \frac{f_2}{g_2}, \quad and \ \ \Pi^{C_1} = \frac{1}{2}\left(f_2^2 + \frac{(f_1 g_1 + \gamma f_3 g_3)^2}{g_1^2 + \gamma g_3^2}\right). \quad (1)$$

If the principal assigns task 3 to Agent 2, the optimal bonuses and the principal's profit are given,

respectively, by

$$b_1^{C_2} = \frac{f_1}{g_1}, \quad b_2^{C_2} = \frac{g_2^2}{g_2^2 + g_3^2}\frac{f_2}{g_2} + \frac{g_3^2}{g_2^2 + g_3^2}\frac{f_3}{g_3}, \quad \text{and} \quad \Pi^{C_2} = \frac{1}{2}\left(f_1^2 + \frac{(f_2 g_2 + f_3 g_3)^2}{g_2^2 + g_3^2}\right). \qquad (2)$$

Agent 1 performs task 3 if and only if $\Pi^{C_1} \geq \Pi^{C_2}$ *and the principal's profit under centralization is* $\Pi^C = \max\{\Pi^{C_1}, \Pi^{C_2}\}.$

If an agent performs only a single task ℓ, the bonus that induces first-best effort in this task is f_ℓ/g_ℓ, which efficiently balances a task's actual marginal productivity and its performance measure sensitivity.[12] Accordingly, Lemma 1 shows that, under a given task assignment, the agent who works only on his specialized task is provided with efficient incentives. By contrast, the optimal bonus for the multitasking agent needs to trade-off the efficient incentives for his specialized task against the efficient incentives for task 3. Consequently, the optimal bonus is a weighted average of the efficient single-task incentives, assigning relatively more weight to the task with the higher performance measure sensitivity. If Agent 1 multitasks, the optimal bonus tends more towards task 3 the higher p and the smaller c_L or c_H, i.e., the lower the agent's expected costs for the additional task. Centralization leads to the first-best effort levels and profit if and only if Agent 1's costs are certain (i.e., $p = 0$ or $p = 1$) and the performance measure is congruent (i.e., f_ℓ/g_ℓ constant for all ℓ). The principal can then centrally implement the efficient task assignment and provide efficient effort incentives by paying both agents the same bonus f_ℓ/g_ℓ.

To simplify the further analysis, we exclude extreme congruity problems that lead to situations where the principal does not benefit from lower expected effort costs of Agent 1 for task 3. We therefore make the following assumption.

Assumption 1 Π^{C_1} *is strictly increasing in* γ *and hence in the probability of low effort costs for task 3, described by* p.

Assumption 1 is equivalent to

$$\gamma > \frac{g_1(f_1 g_3 - 2f_3 g_1)}{f_3 g_3^2}.$$

For this inequality to hold, it is sufficient that $f_1/f_3 \leq 2 \cdot g_1/g_3$, i.e., the performance measure does not extremely overemphasize task 3 relative to task 1. Intuitively, if the performance measure puts far too much weight on task 3 relative to task 1, high costs for task 3 can be beneficial because

---

[12]Compare the agents' incentive compatibility constraints in the proof of Lemma 1.

they counteract the congruity problem by making the agent exert less effort in task 3. Assumption 1 further ensures that the principal cannot earn a higher profit than Π^{C_1} by excluding task 3 from the production process.[13]

4.2 Incentives and Profit under Decentralization

We next analyze optimal incentives under delegation, where Agent 1 decides who should perform task 3 after having observed his effort costs. Consequently, the bonus payments offered by the principal serve two different objectives. In addition to motivating effort, the bonuses also direct Agent 1's decision on task assignment. The following lemma characterizes how the task assignment depends on the bonuses.

Lemma 2 *Consider stage 3 of the model, where Agent 1 assigns task 3 given the incentive contracts offered by the principal. (i) If $b_1/b_2 < 2c_L$, Agent 1 always assigns task 3 to Agent 2. (ii) If $2c_L \leq b_1/b_2 \leq 2c_H$, he performs task 3 himself when $c = c_L$ and assigns the task to Agent 2 when $c = c_H$. (iii) If $2c_H < b_1/b_2$, he always performs task 3 himself.*

Lemma 2 shows that Agent 1's task assignment decision is driven by the relative size of the bonuses and the agent's effort costs for task 3 (see also Proposition 2 in Reichmann and Rohlfing-Bastian (2014)). Intuitively, the larger the bonus ratio b_1/b_2, the more motivated Agent 1 is to exert effort relative to Agent 2. Hence, ceteris paribus, Agent 1 decides to carry out task 3 himself if his own costs are sufficiently low or if he anticipates a relatively low motivation of his colleague. In cases (i) and (iii), Agent 1's task assignment is independent of his realized costs and the principal is thus weakly better off by centrally assigning the task to Agent 2 or Agent 1, respectively, at the first stage. Centralization thus dominates delegation in these situations. We therefore focus on case (ii), where Agent 1 performs task 3 if and only if his costs are low. This case is the only candidate for a situation in which the principal can be strictly better off by choosing delegation rather than centralization. We now derive the incentive contracts that the principal should offer to the agents if she wants Agent 1 to perform task 3 if and only if the agent has low costs for this task.

Lemma 3 *Assume that the principal wants Agent 1 to perform task 3 if and only if $c = c_L$. Define*
$$\hat{c} := \frac{1}{2} \frac{f_1 g_1 + \frac{p}{c_L} f_3 g_3}{g_1^2 + \frac{p}{c_L} g_3^3} \frac{g_2^2 + (1-p)g_3^2}{f_2 g_2 + (1-p)f_3 g_3}.$$

---

[13]If the principal excludes task 3, she earns the profit $\tilde{\Pi} = 1/2 \left(f_1^2 + f_2^2 \right)$. Because $\lim_{\gamma \to 0} \Pi^{C_1} = \tilde{\Pi}$ and Π^{C_1} is strictly increasing in γ by Assumption 1, Π^{C_1} is larger than $\tilde{\Pi}$.

(i) If $c_L \leq \hat{c} \leq c_H$, the optimal bonuses are

$$b_1^D = \frac{g_1^2}{g_1^2 + \frac{p}{c_L}g_3^2}\frac{f_1}{g_1} + \frac{\frac{p}{c_L}g_3^2}{g_1^2 + \frac{p}{c_L}g_3^2}\frac{f_3}{g_3}, \quad b_2^D = \frac{g_2^2}{g_2^2 + (1-p)g_3^2}\frac{f_2}{g_2} + \frac{(1-p)g_3^2}{g_2^2 + (1-p)g_3^2}\frac{f_3}{g_3} \quad (3)$$

and the principal's profit is

$$\Pi^D = \frac{1}{2}\left(\frac{\left(f_1 g_1 + \frac{p}{c_L}f_3 g_3\right)^2}{g_1^2 + \frac{p}{c_L}g_3^2} + \frac{(f_2 g_2 + (1-p)f_3 g_3)^2}{g_2^2 + (1-p)g_3^2}\right). \quad (4)$$

(ii) If $\hat{c} < c_L$, the principal offers the bonuses

$$\hat{b}_1^D = \frac{f_1 g_1 + \frac{f_2 g_2}{2c_L} + p\frac{f_3 g_3}{c_L} + (1-p)\frac{f_3 g_3}{2c_L}}{g_1^2 + p\frac{g_3^2}{c_L} + \frac{1}{4c_L^2}\left(g_2^2 + (1-p)g_3^2\right)}, \quad \hat{b}_2^D = \frac{1}{2}\frac{\hat{b}_1^D}{c_L} \quad (5)$$

and her profit is

$$\hat{\Pi}^D = \frac{1}{2}\frac{\left(f_1 g_1 + \frac{f_2 g_2}{2c_L} + p\frac{f_3 g_3}{c_L} + (1-p)\frac{f_3 g_3}{2c_L}\right)^2}{g_1^2 + p\frac{g_3^2}{c_L} + \frac{1}{4c_L^2}\left(g_2^2 + (1-p)g_3^2\right)}. \quad (6)$$

The principal chooses the optimal bonuses in order to balance two objectives; the provision of effort incentives and the implementation of the desired task assignment. In case (i) of Lemma 3, the bonuses b_1^D and b_2^D are optimal from a pure incentive perspective *and* induce the desired task assignment, i.e., the principal's two objectives are not in conflict. Regarding the optimal bonus formulae, note that the principal stipulates the contracts not knowing who will carry out task 3. As a consequence, each agent's optimal bonus trades off the efficient incentives for the agent's specialized task against the efficient incentives for task 3, weighted with the probability that the agent performs this task. For example, because Agent 1 performs task 3 with probability p, his bonus b_1^D leans more towards f_3/g_3 the higher p. To understand the circumstances under which case (i) occurs, note that $\hat{c} = 1/2 \cdot b_1^D/b_2^D$. Hence, by Lemma 2, the condition $c_L \leq \hat{c} \leq c_H$ describes the situation where the bonuses b_1^D and b_2^D have the appropriate relative size to induce Agent 1 to perform task 3 if and only if he has low costs. By contrast, if $\hat{c} < c_L$, as in case (ii) of Lemma 3, Agent 1 never wants to perform task 3 given that the principal pays the bonuses b_1^D and b_2^D. The principal therefore has to adjust the bonuses to induce the desired task assignment. The optimal bonuses $\hat{b}_1^D$ and $\hat{b}_2^D$ thus reflect the trade-off between the principal's two objectives. Typically, $\hat{b}_1^D$

13

should be larger than b_1^D, while $\hat{b}_2^D$ is smaller than b_2^D.[14]

With a congruent performance measure, the bonuses do not need to address any congruity problems and the principal therefore pays both agents the same bonus, $b_1^D = b_2^D$. It follows that $\hat{c} = 1/2$ and, consequently, case (i) is relevant whenever $c_L \leq 1/2$ and case (ii) otherwise. When the performance measure is incongruent, the bonuses b_1^D and b_2^D differ and the threshold $\hat{c}$ depends on the parameters of the model. In particular, when there is a congruity problem with Agent 1, i.e., $f_1/g_1 \neq f_3/g_3$, the agent's bonus b_1^D, and hence also $\hat{c}$, depend on the low-cost parameter c_L. The higher Agent 1's cost for task 3, the less weight his bonus attaches to the efficient incentives for this task, f_3/g_3, and the more weight it attaches to the efficient incentives for the specialized task, f_1/g_1. Thus, the bonus b_1^D, and consequently the threshold $\hat{c}$, are decreasing in c_L if and only if $f_3/g_3 > f_1/g_1$. It follows that, if task 3 calls for higher incentives than Agent 1's specialized task, case (i) occurs when c_L is sufficiently small and c_H sufficiently large. Otherwise, it depends on the specific situation whether case (i) is more or less likely to occur when c_L decreases.

Lemma 3 does not consider situations with $c_H < \hat{c}$, where Agent 1 always wants to perform task 3 under the bonuses b_1^D and b_2^D, i.e., even if he has high costs. We omit this case also in the remainder of this paper because it would not lead to any new insights. This means that we focus on a situation where either c_H is sufficiently large or the congruity problem is not so severe that it calls for a bonus b_1^D that is more than twice as large as the bonus b_2^D. As long as $b_1^D/b_2^D < 2$, the case $c_H < \hat{c} = 1/2 \cdot b_1^D/b_2^D$ cannot occur because $c_H > 1$.

5 Optimal Organizational Design

5.1 Congruent Performance Measure

We first characterize the optimal organizational design and, in particular, the optimal interplay between the delegation of task assignment and the provision of monetary incentives for the case of a congruent performance measure where f_ℓ/g_ℓ is constant for all tasks ℓ. Without loss of generality, we assume that the tasks' marginal productivities are identical to their performance measure sensitivities, $f_\ell/g_\ell = 1$ for all ℓ. Applying Lemma 1, the principal's profit under centralization is $\Pi^C = 1/2 \left(f_1^2 + f_2^2 + f_3^2 \cdot \max\{1, \gamma\} \right)$. Since there is no congruity problem, the optimal task assignment under centralization only depends on effort cost considerations. If $\gamma > 1$, the principal will assign task 3 to Agent 1; otherwise, Agent 2 performs the task. Independent of the task assignment,

---

[14]We formally proof this statement for the case of a congruent performance measure in Section 5.1.

the principal pays bonuses of 1 to both agents, which provide efficient effort incentives given that $f_\ell/g_\ell = 1$. An efficiency loss compared to the first-best solution only arises because the principal's task assignment decision is based on expectations about c and, thus, it is not necessarily the agent with the lower costs who carries out task 3. The principal might therefore benefit from delegating the task assignment to the informed Agent 1 in order to induce a situation where this agent performs task 3 if and only if his costs are low. The corresponding optimal bonuses and profit are given in Lemma 3. The following proposition uses the previous results to characterize the optimal organizational design and the associated bonuses.

Proposition 1 *Assume that the performance measure is congruent such that $f_\ell/g_\ell = 1$ for all ℓ and that Assumption 1 holds.*

(i) If $c_L \leq 1/2$, the principal implements delegation and offers the bonuses $b_1^D = b_2^D = 1$. The outcome corresponds to the first-best solution.

(ii) If $c_L > 1/2$, there exists a threshold $\bar{c} \in (1/2, 1)$ such that the principal prefers delegation if and only if $c_L \leq \bar{c}$. Under delegation, the principal pays the bonuses $\hat{b}_1^D > 1$ and $\hat{b}_2^D < 1$. Under centralization, the agents' bonuses are equal to 1.

(iii) Decision-making authority on task assignment and monetary incentives are complements.

Case (i) of Proposition 1 corresponds to case (i) of Lemma 3. With a perfect performance measure, the bonuses $b_1^D = b_2^D = 1$ provide first-best effort incentives under delegation. Furthermore, because $\hat{c} = 1/2$, first-best effort incentives and task assignment are not in conflict whenever $c_L \leq 1/2$. Agent 1 is then willing to multitask in the low-cost case given that the principal pays efficient bonuses. Delegation hence leads to the first-best effort *and* the first-best task allocation. This cannot be accomplished under centralization, which does not utilize decentralized information on effort costs.

When the low cost parameter c_L exceeds the threshold of $1/2$ (case (ii) of Proposition 1, corresponding to case (ii) of Lemma 3), the principal first maintains delegation but has to adapt the bonus payments to ensure that Agent 1 chooses the desired task allocation. The reason is that, if $1/2 < c_L$, Agent 1 will never perform task 3 himself under bonuses of 1. Instead, he prefers Agent 2 to perform the task to save effort costs. In order to motivate Agent 1 to carry out the third task when he has lower costs than Agent 2, the principal needs to increase the bonus of Agent 1 and lower the bonus of Agent 2 relative to the efficient bonuses of 1. The larger c_L, the stronger the

bonuses need to be distorted. As a consequence, when c_L exceeds a certain threshold $\bar{c}$, delegation does no longer maximize profits and the principal switches to centralization, accepting an inefficient task allocation but providing efficient incentives.

From part (i) and (ii) of Proposition 1 it follows that monetary incentives and the delegation of task assignment are complements: If the principal makes Agent 1 responsible for the task assignment, she pays this agent a weakly higher bonus than under centralization. If Agent 1's potential cost advantage over Agent 2 is not very strong ($1/2 < c_L \leq \bar{c}$), his bonus needs to be strictly larger under delegation than under centralization. As a result, he works even harder than in the first-best. Agent 2, who is not granted any decision-making authority on task assignment, obtains an inefficiently low bonus and works less than in the first-best.

5.2 Incongruent Performance Measure

In this section, we demonstrate that the relationship between the delegation of decision-making authority on task assignment and the optimal adaptation of incentives is no longer univocal with an incongruent performance measure. To keep the analysis tractable, we restrict our attention to a situation where incentive provision and task assignment are not in conflict under delegation, i.e., we focus on case (i) of Lemma 3.

Assumption 2 *Agent 1's effort costs $c \in \{c_L, c_H\}$ for task 3 are such that $c_L \leq \hat{c} \leq c_H$, where $\hat{c}$ is defined in Lemma 3.*

Proposition 1 has shown that, when the performance measure is congruent and Assumption 2 holds, delegation leads to the first-best solution and thus always dominates centralization. This might no longer hold with an incongruent performance measure because the two organizational forms then exhibit different types of congruity problems. Centralization fixes the task assignment and thus also the congruity problem ex ante. By contrast, under delegation, either agent may perform task 3, implying that one out of two congruity problems can arise. The relative likelihood of the two congruity problems is determined by p, the probability with which Agent 1 performs task 3. Consequently, changes in p may have quite different impacts on the optimality of the two organizational forms. Assumption 1 implies that the profit under centralization, Π^C, is weakly increasing in p so that the principal always benefits when Agent 1 is more likely to have low effort costs in task 3. When the task assignment is delegated to Agent 1, however, the impact of p on the principal's expected profit Π^D is not univocal. This can be seen from the derivative of Π^D with

respect to p, which can be written as

$$\frac{\partial \Pi^D}{\partial p} = \frac{1 - c_L}{c_L} f_3^2 + \frac{g_2^2}{(g_2^2 + (1-p)g_3^2)^2} \Delta_{23} - \frac{c_L g_1^2}{(c_L g_1^2 + p g_3^2)^2} \Delta_{13}. \tag{7}$$

The term $\Delta_{i3} := (f_3 g_i - f_i g_3)^2$ denotes the congruity problem arising when Agent i performs task 3. Because either agent can be the multitasking agent, both Δ_{13} and Δ_{23} affect the principal's expected profit Π^D. As p increases, Agent 1 is more likely to have lower costs than Agent 2 and thus more likely to perform task 3. This entails three different effects on Π^D, which are given by the three terms on the right-hand side of equation (7). First, there is a positive effect due to lower average effort costs. Second, if a congruity problem arises in case Agent 2 performs task 3, i.e., $\Delta_{23} \neq 0$, there is another positive effect because it becomes less likely that this agent has to deal with two tasks. Third, if a congruity problem occurs when Agent 1 multitasks, i.e., $\Delta_{13} \neq 0$, there is a negative effect because this agent is now more likely to carry out task 3. We next show that the last effect may dominate and use this result to characterize conditions for when centralization dominates delegation and vice versa. To derive intuitively meaningful conditions, it is necessary to put more structure on the problem. We do so by focussing on a situation where all tasks are equally productive, i.e., $f_1 = f_2 = f_3$, and the principal faces the same congruity problem with each agent, i.e., $g_1 = g_2$ implying that $\Delta_{13} = \Delta_{23}$.[15]

Lemma 4 *Assume that $f_1 = f_2 = f_3$ and $g_1 = g_2 \neq g_3$ and that Assumption 2 holds. There is a threshold $\tilde{c} \in (0,1)$ such that Π^D is initially decreasing in p if and only if $c_L \geq \tilde{c}$.*

Lemma 4 shows that the principal's profit is initially decreasing in p when c_L is sufficiently large. Intuitively, if c_L is small, the cost advantage of Agent 1 compared to Agent 2 is large so that the average cost effect, represented by the first term on the right-hand side of (7), is relatively large. Furthermore, as c_L approaches zero, Agent 1's effort in task 3 is high and will hardly be affected by any congruity problem. Hence, the last term in (7) is small and cannot dominate.

Figure 2 illustrates a situation where the the principal's profit under delegation is first decreasing in p and the consequences for the optimal organizational design. The figure depicts the principal's expected profits Π^D, Π^{C_1}, and Π^{C_2} as functions of p for the parameter values $f_1 = f_2 = f_3 = g_1 = g_2 = 0.1$, $g_3 = 0.3$, $c_L = 0.25$ and $c_H = 5$. Accordingly, there is a congruity problem with both agents because, for task 3, the performance measure sensitivity exceeds the actual productivity. The

---

[15]The purpose of these assumptions is to reduce the parameter space significantly. The result below can also be derived for other parameter constellations.
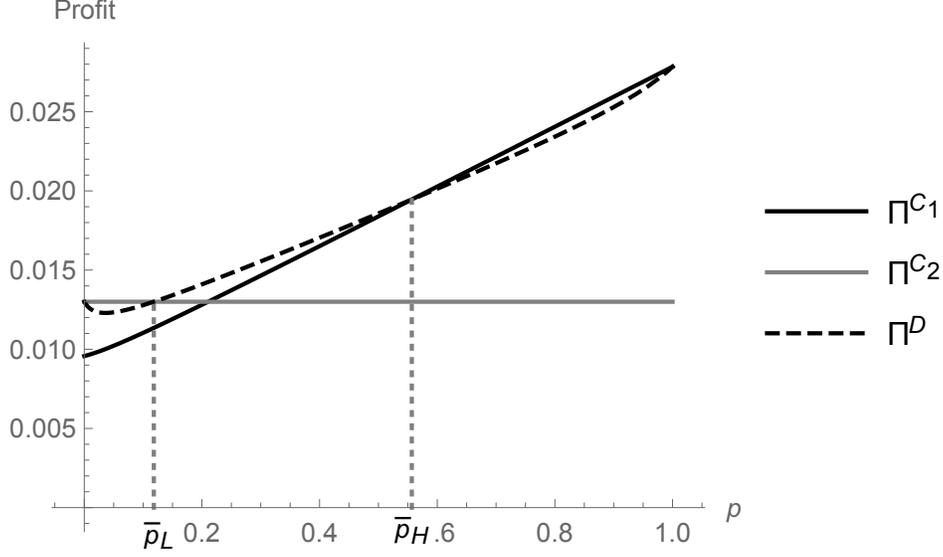
Figure 2: Optimal Organizational Design

initially decreasing function Π^D implies that the principal implements centralization for sufficiently small p. Agent 2 then performs task 3 because it is relatively unlikely that Agent 1 has low costs for this task. For intermediate values of p, the principal prefers delegation to centralization. It is then relatively uncertain which agent will have lower costs for task 3 and therefore the principal should not assign the task ex ante. Finally, if p is sufficiently large and hence Agent 1 is relatively likely to have low costs, the principal implements centralization with Agent 1 as the multitasking agent.[16] Overall, there are two thresholds $\bar{p}_L$ and $\bar{p}_H$, with $\bar{p}_L < \bar{p}_H$, such that: The principal implements centralization with Agent 2 performing task 3 if $p \leq \bar{p}_L$, delegation if $\bar{p}_L < p \leq \bar{p}_H$, and centralization with Agent 1 performing task 3 if $\bar{p}_H < p$.

The following proposition generalizes the principal's optimal organizational design for sufficiently small p and derives the optimal interaction between the delegation of the task assignment and monetary incentives.

Proposition 2 *Assume that Assumption 1 and Assumption 2 hold. Further assume that $f_1 = f_2 = f_3$ and $g_1 = g_2 \neq g_3$. There are thresholds $\hat{p}_1, \hat{p}_2 \in (0,1)$ such that*

(i) if $c_L \geq \tilde{c}$ and $p \leq \hat{p}_1$, then centralization with Agent 2 performing Task 3 is optimal,

(ii) if $c_L < \tilde{c}$ and $p \leq \hat{p}_2$, then delegation is optimal.

---

[16]For the given parameter values, Assumption 2 holds for all $p \leq 0.9$. For $p > 0.9$, Assumption 2 does not hold and hence the principal earns $\hat{\Pi}^D$ under delegation. However, because $\hat{\Pi}^D < \Pi^D$ and $\Pi^D < \Pi^C$, centralization still dominates delegation.

Suppose that, due to an exogenous decrease of c_L, the principal switches from a situation as described in case (i) to a situation as described in case (ii). The delegation of task assignment and monetary incentives are complements if $g_3 < g_1$ and substitutes if $g_3 > g_1$.

Case (i) of the proposition generalizes the observation from Figure 2. When it is relatively unlikely that Agent 1 will have low costs for task 3 and the principal centralizes the task assignment, she should assign the additional task to Agent 2. This is the optimal organizational design when c_L is relatively large because then the delegation profit is initially decreasing in p. Otherwise, as case (ii) points out, delegation is optimal. Hence, with an incongruent performance measure, centralization may dominate delegation even when Assumption 2 holds, i.e., when there is no conflict between providing effort incentives and inducing an efficient task allocation under delegation. Thus, we can conclude from a comparison of Proposition 1 and Proposition 2 that an incongruent performance measure can lead to less delegation relative to a congruent one. The reason is that delegation entails ex ante uncertainty about the task assignment, which is innocuous when no congruity problems exists, but otherwise aggravates such problems.

To understand the result on the interaction between delegation and monetary incentives, assume that an exogenous decrease of c_L makes the principal switch from centralization with Agent 2 performing task 3 (case (i)) to delegation (case (ii)). According to Lemma 1 and Lemma 3, Agent 1's bonus then changes from

$$b_1^{C_2} = \frac{f_1}{g_1} \quad \text{to} \quad b_1^D = \frac{g_1^2}{g_1^2 + \frac{p}{c_L}g_3^2}\frac{f_1}{g_1} + \frac{\frac{p}{c_L}g_3^2}{g_1^2 + \frac{p}{c_L}g_3^2}\frac{f_3}{g_3}.$$

Because Agent 1 may perform task 3 under delegation, his optimal bonus, b_1^D, needs to take into account the efficient single-task incentives for task 3, described by f_3/g_3. When these incentives are higher than the efficient single-task incentives for task 1, i.e., $f_3/g_3 > f_1/g_1$, then Agent 1's bonus is higher under delegation than under centralization. Hence, delegation and monetary incentives are complements, which implies that the optimal interaction between the two instruments does not change compared to a congruent performance measure. Note, however, that here the complementarity is due to the congruity problem rather than a conflict between effort incentives and task allocation as in the case of a congruent performance measure. By contrast, if $f_3/g_3 < f_1/g_1$, Agent 1's bonus decreases if he obtains decision-making authority on the task assignment. Consequently, with an incongruent performance measure, delegation of task assignment and monetary incentives can be substitutes. When task 1 and 3 are equally productive, this case occurs when

the performance measure puts too much emphasis on task 3 (i.e., $g_3 > g_1$). The principal then mitigates the resulting congruity problem by lowering the bonus payment to Agent 1.

Note that, as with a congruent performance measure, a switch from centralization to delegation will also affect Agent 2's optimal incentives. His bonus changes from

$$b_2^{C_2} = \frac{g_2^2}{g_2^2 + g_3^2} \frac{f_2}{g_2} + \frac{g_3^2}{g_2^2 + g_3^2} \frac{f_3}{g_3} \quad \text{to} \quad b_2^D = \frac{g_2^2}{g_2^2 + (1-p)g_3^2} \frac{f_2}{g_2} + \frac{(1-p)g_3^2}{g_2^2 + (1-p)g_3^2} \frac{f_3}{g_3}.$$

He performs task 3 less often under delegation than under centralization, which implies that his optimal bonus under delegation, b_2^D, is larger (smaller) than under centralization if $f_2/g_2 > f_3/g_3$ ($f_2/g_2 < f_3/g_3$). Hence, for the case of equally productive tasks, his bonus increases under delegation if the performance measure overemphasizes task 3 and decreases otherwise. Intuitively, because the congruity problem with Agent 2 occurs less often under delegation, the principal can adjust the agent's bonus towards the efficient single-task incentives for his main task. With a congruent performance measure, the principal may also adapt Agent 2's bonus after a change from centralization to delegation (compare Proposition 1, case (ii)). However, adaption is then due to the need to provide Agent 1 with the proper incentives to allocate the third task.

Proposition 2 describes one possible situation where the interaction between monetary incentives and the delegation of task assignment is not univocal. The changes in the organizational design are driven by a change of the cost parameter c_L. By contrast, Figure 2 describes another situation where similar organizational changes can be observed, which are due to changes in the probability p. On the one hand, when p increases from $p < \bar{p}_L$ to an intermediate value of p where $\bar{p}_L < p < \bar{p}_H$, the principal also switches from centralization with Agent 2 performing task 3 to delegation. He then decreases Agent 1's incentives (because $g_3 > g_1$ holds in the example) and hence delegation and monetary incentives are substitutes. On the other hand, when p decreases from $p > \bar{p}_H$ to an intermediate value, the principal switches from centralization with Agent 1 performing task 3 to delegation. In this case, he increases Agent 1's incentives under delegation because the agent is then less likely to incur a congruency problem compared to centralization. Delegation and monetary incentives hence become complements.

6 Discussion

In this section, we discuss our results against the background of the fundamental assumptions of the model and the robustness of the results for potential deviations from these assumptions.

20

First, we assume that under delegation, the contract does not condition on who carried out task 3. The application we have in mind is a short-term task allocation problem where an additional task may arise several times during the production process and then has to be carried out quickly, which makes it too costly to monitor who performed the task in each instance. We have not incorporated this aspect in our basic model to keep the analysis tractable. However, we can readily extend our model to a situation where task 3 may arise several times in the given contracting period, the agents' relative costs may vary in each instance, and the principal can trace the task assignment under delegation by incurring some monitoring costs. The model then has to be adapted as follows. The contracting period consists of n time intervals. In each interval, task 3 arises with some given probability and Agent 1 privately observes his costs for the task each time the task arises. Let e_3^t denote the effort in task 3 in time interval $t = 1, \ldots, n$, given that the task arises. Further assume that $\Pr[Y = 1] = \min\{f_1 e_1 + f_2 e_2 + f_3 \sum_{t=1}^{n} e_3^t, 1\}$ and $\Pr[P = 1] = \min\{g_1 e_1 + g_2 e_2 + g_3 \sum_{t=1}^{n} e_3^t, 1\}$, where $e_3^t = 0$ if task 3 does not arise in time interval t. Under centralization, at the beginning of the contracting period, the principal chooses one agent who is always responsible for task 3. Under delegation, in each time interval t where the task arises, Agent 1 decides whether he performs the task or assigns it to Agent 2. The principal can monitor how often task 3 had to be carried out and who was the responsible person in each case, but then incurs monitoring costs $M > 0$. Tracing the task assignment enables the principal to pay bonuses and fixed wages contingent on the task assignment, which can help provide better incentives for effort provision and task allocation. If $n = 1$ (as in our basic model), it can be shown that the principal can provide both agents with efficient effort incentives given their task assignment. Moreover, she can choose the fixed payment in order to induce the efficient task assignment decision *and* ensure the agents' participation in the contract. Hence, if the principal monitors the task assignment, delegation induces the same overall outcome that would be achieved if the principal could observe Agent 1's effort cost parameter c before offering contracts. The principal will therefore monitor the task assignment if M is sufficiently close to zero, and delegation with monitoring then is the optimal organizational design. However, if M is sufficiently large, monitoring becomes prohibitively costly and the analysis of our basic model applies. As n increases, tracing task assignments becomes more costly. In addition, the advantage of monitoring diminishes because the contracting problem becomes more complex and, even if wage payments are contingent on the task assignments, the efficient effort and task assignments are in general not implementable. Hence, monitoring becomes less attractive compared to the case where $n = 1$. When monitoring is too costly, the solution procedure for $n > 1$ is analogous to the one

21

presented in this paper and the results are qualitatively the same.

Second, we assume that no interdependencies between the tasks are present. Instead, it could be plausible to assume that an agent's specialized task ℓ ($\ell = 1, 2$) and task 3 are complements or substitutes. Consider the following example for illustration: The two agents work for a specific product line in a company. Agent 1 is specialized in task 1 which are the marketing activities related to the product line. Agent 2 is specialized in task 2, the production management of the product line. The third task is to handle requests from other business units. On the one hand, executing task 3 may interfere with the specialized tasks, implying that the tasks are substitutes. On the other hand, if requests typically regard the production process, task 2 and task 3 could be complements for Agent 2, the production manager. In terms of our model, this type of task interaction would be expressed in the cost function. For example, for Agent 2 the cost function for performing his specialized task and task 3 would be $\kappa(e_2, e_3) = 1/2(e_2^2 + e_3^2) + \delta e_2 e_3$. For $\delta < 0$, task 2 and task 3 are complements, whereas for $\delta > 0$ they are substitutes. Introducing such task interdependencies in our model has two effects. First, if task ℓ ($\ell = 1, 2$) and task 3 are complements (substitutes), there is another advantage (disadvantage) of assigning task 3 to the agent in charge of task ℓ. In the example, if $\delta < 0$, the production manager has a comparative advantage in task 3 because working in production lowers the costs of answering requests regarding the production process. This makes assigning task 3 to him more attractive. Second, task interdependencies affect the congruity problems the principal faces. The first effect adds another trade-off regarding the optimal task assignment to the problem, while the second effect is mainly a technicality that can be accommodated in the model (Schöttner 2008). Consequently, the basic trade-offs of our model remain existent.

Third, we assume risk-neutral contracting parties. Introducing either limited liability or risk aversion for the agents would lead to rents or risk-premia for the agents under each organizational form. Consequently, delegation cannot lead to the first-best allocation with a congruent performance measure anymore. Besides, there is no clear advantageous or disadvantageous effect on one of the organizational form relative to the other. Most probably, monetary incentives would have to be decreased, but the main trade-offs do not change.

Finally, we assume that the principal only has an aggregate, team-based performance measure at hand for designing incentive contracts. The use of such measures is commonplace (Che and Yoo 2001) and it has been shown that aggregate performance measures might be optimal under some circumstances (Corts 2007; Arya and Mittendorf 2011). In our setting, additional performance

measures which are informative about the agents' actions, would help the principal to deal with the congruency problem.

7   Conclusion

This article studies the optimal allocation of decision-making authority on task assignment and corresponding optimal incentive contracts against the background of different performance measure qualities. We find that the optimal interplay of decision-making authority and monetary incentives crucially depends on the characteristics of the performance measure. When the performance measure is congruent, i.e., perfectly reflects the tasks' true productivities, delegation and incentives are always complements. By contrast, with an incongruent performance measure, the two instruments can also be substitutes. The nature of the interaction then depends on the type of congruity problem that is introduced by allocating the third task to an agent. Our analysis further demonstrates that delegating the task assignment to an agent with private information on his effort cost may achieve the first-best allocation when centralizing the task assignment results in an inefficient allocation. In our model, we do not allow for communication between principal and agents. The result on the feasibility of first-best under delegation implies that the principal may not even benefit from communication in the given framework. This is the case when the informed agent's incentives to assign tasks are sufficiently well aligned with the principal's preferred task allocation, i.e., c_L is sufficiently small, and the performance measure is congruent (compare Proposition 1). Moreover, we confirm that delegating the task assignment typically also affects the optimal incentives of agents who do not obtain decision-making authority on the task assignment (Reichmann and Rohlfing-Bastian 2014). In our model, this can be due to two different reasons: First, the informed agent's task-assignment decision is affected by the incentives of his colleague. Second, delegation changes the average task assignment for both agents and therefore both agents' optimal effort incentives when the performance measure is incongruent. The crucial ingredients for our results are that performance measurement may be inaccurate and delegation affects the task assignment of a group of agents. We expect qualitatively similar results to hold in other organizational contexts that also exhibit these two features.

Previous theoretical papers on the delegation of decision rights and incentives typically predict an univocal relationship between the two instruments. We show that this does not hold for the delegation of task assignment in a multi-agent setting, and De Varo and Prasad (2015) derive a similar

result in a model where an agent can choose between two tasks that exhibit a positive risk-return tradeoff. These findings suggest that the relation between decision rights and incentives crucially depends on the type of decision-making authority to be delegated. The measures of authority employed by previous empirical studies show a considerable amount of variety. Proxies range from pure hierarchical positions (e.g., officer status as in Wulf (2007)) to the influence about the range of tasks (e.g., DeVaro and Kurtulus 2010; De Varo and Prasad 2015) and the discretion with respect to various operational tasks (e.g., Nagar 2002; Jia and van Veen-Dirks 2015). Distinguishing more clearly between different types of decision rights might provide deeper insights into firms' optimal organizational architecture.

Appendix

Proof of Lemma 1. First consider the case where the principal wants Agent 1 to perform task 3. The principal solves the following optimization problem at the first stage of the game:

$$\max_{\substack{s_k,b_k,e_\ell \\ k=1,2 \\ l=1,2,3}} \mathrm{E}\left[(f_1e_1 + f_2e_2 + f_3e_3) - s_1 - s_2 - (g_1e_1 + g_2e_2 + g_3e_3)(b_1 + b_2)\right] \tag{8}$$

$$\text{s.t.} \quad (e_1, e_3) = \mathrm{argmax}_{\hat{e}_1,\hat{e}_2} s_1 + (g_1\hat{e}_1 + g_2e_2 + g_3\hat{e}_3)b_1 - \frac{\hat{e}_1^2}{2} - c\frac{\hat{e}_3^2}{2}, \tag{9}$$

$$e_2 = \mathrm{argmax}_{\hat{e}_2} s_2 + (g_1e_1 + g_2\hat{e}_2 + g_3e_3)b_2 - \frac{\hat{e}_2^2}{2}, \tag{10}$$

$$0 \leq \mathrm{E}\left[s_1 + (g_1e_1 + g_2e_2 + g_3e_3)b_1 - \frac{e_1^2}{2} - c\frac{e_3^2}{2}\right], \tag{11}$$

$$0 \leq \mathrm{E}\left[s_2 + (g_1e_1 + g_2e_2 + g_3e_3)b_2 - \frac{e_2^2}{2}\right], \tag{12}$$

where $\mathrm{E}[\cdot]$ denotes the expectations operator with respect to the random variable c. Accordingly, the principal maximizes expected firm value net of the agents' expected payments, taking into account the agents' incentive compatibility constraints (9), (10) and participation constraints (11), (12). From (9) and (10) we obtain that $e_1 = g_1b_1$, $e_2 = g_2b_2$, and $e_3 = g_3/c \cdot b_1$. These equations can be used to replace the effort levels in the principal's optimization problem. Since (11) and (12) must be binding under the optimal contract, we can simplify the principal's problem to

$$\max_{b_1,b_2} \mathrm{E}\left[f_1g_1b_1 + f_2g_2b_2 + f_3\frac{g_3}{c}b_1 - \frac{(g_1b_1)^2}{2} - \frac{(g_2b_2)^2}{2} - \frac{(g_3b_1)^2}{2c}\right]. \tag{13}$$

Differentiating (13) with respect to b_1 and b_2 gives the optimal bonuses $b_1^{C_1}$ and $b_2^{C_1}$ in expression (1). Inserting the optimal bonuses into the principal's profit function (13) gives the principal's expected profit Π^{C_1} in expression (1). If the principal wants Agent 2 to perform task 3, the procedure is analogous with Agent 2 being the multitasking agent and leads to bonuses and profit given in expression (2).

Proof of Lemma 2. When deciding on the task assignment at stage 3, Agent 1 anticipates the effort choices at stage 4. When Agent 1 himself carries out task 3, he chooses effort $e_1 = g_1 b_1$ and $e_3 = g_3/c \cdot b_1$, while Agent 2 exerts effort $e_2 = g_2 b_2$. Agent 1's expected payoff thus is

$$s_1 + (g_1^2 b_1 + g_2^2 b_2 + \frac{g_3^2}{c} b_1) b_1 - \frac{(g_1 b_1)^2}{2} - \frac{(g_3 b_1)^2}{2c} = s_1 + \frac{(g_1 b_1)^2}{2} + g_2^2 b_2 b_1 + \frac{(g_3 b_1)^2}{2c}. \tag{14}$$

If Agent 2 performs task 3, we obtain for Agent 1's expected payoff

$$s_1 + \frac{(g_1 b_1)^2}{2} + g_2^2 b_2 b_1 + g_3^2 b_2 b_1. \tag{15}$$

At stage 3, Agent 1 decides to perform task 3 himself iff (14) is at least as high as (15), i.e., $b_1/b_2 \geq 2c$. This condition implies the three cases described in Lemma 2.

Proof of Lemma 3. From the perspective of the principal at stage 1, Agent 1 will perform task 3 with probability p and Agent 2 will perform the task with probability $1 - p$. Taking the agents' incentive compatibility constraints and (binding) participation constraints into account, the principal's problem is

$$\max_{b_1, b_2} \; f_1 g_1 b_1 + f_2 g_2 b_2 + f_3 \left(p \frac{g_3}{c_L} b_1 + (1-p) g_3 b_2 \right)$$
$$- \left(\frac{(g_1 b_1)^2}{2} + p \frac{(g_3 b_1)^2}{2 c_L} \right) - \left(\frac{(g_2 b_2)^2}{2} + (1-p) \frac{(g_3 b_2)^2}{2} \right) \tag{16}$$
$$\text{s.t. } c_L \leq \frac{1}{2} \frac{b_1}{b_2} < c_H \tag{17}$$

First assume that the constraints in (17) are not binding. The optimal bonuses are then given by the first-order conditions for maximizing (16),

$$f_1 g_1 + p f_3 \frac{g_3}{c_L} - \left(g_1^2 b_1 + p \frac{g_3^2 b_1}{c_L} \right) = 0,$$
$$f_2 g_2 + (1-p) f_3 \frac{g_3}{c_L} - \left(g_2^2 b_2 + (1-p) g_3^2 b_2 \right) = 0,$$

from which we obtain b_1^D and b_2^D as given in case (i) of Lemma 3. We can now characterize under what circumstances the constraints in (17) are not binding: if $c_L \leq \dfrac{1}{2}\dfrac{b_1^D}{b_2^D} \leq c_H$. Defining $\hat{c} := \dfrac{1}{2}\dfrac{b_1^D}{b_2^D}$, case (i) of the lemma follows. Now assume that $\hat{c} < c_L$. The first inequality in (17) is then binding. Hence, the optimal solution comprises $b_2 = \dfrac{1}{2}\dfrac{b_1}{c_L}$. Using this relationship to replace b_2 in the principal's objective function, the optimal b_1 maximizes

$$
f_1 g_1 b_1 + f_2 g_2 \left(\frac{1}{2}\frac{b_1}{c_L}\right) + f_3 \left(p\frac{g_3}{c_L}b_1 + (1-p)g_3\left(\frac{1}{2}\frac{b_1}{c_L}\right)\right)
$$
$$
- \left(\frac{(g_1 b_1)^2}{2} + p\frac{(g_3 b_1)^2}{2c_L}\right) - \left(\frac{\left(g_2\left(\frac{1}{2}\frac{b_1}{c_L}\right)\right)^2}{2} + (1-p)\frac{\left(g_3\left(\frac{1}{2}\frac{b_1}{c_L}\right)\right)^2}{2}\right).
$$

From the corresponding first-order condition we obtain $\hat{b}_1^D$ as given in case (ii) of Lemma 3.

Proof of Proposition 1. Case (i) of the proposition follows directly from Lemma 1 and case (i) of Lemma 3, using that $f_\ell = g_\ell$ for all ℓ. Now consider case (ii) of the proposition. By Lemma 1 and case (ii) of Lemma 3, delegation dominates centralization iff

$$
\frac{\left(f_1^2 + p\frac{f_3^2}{c_L} + \left(f_2^2 + (1-p)f_3^2\right)\frac{1}{2c_L}\right)^2}{f_1^2 + p\frac{f_3^2}{c_L} + \left(f_2^2 + (1-p)f_3^2\right)\frac{1}{4c_L^2}} > f_1^2 + f_2^2 + f_3^2 \cdot \max\{1, \gamma\}. \tag{18}
$$

First consider the case $\gamma < 1$. It can be shown that the left-hand side of condition (18) is decreasing in c_L for $c_L > \frac{1}{2}$. To prove the claim on the optimality of delegation, it thus suffices to show that condition (18) holds as c_L approaches $\frac{1}{2}$ but does not hold as c_L goes to 1. We obtain

$$
\lim_{c_L \to \frac{1}{2}} \frac{\left(f_1^2 + p\frac{f_3^2}{c_L} + \left(f_2^2 + (1-p)f_3^2\right)\frac{1}{2c_L}\right)^2}{f_1^2 + p\frac{f_3^2}{c_L} + \left(f_2^2 + (1-p)f_3^2\right)\frac{1}{4c_L^2}} = \frac{\left(f_1^2 + 2pf_3^2 + \left(f_2^2 + (1-p)f_3^2\right)\right)^2}{f_1^2 + 2pf_3^2 + \left(f_2^2 + (1-p)f_3^2\right)}
$$
$$
= f_1^2 + 2pf_3^2 + \left(f_2^2 + (1-p)f_3^2\right) > f_1^2 + f_2^2 + f_3^2.
$$

As c_L goes to 1, we have

$$
\lim_{c_L \to 1} \frac{\left(f_1^2 + p\frac{f_3^2}{c_L} + \left(f_2^2 + (1-p)f_3^2\right)\frac{1}{2c_L}\right)^2}{f_1^2 + p\frac{f_3^2}{c_L} + \left(f_2^2 + (1-p)f_3^2\right)\frac{1}{4c_L^2}} = \frac{\left(f_1^2 + pf_3^2 + \left(f_2^2 + (1-p)f_3^2\right)\frac{1}{2}\right)^2}{f_1^2 + pf_3^2 + \left(f_2^2 + (1-p)f_3^2\right)\frac{1}{4}}
$$
$$
= \frac{\left(f_1^2 + \frac{1}{2}f_2^2 + \frac{1}{2}f_3^2 + \frac{1}{2}pf_3^2\right)^2}{f_1^2 + \frac{1}{4}f_2^2 + \frac{1}{4}f_3^2 + \frac{3}{4}pf_3^2}
$$

26

The last expression is smaller than $f_1^2 + f_2^2 + f_3^2$ iff

$$\left(f_1^2 + \frac{1}{2}f_2^2 + \frac{1}{2}f_3^2 + \frac{1}{2}pf_3^2\right)^2 - \left(f_1^2 + \frac{1}{4}f_2^2 + \frac{1}{4}f_3^2 + \frac{3}{4}pf_3^2\right)\left(f_1^2 + f_2^2 + f_3^2\right) < 0$$

$$\Leftrightarrow -\frac{1}{4}\left(f_1^2 + pf_3^2\right)\left(f_2^2 + f_3^2 - pf_3^2\right) < 0,$$

and the last condition clearly holds.

Now consider the case $\gamma \geq 1$. The principal then prefers delegation to centralization iff

$$\frac{\left(f_1^2 + p\frac{f_3^2}{c_L} + \left(f_2^2 + (1-p)f_3^2\right)\frac{1}{2c_L}\right)^2}{f_1^2 + p\frac{f_3^2}{c_L} + \left(f_2^2 + (1-p)f_3^2\right)\frac{1}{4c_L^2}} - \left(f_1^2 + f_2^2 + \gamma f_3^2\right) > 0. \tag{19}$$

The left-hand side of (19) is decreasing in c_L for $c_L > \frac{1}{2}$. We further obtain

$$\lim_{c_L \to \frac{1}{2}} \left[\frac{\left(f_1^2 + p\frac{f_3^2}{c_L} + \left(f_2^2 + (1-p)f_3^2\right)\frac{1}{2c_L}\right)^2}{f_1^2 + p\frac{f_3^2}{c_L} + \left(f_2^2 + (1-p)f_3^2\right)\frac{1}{4c_L^2}} - \left(f_1^2 + f_2^2 + \gamma f_3^2\right)\right]$$

$$= f_1^2 + 2pf_3^2 + \left(f_2^2 + (1-p)f_3^2\right) - \left(f_1^2 + f_2^2 + \left(2p + \frac{1-p}{c_H}\right)f_3^2\right) > 0.$$

Above, we have shown that

$$\lim_{c_L \to 1} \frac{\left(f_1^2 + p\frac{f_3^2}{c_L} + \left(f_2^2 + (1-p)f_3^2\right)\frac{1}{2c_L}\right)^2}{f_1^2 + p\frac{f_3^2}{c_L} + \left(f_2^2 + (1-p)f_3^2\right)\frac{1}{4c_L^2}} - \left(f_1^2 + f_2^2 + f_3^2\right) < 0.$$

Hence, because $\gamma \geq 1$, we also have

$$\lim_{c_L \to 1} \left[\frac{\left(f_1^2 + p\frac{f_3^2}{c_L} + \left(f_2^2 + (1-p)f_3^2\right)\frac{1}{2c_L}\right)^2}{f_1^2 + p\frac{f_3^2}{c_L} + \left(f_2^2 + (1-p)f_3^2\right)\frac{1}{4c_L^2}} - \left(f_1^2 + f_2^2 + \gamma f_3^2\right)\right] < 0.$$

By case (ii) of Lemma 3, under delegation the principal pays the bonuses

$$\hat{b}_1^D = \frac{f_1^2 + \frac{f_2^2}{2c_L} + p\frac{f_3^2}{c_L} + (1-p)\frac{f_3^2}{2c_L}}{f_1^2 + p\frac{f_3^2}{c_L} + \frac{1}{4c_L^2}\left(f_2^2 + (1-p)f_3^2\right)}, \quad \hat{b}_2^D = \frac{1}{2}\frac{\hat{b}_1^D}{c_L}. \tag{20}$$

We obtain that $\hat{b}_1^D > 1 \Leftrightarrow c_L > \frac{1}{2}$ and $\hat{b}_2^D < 1 \Leftrightarrow c_L > \frac{1}{2}$. By the formulae in (1) and (2), the bonuses under centralization are equal to 1.

Proof of Lemma 4. Consider the function $\Pi^D(p)$ as given in (4). Defining $f := f_1 = f_2 = f_3$ and $g := g_1 = g_2$, we obtain

$$\frac{\partial \Pi^D}{\partial p} = f^2 \left(-1 + \frac{1}{c_L} + \frac{g^2(g - g_3)^2}{(g^2 + g_3^2(1 - p))^2} - \frac{c_L g^2(g - g_3)^2}{(c_L g^2 + p g_3^2)^2} \right). \tag{21}$$

It follows that, for any strictly positive c_L, we have $\left. \frac{\partial \Pi^D}{\partial p} \right|_{p=0} < 0$ iff

$$-1 + \frac{1}{c_L} + \frac{g^2(g - g_3)^2}{(g^2 + g_3^2)^2} - \frac{(g - g_3)^2}{c_L g^2} < 0. \tag{22}$$

For $c_L = 1$, condition (22) can be simplified to $\frac{g^4}{(g^2 + g_3^2)^2} < 1$ and thus holds. For a general parameter c_L, condition (22) can be transformed to

$$\frac{(2g - g_3)(g^2 + g_3^2)^2}{g^2(2g^3 + g^2 g_3 + g_3^3)} < c_L.$$

If $2g > g_3$, the left-hand side of the above inequality is positive and we can define $\tilde{c} := \frac{(2g - g_3)(g^2 + g_3^2)^2}{g^2(2g^3 + g^2 g_3 + g_3^3)}$. If $2g \leq g_3$, we have to take into account that $\lim_{c_L \to 0, p \to 0} \frac{\partial \Pi^D}{\partial p}$ does not exist. We then define $\tilde{c} := \epsilon$ where ϵ denotes an arbitrary small but positive number. Hence, Lemma 4 follows.

Proof of Proposition 2. We have $\Pi^{C_2} \geq \Pi^{C_1}$ if and only if $p \leq \tilde{p} := \frac{c_L c_H - c_L}{c_H - c_L} \in (0, 1)$. Moreover, $\frac{\partial^2 \Pi^D}{\partial p^2} > 0$ and, hence, Π^D is strictly convex in p. Assume that $c_L > \tilde{c}$ and hence, by Lemma 4, Π^D is decreasing in p for sufficiently small values of p. Because $\Pi^D(0) = \Pi^{C_2}$ and $\Pi^D(1) = \Pi^{C_1}(1) > \Pi^{C_2}$, there is a unique $p' \in (0, 1)$ such that $\Pi^D(p') = \Pi^{C_2}$. We have $\Pi^{C_2} \geq \Pi^D(p)$ and $\Pi^{C_2} \geq \Pi^{C_1}$ for all $p \in [0, \min\{\tilde{p}, p'\}]$. Now assume that $c_L \leq \tilde{c}$ and, hence, Π^D is increasing in p. It follows that $\Pi^D(p) > \Pi^{C_2} \geq \Pi^{C_1}$ for $p \in [0, \tilde{p}]$. Defining $\hat{p}_1 := \min\{\tilde{p}, p'\}$ if $c_L \geq \tilde{c}$ and $\hat{p}_2 := \tilde{p}$ otherwise, we obtain part (i) and (ii) of the proposition.

Now assume that the principal switches from centralization with Agent 2 performing task 3 to delegation because c_L decreases. According to Lemma 1 and Lemma 3, Agent 1's bonus changes from

$$b_1^{C_2} = \frac{f_1}{g_1} \quad \text{to} \quad b_1^D = \frac{g_1^2}{g_1^2 + \frac{p}{c_L} g_3^2} \frac{f_1}{g_1} + \frac{\frac{p}{c_L} g_3^2}{g_1^2 + \frac{p}{c_L} g_3^2} \frac{f_3}{g_3}.$$

We have $b_1^{C_2} > b_1^D$ iff $f_1/g_1 > f_3/g_3$ or $g_3 > g_1$.

References

AGHION, P., AND J. TIROLE (1997): "Formal and Real Authority in Organizations," *Journal of Political Economy*, 105(1), 1–29.

ARYA, A., AND B. MITTENDORF (2011): "The Benefits of Aggregate Performance Metrics in the Presence of Career Concerns," *Management Science*, 57(8), 1424–1437.

ATHEY, S., AND J. ROBERTS (2001): "Organizational Design: Decision Rights and Incentive Contracts," *American Economic Review*, 91(2), 200–205.

BAKER, G., R. GIBBONS, AND K. MURPHY (1999): "Informal Authority in Organizations," *Journal of Law, Economics and Organizations*, 15(1), 56–73.

BAKER, G. P. (1992): "Incentive Contracts and Performance Measurement," *Journal of Political Economy*, 100(3), 598–614.

BAKER, G. P. (2002): "Distortion and Risk in Optimal Incentive Contracts," *Journal of Human Resources*, 37(4), 728–751.

BARON, D. P., AND D. BESANKO (2001): "Strategy, Organization and Incentives: Global Corporate Banking at Citibank," *Industrial and Corporate Change*, 10(1), 1–36.

BESTER, H., AND D. KRÄHMER (2008): "Delegation and Incentives," *RAND Journal of Economics*, 39(3), 664–682.

BRICKLEY, J. A., C. W. SMITH, AND J. L. ZIMMERMAN (2009): *Managerial Economics and Organizational Architecture*. McGraw-Hill/Irwin New York.

CHE, Y. K., AND S. W. YOO (2001): "Optimal Incentives for Teams," *American Economic Review*, 91(3), 525–541.

CORTS, K. S. (2007): "Team versus Individual Accountability: Solving Multitask Problems through Job Design," *RAND Journal of Economics*, 38(2), 467–479.

DE VARO, J., AND S. PRASAD (2015): "The Relationship Between Delegation and Incentives Across Occupations: Evidence and Theory," *Journal of Industrial Economics*, 63(2), 279–312.

DESSEIN, W. (2002): "Authority and Communication in Organizations," *Review of Economic Studies*, 69(4), 811–838.

DeVaro, J., and F. A. Kurtulus (2010): "An Empirical Analysis of Risk, Incentives and the Delegation of Worker Authority," *Industrial and Labor Relations Review*, 63(4), 637–657.

Feltham, G. A., and C. Hofmann (2007): "Limited Commitment in Multi-Agent Contracting," *Contemporary Accounting Research*, 24(2), 345–375.

Feltham, G. A., C. Hofmann, and R. J. Indjejikian (2016): "Performance Aggregation and Decentralized Contracting," *The Accounting Review*, 91(1), 99–117.

Feltham, G. A., and J. Xie (1994): "Performance Measure Congruity and Diversity in Multi-Task Principal/Agent Relations," *The Accounting Review*, 69(3), 429–453.

Garnier, J.-P. (2008): "Rebuilding the R&D Engine in Big Pharma," *Harvard Business Review*, 86(5), 68–76.

Grant, R. M. (2007): "Organizational Restructuring within the RoyalDutch/Shell Group," in *Cases to Accompany Contemporary Strategic Analysis, 6. edition*, ed. by R. Schmalensee, and R. Willig. Wiley and Sons.

Hemmer, T. (1995): "On the Interrelation between Production Technology, Job Design, and Incentives," *Journal of Accounting and Economics*, 19(2-3), 209–245.

Holmström, B., and P. Milgrom (1991): "Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership, and Job Design," *Journal of Law, Economics, and Organization*, 7, Special Issue, 24–52.

Holmström, B. (1982): "Moral Hazard in Teams," *The Bell Journal of Economics*, 13(2), 324–340.

Holmström, B., and P. Milgrom (1991): "Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership, and Job Design," *Journal of Law, Economics, and Organization*, 7 (Special Issue: Papers from the Conference on the New Science of Organization), 24–52.

——— (1994): "The Firm as an Incentive System," *American Economic Review*, 84(4), 972–991.

Hong, B., L. Kueng, and M.-J. Yang (2015): "Estimating Management Practice Complementarity Between Decentralization and Performance Pay," Discussion paper, National Bureau of Economic Research.

Iтон, H. (1994): "Job Design, Delegation and Cooperation: A Principal-Agent Analysis," *European Economic Review*, 38, 691–700.

Jia, Y., and P. van Veen-Dirks (2015): "Control System Design at the Production Level," *Working Paper*.

Kragl, J., and A. Schöttner (2014): "Wage Floors, Imperfect Performance Measures, and Optimal Job Design," *International Econonomic Review*, 55(2), 525–550.

Lando, H. (2004): "Are Delegation and Incentives Complementary Instruments?," *Working Paper*.

Lashinsky, A. (2011): "How Apple Works: Inside the World's Biggest Startup," http://tech.fortune.cnn.com/2011/08/25/how-apple-works-inside-the-worlds-biggest-startup/.

Macho-Stadler, I., and J. Pèrez-Castrillo (1998): "Centralized and Decentralized Contracts in a Moral Hazard Environment," *Journal of Industrial Economics*, 46(4), 489–510.

Melumad, N. D., D. Mookherjee, and S. J. Reichelstein (1992): "A Theory of Responsibility Centers," *Journal of Accounting and Economics*, 15(4), 445–484.

——— (1995): "Hierarchical Decentralization of Incentive Contracts," *RAND Journal of Economics*, 26(4), 654–673.

Milgrom, P., and J. Roberts (1992): *Economics, Organization and Management*. Prentice Hall Englewood Cliffs.

Mookherjee, D. (2006): "Decentralization, Hierarchies, and Incentives: A Mechanism Design Perspective," *Journal of Economic Literature*, 44(2), 367–390.

Nagar, V. (2002): "Delegation and Incentive Compensation," *The Accounting Review*, 77(2), 379–395.

Prendergast, C. (2002): "The Tenuous Trade-Off between Risk and Incentives," *Journal of Political Economy*, 110(5), 1071–1102.

Raith, M. (2008): "Specific Knowledge and Performance Measurement," *RAND Journal of Economics*, 39(4), 1059–1079.

RAJAN, M. V., AND S. REICHELSTEIN (2004): "Anniversary Article: A Perspective on "Asymmetric Information, Incentives and Intrafirm Resource Allocation"," *Management Science*, 50(12), 1615–1623.

RATTO, M., AND W. SCHNEDLER (2008): "Too Few Cooks Spoil the Broth: Division of Labour and Directed Production," *The B.E. Journal of Economic Analysis & Policy*, 8(1), Article 27.

REICHMANN, S., AND A. ROHLFING-BASTIAN (2014): "Decentralized Task Assignment and Centralized Contracting: On the Optimal Allocation of Authority," *Journal of Management Accounting Research*, 26(1), 33–55.

SCHMITZ, P. W. (2005): "Allocating Control in Agency Problems with Limited Liability and Sequential Hidden Actions," *RAND Journal of Economics*, 36(2), 318–336.

SCHÖTTNER, A. (2008): "Relational Contracts, Multitasking, and Job Design," *Journal of Law, Economics & Organization*, 24(1), 138–162.

SHIN, D., AND R. STRAUSZ (2014): "Delegation and Dynamic Incentives," *RAND Journal of Economics*, 45(3), 495–520.

WULF, J. (2007): "Authority, Risk, and Performance Incentives: Evidence from Division Manager Positions Inside Firms," *The Journal of Industrial Economics*, 55(1), 169–196.