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Delegation and incentives

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This article analyzes the relation between authority and incentives. It extends the standard principal-agent model by a project selection stage in which the principal can either delegate the choice of project to the agent or keep the authority. The agent's subsequent choice of effort depends both on monetary incentives and the selected project. We find that the consideration of effort incentives makes the principal less *likely to delegate the authority over projects to the agent. In fact, if the agent is protected by limited liability, delegation is* never *optimal.*

1. Introduction

■ How are decision rights and effort incentives related in the design of an organization? By specifying a structure of authority, an organization determines which of its members have the right to select certain decisions. Its overall efficiency depends on how closely the individual decision makers' interests are aligned with the organization's objective. The structure of authority, however, also determines to what extent the organization's members are affected by decisions that are taken by other members (see Simon, 1951). This in turn influences their incentives to provide effort for the organization's success. The optimal allocation of authority and the provision of effort incentives are therefore interdependent.[1]

As an example, consider investment decisions within a firm. If the management derives private benefits from "empire building," it favors projects that increase the firm's size. It tends to undertake inefficiently large investments, but it is also willing to invest more effort on such projects as they generate larger private benefits. In contrast, when the firm owners take investment decisions, they are concerned with maximizing the firm's market value rather than its size. Yet, they have to take into account that the management may show little enthusiasm to spend much effort on projects that prevent it from empire building.

Of course, the relation between incentive effects and decisions rights is relevant not only at the level of owners and management but at all layers of hierarchy within a firm. For instance, it is not atypical for middle managers to have goals which are different from general management

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[1] This point is noted already by Mirrlees (1976), who studies the optimal structure of incentives and authority in a hierarchical structure to explain the distribution of incomes within the firm.

goals. As Guth and MacMillan (1986) note, this implies that "the level of effort that an individual middle manager will apply to the implementation of a particular strategy depends on his/her [. . .] perception of the likelihood that successful performance will lead to an outcome he/she desires." Therefore, when general management selects a strategy, it has to consider also the objectives of middle managers.

To study the interaction between authority and effort incentives, we extend the standard principal-agent environment (see Holmstrom, 1979; Grossman and Hart, 1983; Sappington, 1983), in which the principal provides the agent with monetary incentives to exert a non-observable effort on a joint project.[2] The agent's effort determines the likelihood that the project succeeds. Whereas in the standard model the project is taken as given, we add a project selection stage where one out of a number of feasible projects is chosen. Projects generate private benefits, and the parties' preferences over projects diverge. To create a role for decision rights, we follow the emerging literature on contractible control by assuming that only the authority over project selection is contractible, because the selection of a particular project is neither *ex ante* nor *ex post* verifiable (e.g., Aghion and Tirole, 1997; Aghion, Dewatripont, and Rey, 2002; Hart and Holmstrom, 2002).[3] Thus, in addition to a wage schedule that is contingent on the project's outcome, the contract between the principal and the agent specifies which party has the right to select a project. The principal can either maintain the decision right over project selection or he can delegate this right to the agent. Because the agent's private benefits vary with the type of project, his effort incentives are determined jointly by the wage schedule and the allocation of authority.

Our main finding is that the consideration of effort incentives makes the principal *less* likely to delegate the authority over projects to the agent. We obtain this conclusion for two types of environments: first, we assume that there are no restrictions on monetary transfers between the principal and the agent. In this case, the agent is not protected by limited liability and the principal can extract the entire surplus from the relation. In the second environment, we assume that limited liability precludes negative wages so that the principal has to give the agent a rent to induce effort. For both environments, we compare the optimal allocation of authority with the hypothetical situation in which the agent's effort is publicly observable and contracted upon. This benchmark allows us to isolate the extent to which incentive considerations affect control rights when effort is not contractible. We find that both with and without limited liability, the range of parameter constellations where delegation is optimal shrinks relative to our benchmark. The driving force behind this observation is that when the principal keeps authority, he will take into account that the agent's subsequent choice of effort is positively related to the private benefits he derives from the selected project. Rather than resorting to delegation for incentive reasons, it turns out to be more efficient to exploit the fact that also the principal's project selection generates effort incentives. Indeed, this effect is most drastic under limited liability: if in this environment delegation were optimal for incentive reasons, then it would also be optimal for the principal to select the same project as the agent. Thus, by keeping authority, the principal can always ensure himself at least the same payoff as by delegation. Actually, we can show that he can even do better than selecting the agent's favorite project, which implies that delegation is *never* optimal under limited liability.

Our analysis contributes to the above-mentioned literature on contractible control. A standard result from this literature is that the decision right should be given to the party whose preferences over decisions are most closely aligned with the organization's objectives (see Hart and Holmstrom, 2002; Bester, 2005). This minimizes the inefficiencies that arise because the party endowed with authority will opportunistically select a decision in its own interest. A main insight

[2] For surveys on the canonical principal-agent problem and its extensions, see Sappington (1991) and Prendergast (1999).

[3] This feature distinguishes this approach from the earlier literature on the property rights theory of the firm (Grossman and Hart, 1986; Hart and Moore, 1990), in which decisions are *ex ante* noncontractible but *ex post* contractible.

of our article is that this argument needs to be modified when effort considerations are relevant. This is so because the principal will not always implement his ideal decision. As explained above, he will take into account that his choice affects the agent's effort incentives. Therefore, he may bias his decision making in favor of the agent to induce him to exert more effort. Leaving the control right with the principal has the key advantage that effort considerations induce him to act less opportunistically.

Our finding that incentive effects lead to less delegation might appear surprising in light of the incentive view of delegation in Aghion and Tirole (1997), where delegation of responsibility motivates the agent to acquire information about the benefits of different projects. In line with the incentive view, also in our model the agent can be induced to provide more effort by transferring decision rights to him. For a given bonus scheme, his effort incentives are maximized by empowering him to select his favorite project. However, unlike in Aghion and Tirole (1997), there are two reasons for why the principal refrains from using delegation as an incentive device: first, whereas in Aghion and Tirole (1997) the principal cannot use monetary incentives, in our model he is able to use bonus payments as an alternative incentive device.[4] The second important difference is that in our model the agent's effort choice occurs *after* a project has been determined; the agent's task thus consists of completing a project. In contrast, in Aghion and Tirole (1997), the agent invests effort *before* the selection stage to acquire information about potential projects. This difference in timing has an important consequence for the selection of projects if the principal maintains the decision right over projects. Whereas in Aghion and Tirole (1997) effort is sunk at the project selection stage, in our model the principal anticipates that—for a given bonus system—effort incentives increase with the agent's private benefits from the project. Therefore, the agent's preferences affect the choice of project even when the principal keeps authority. Because the principal's choice already takes into account that the agent is motivated by his private benefits, delegating authority for incentive reasons becomes less attractive. The comparison of Aghion and Tirole's (1997) and our analysis suggests that the effectiveness of delegation may depend critically on the nature and the sequencing of tasks that an organization faces. Delegation of decisions is likely to be an effective instrument to motivate subordinates to invest pre-decisional effort (such as information acquisition) but might be a suboptimal way to induce post-decisional effort (such as working on the project).

The literature on agency provides several insights into the relation between incentives and organizational design that are related to our analysis. For example, as shown by Holmstrom and Milgrom (1991), in a multitasking environment the number of tasks that an agent optimally performs depends on the reliability of performance measures. In our model, under delegation, the agent faces the dual task of selecting a project and devoting effort on its completion. Even in the absence of limited liability restrictions, the principal cannot design a payment schedule that induces the agent to perform both tasks efficiently. Yet, this does not imply that delegation is always inferior. Indeed, if the principal keeps authority, he becomes involved in a kind of two-sided moral hazard problem (see, e.g., Cooper and Ross, 1985; Dybvig and Lutz, 1993); Bhattacharyya and Lafontaine, 1995) because he selects the project and the agent the effort.

In our analysis, the only available performance measure of the agent's effort is the project outcome. This differs from Prendergast (2002), where the principal's delegation decision depends on the choice between monitoring inputs or outputs. If he monitors the agent's effort input, he restricts the set of activities that the agent is allowed to engage in. Alternatively, the principal can monitor the agent's output and delegate the choice of action to the agent. The comparison between these alternatives shows that the principal will delegate decision-making power more in uncertain environments.

Several authors investigate the relation between private information and the allocation of authority (see Riordan and Sappington, 1987; Athey and Roberts, 2001; Dessein, 2002). This literature argues that delegation leads to a loss of control but helps to exploit decentralized

[4] Aghion and Tirole (1997) briefly discuss monetary incentives in an extension of their basic model.

information which might be hard to elicit if the principal keeps authority. To focus on the relation between effort incentives and authority, our analysis abstracts from private information. Yet, as we point out in the concluding remarks, it may be interesting to extend our model to situations in which both incentives for information revelation and effort incentives play a role.

From a different perspective, Melumad and Reichelstein (1987) and Melumad, Mookherjee, and Reichelstein (1995, 1997) compare centralized decision making and delegation in adverse selection environments where, in contrast to our analysis, decisions are contractible. When the revelation principle applies, centralized decision making is always optimal because the agent can be induced to communicate his information truthfully. Yet, under some conditions, the same outcome can also be achieved without communication by simply delegating decisions to the agent. This implies that delegation may gain an advantage when centralized contracts cannot be fully state contingent. One interpretation of this observation is that the scope for delegation increases with *less* contractual flexibility. Perhaps surprisingly, in our model we obtain the opposite conclusion as we show that delegation is never optimal with limited liability restrictions, whereas it may be optimal in the absence of such restrictions. This means that in our analysis, the scope for delegation increases when financial contracting becomes *more* flexible.[5] Of course, if decisions were verifiable so that payments could additionally be made contingent on decisions, the advantage of delegation would disappear. Overall, this suggests that the relation between delegation and contractual flexibility may be nonmonotonic.

Finally, there is a literature on optimal delegation when the agent has private information and the set of decisions from which the agent can choose is contractible.[6] In this context, Szalay (2005) finds that effort concerns can cause the principal to restrict the amount of delegation. He shows that constraining the agent's freedom of choice can be optimal to induce *ex ante* information acquisition. Although this finding has a similar flavor as our main result, its underlying force is very different, because it relies on the principal's ability to contractually prohibit certain decisions.

The remainder of this article is organized as follows. Section 2 extends the standard principal-agent framework by introducing decision rights over projects as part of the contracting problem. In Section 3, we consider the relation between authority and incentives in the absence of limited liability restrictions. Section 4 analyzes the optimal allocation of decision rights when the agent is protected by limited liability. In Section 5, we consider an extension of the model in Section 2. Section 6 contains concluding remarks. The proofs of all formal results are relegated to an Appendix.

2. The model

■ We consider a risk-neutral principal and a risk-neutral agent who can jointly undertake a project $d \in D$, where $D = [0, 1]$ is the set of feasible projects. The selection of a particular project is not verifiable to outsiders and, hence, not contractible. A typical example is a firm that engages in R&D to develop a new product or technique. These activities involve decisions on the specification of the product, on the laboratory equipment, on the research strategy, and so on. The details of such decisions are often not verifiable to outsiders. Therefore, only the *decision right* over D can be assigned contractually either to the principal or to the agent. If the principal keeps authority, he maintains control over the critical resources to initiate a project. Otherwise, if he delegates the decision right, he transfers the control over these resources to the agent.

A project can either succeed or fail. This outcome is verifiable. In the R&D example, it is publicly observable whether the firm wins a patent, introduces a new product, or gets approval of its innovation by regulatory institutions. The likelihood of success and failure depends on the agent's effort $e \in \{e_L, e_H\}$. The agent chooses his effort *after* a project d has been determined. Even though the choice of d is not publicly verifiable, we assume that it is internally observable for

[5] We thank an anonymous referee for indicating this interpretation to us.

[6] The seminal paper is Holmstrom (1984). For recent contributions see, for example, Alonso and Matouschek (2008) or Mylovanov (2008).

the principal and the agent. Thus, at the stage where the agent chooses his effort, he is informed about project d also when the principal has the decision right. If the agent selects effort e, he incurs effort cost $c(e)$ and the project succeeds with probability $p(e)$. Let $p_H \equiv p(e_H) > p_L \equiv p(e_L) > 0$ and $c \equiv c(e_H) > c(e_L) \equiv 0$. To avoid case distinctions, we further assume $(p_H - p_L)/p_L \geq 1$ so that increasing effort has a sufficiently strong impact on the probability of success.[7] As in the standard principal-agent model with moral hazard, the agent's effort choice is not observable.

In the event of project failure, the private benefits of the principal and the agent are zero. If project d succeeds, the principal and the agent receive the private benefits $u_P(d)$ and $u_A(d)$, respectively. These benefits are nonobservable to outsiders so that they do not publicly reveal the choice of project.[8] The agent's private benefits may, for example, comprise work satisfaction or reputational benefits. One component of the principal's private benefits may be cash flow, which frequently is inherently difficult to verify. For instance, if the firm operates in several businesses, it may be impossible for a court to ascribe money streams to a particular project.[9] Beside cash flow, projects might create nonverifiable spillovers to other businesses of the firm in the form of learning externalities, fostering customer relations, or reputation effects. Finally, both the principal and the agent may have personal stakes in some projects.

The principal's and the agent's benefits depend on the selected project as[10]

$$u_P(d) = 1 - k_P(d_P - d)^2, \quad u_A(d) = 1 - k_A(d_A - d)^2, \tag{1}$$

with $0 < k_P < 1$, $0 < k_A < 1$. Thus, the principal's benefit reaches a unique maximum for $d = d_P$, and the agent's benefit is maximized for $d = d_A$. Each party's utility decreases with the distance between its ideal and the actual project; the weights k_P and k_A describe how much the principal and the agent care about the selection of a project. These weights will turn out to be important for the optimal allocation of decision rights. The principal and the agent do not have fully congruent interests over the selection of a project because[11]

$$0 \leq d_P < d_A \leq 1. \tag{2}$$

If the project succeeds, the principal pays the agent the wage w_S; in the case of failure, the agent receives the wage w_F. Let $w = (w_S, w_F)$. Then the expected payoffs of the principal and the agent are

$$\begin{aligned} U_P(d, e, w) &\equiv p(e)[u_P(d) - w_S] - (1 - p(e))w_F, \\ U_A(d, e, w) &\equiv p(e)[u_A(d) + w_S] + (1 - p(e))w_F - c(e). \end{aligned} \tag{3}$$

As the agent's outside option payoff is $\bar{U}_A = 0$, the principal has to design a contract so that the *participation constraint*

$$U_A(d, e, w) \geq 0 \tag{4}$$

is satisfied, which guarantees that the agent accepts the contract. We assume that neither the agent nor the principal can credibly threaten to quit *after* a project has been selected.

In addition to the agent's participation constraint, the principal faces the usual incentive constraint because the agent's effort is not observable. The agent's effort choice is determined by

[7] A comparison with an earlier version of this article (Bester and Krähmer, 2007), in which this assumption is not made, shows that it does not qualitatively affect the results.

[8] The assumption of nonobservability might be relaxed by allowing for noisy observation of benefits as in Bester (2002), where the optimality of delegation is also affected by the precision of a public signal about the principal's payoff.

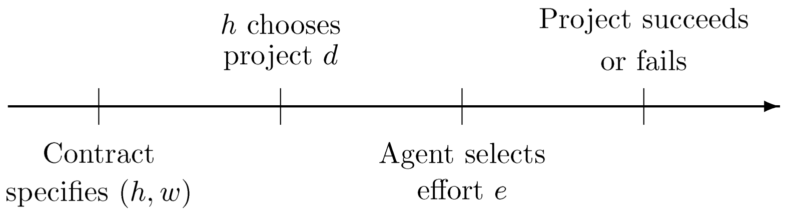
[9] Indeed, it is common in the literature to assume that cash flow is nonverifiable (see, e.g., Baker, 1992; Bolton and Scharfstein, 1996; Lewis and Sappington, 1997).

[10] A similar preference structure is used in, for example, Crawford and Sobel (1982) and Dessein (2002).

[11] The assumption that $d_P < d_A$ is not significant. What is important is that the principal and the agent have different ideal projects.

FIGURE 1

THE SEQUENCE OF EVENTS



the *effort incentive constraint*

$$e = \tilde{e}(d, w) \equiv \underset{e \in \{e_L, e_H\}}{\operatorname{argmax}} \; U_A(d, e, w), \tag{5}$$

where as a tie-breaking rule we assume $\tilde{e}(d, w) = e_H$ if the agent is indifferent between high and low effort. Note that the agent's effort incentives depend not only on the wage schedule w but also on the project d. The higher his private benefit $u_A(d)$, the more inclined the agent is to exert high effort.

Because d is not contractible, the principal offers the agent a contract which in addition to the wages w specifies which party gets the authority to select the project. We describe the allocation of authority by $h \in \{P, A\}$. Thus, if $h = P$, the principal retains the right to select $d \in D$; if $h = A$, he delegates the selection of a project to the agent. If party $h \in \{P, A\}$ has the authority over the project decision, it will select d to maximize its own expected payoff *ex post* after wages have been set at the contracting stage. Therefore, d is determined by the *decision incentive constraint*

$$d = \tilde{d}(h, w) \equiv \underset{d \in D}{\operatorname{argmax}} \; U_h(d, \tilde{e}(d, w), w). \tag{6}$$

Note that according to the effort incentive constraint (5), the agent's effort depends on d. Therefore, if $h = P$, the principal's decision $\tilde{d}(P, w)$ takes this incentive effect into account. In contrast, if $h = A$, the agent's decision $\tilde{d}(A, w)$ is simply d_A, independent of w. In what follows, we say that a project-effort combination (d, e) can be *implemented* by the contract (h, w) if it satisfies the effort incentive constraint (5) and the decision incentive constraint (6).

The time structure of the model is summarized in Figure 1: first, the principal and the agent sign a contract that specifies the wage schedule w and the party h who has the authority to select a project d at the subsequent stage. After a project has been determined, the agent chooses his effort e. This choice affects the probability of success and failure in the final stage.

In the following, we study the optimal contract in two settings: we first consider the case without restrictions on the wage schedule w. In this case, the principal's problem is to choose (h, d, e, w) so that his expected payoff $U_P(d, e, w)$ is maximized subject to the constraints (4)–(6). Then we consider the case where limited liability or wealth restrictions prevent payments from the agent to the principal. In this case, the principal faces the additional constraint $w \geq 0$. In both cases, we illustrate our analytical results by a numerical example in which we set $d_P = 0$, $d_A = 1$, $p_H = 8/10$, $p_L = 4/10$, and $k_A = 1/2$. This allows us to describe how the optimal contract depends on the agent's effort cost c and the principal's preference intensity k_P.

We will contrast our findings with the *benchmark case* in which the agent's effort choice is observable and contracted upon. Of course, it might be not realistic to assume that effort is observable. However, a comparison with this hypothetical situation allows us to isolate incentive effects as in the benchmark case these effects obviously play no role for the optimal assignment of authority. If effort is contracted upon, the principal can ignore the effort incentive constraint (5). Also, because e is fixed by the contract, the decision incentive constraint becomes

$$d = \underset{d \in D}{\operatorname{argmax}} \; U_h(d, e, w). \tag{7}$$

The benchmark solution (h, d, e, w) thus maximizes the expected payoff $U_P(d, e, w)$ subject to the participation constraint (4) and the decision incentive constraint (7).

Our set-up contains a number of simplifications that keep the analysis tractable: the success probability of a project depends on effort only and is independent of the project itself. Also, private benefits are not directly affected by effort choice. This allows us to disentangle "effort" from "project choice" and renders each party's ideal project independent of effort. Further, we consider only binary signals (success and failure) of the agent's effort, and focus on a parametric specification of benefits. These assumptions allow us to explicitly derive the optimal allocation of authority and to show that incentive considerations imply *less* delegation relative to the benchmark. Section 6 provides a generalization that does not impose these special features. For this general model, we can derive the weaker conclusion that incentives do not imply more delegation.

3. Authority and incentives

■ In this section, we study the optimal allocation of authority in the absence of nonnegativity restrictions on the wage schedule w. Thus, the agent is not protected by limited liability and he may face a penalty $w_F < 0$ if the project fails. Obviously, in this situation, the agent's participation constraint (4) is always binding for a solution of the principal's problem. Because both parties are risk neutral, this means that the principal can appropriate the entire expected surplus

$$p(e)[u_P(d) + u_A(d)] - c(e). \tag{8}$$

Effectively, without limited liability restrictions, the principal's problem is equivalent to maximizing the expected surplus in (8) subject to the effort incentive constraint (5) and the decision incentive constraint (6).

The principal's problem would be trivial if the decision d was contractible, that is, in the absence of the decision incentive constraint (6). In this case, the principal could achieve the first best by contractually committing to the surplus maximizing decision

$$d^* \equiv \underset{d \in D}{\operatorname{argmax}}\, [u_P(d) + u_A(d)] = \frac{d_P k_P + d_A k_A}{k_P + k_A} \tag{9}$$

and to a wage schedule that induces the agent to exert effort whenever this is optimal. Note that $d_P < d^* < d_A$ as d^* is a convex combination of d_P and d_A. Further, the joint surplus in (8) is larger the closer the decision d is to the surplus maximizing decision d^*.

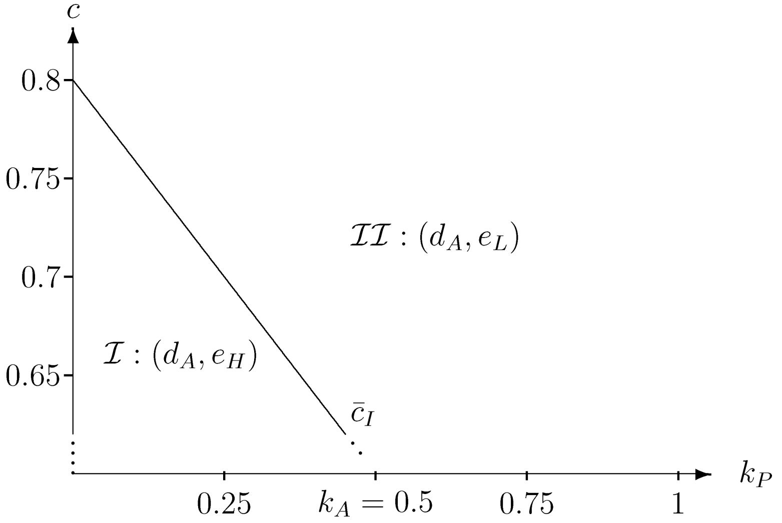
When only decision rights are contractible, the principal faces a fundamental commitment problem when he keeps the decision right: from an *ex ante* point of view, he would like to commit to the first-best project d^*, which maximizes the joint surplus. However, *ex post*, after the agent has accepted the contract, he selects the project which maximizes his expected *private* benefits net of expected wage payments. Thus, the principal's *ex ante* and *ex post* interests diverge. This is a basic consequence of the noncontractibility of d.

To gain further insights into the principal's commitment problem, it is useful to consider the benchmark case in which effort is contracted upon. Suppose first that the principal keeps authority. Because e is contractually fixed, (7) implies that he selects his ideal project d_P. Hence, under P-authority, he realizes the *ex ante* surplus $p(e)\,[u_P(d_P) + u_A(d_P)] - c(e)$. When he delegates the decision instead, the agent chooses his ideal project d_A. Hence, under A-authority, the principal realizes the *ex ante* surplus $p(e)\,[u_P(d_A) + u_A(d_A)] - c(e)$. It is easy to see that, irrespective of e, delegation generates a higher surplus when the agent cares more about the decision than the principal, that is, when $k_A > k_P$. This is so because in this case, the agent's decision d_A is closer to the first-best decision d^* than the principal's decision d_P. In other words, when $k_A > k_P$, the principal can mitigate his commitment problem by delegating the decision to the agent.[12] We summarize this insight in the following.

[12] This observation is similar to the findings of Hart and Holmstrom (2002) and Bester (2005), who study the optimal allocation of decision rights in the absence of incentive effects.

FIGURE 2

PROJECT-EFFORT COMBINATIONS UNDER *A*-AUTHORITY



Observation 1. If effort is contractually fixed, A-authority is uniquely optimal if and only if $k_P < k_A$, and P-authority is uniquely optimal if and only if $k_P > k_A$.

We now turn to the problem when effort incentive considerations matter. We first study the optimal contract under A-authority, where the principal delegates the decision right to the agent by setting $h = A$. In this case, the decision incentive constraint (6) immediately implies that the agent always selects his ideal project d_A. Thus, the principal can only decide whether he wants to implement high effort by a steep wage schedule or low effort by a flat schedule. This decision depends on the agent's effort cost c. To state this formally, we define

$$\bar{c}_I \equiv (p_H - p_L)[2 - k_P(d_A - d_P)^2]. \tag{10}$$

Proposition 1. The optimal project-effort combination under A–authority has the following properties:

(i) If $c \leq \bar{c}_I$, *then* d_A *and* e_H are implemented.
(ii) If $c > \bar{c}_I$, then d_A and e_L are implemented.

Figure 2 illustrates the optimal implementation of effort under A-authority for our numerical example. The borderline between regions $\mathcal{I}$ and $\mathcal{II}$ is defined by $c = \bar{c}_I$. It is downward sloping because the joint surplus decreases when the principal cares more about the fact that he cannot realize his ideal project under A-authority. For parameter values of k_P and c that lie in region $\mathcal{I}$, the effort cost c is sufficiently small so that the principal optimally induces the agent to exert high effort. Above this line, in region $\mathcal{II}$, the effort cost is too large and so the principal optimally implements low effort under A-authority.

Next, we study the optimal contract under P-authority, where the principal maintains the decision right by setting $h = P$. When the principal selects the project *ex post*, he takes into account the agent's effort incentives as described by the effort incentive constraint (5). This is the critical difference from the previously described benchmark case with contractually fixed effort. In fact, to induce the agent to select high effort, it may now be optimal for the principal not to select his ideal project d_P but some $d > d_P$. Of course, this can happen only if the bonus $w_S - w_F$ by itself is not sufficient to provide effort incentives. The following lemma states more precisely the conditions under which a given wage schedule w induces the principal to select some $d > d_P$.

Lemma 1. The project-effort combination (d, e_H) with $d > d_P$ can be implemented under P-authority if and only if

$$U_A(d, e_H, w) = U_A(d, e_L, w) \quad \text{and} \quad U_P(d, e_H, w) \geq U_P(d_P, e_L, w).$$

The first condition requires the agent's effort incentive constraint to be binding. Obviously, this must be the case because otherwise the principal would select some $d' < d$, which is closer to his ideal project d_P and still motivates the agent to exert high effort. Only the consideration that the agent would switch to low effort can force the principal to select $d > d_P$. The second condition requires that at the project selection stage the principal indeed prefers project d in combination with high effort over his ideal project d_P in combination with low effort.

To understand the interaction between the principal's project choice and the bonus, note that the first condition in Lemma 1 can be satisfied for an arbitrary project d simply by setting the bonus $w_S - w_F$ appropriately. Actually, there is a tradeoff between motivating the agent by the choice of project and the bonus payment: because the agent is more inclined to exert effort on projects that yield higher private benefits for him, the minimal bonus that induces high effort decreases with the distance between d and the agent's ideal project d_A. Therefore, as long as the second condition of Lemma 1 remains satisfied, the principal can commit himself to select a project that is closer to d_A by offering a lower bonus at the contracting stage. In this sense, the specification of monetary incentives under P-authority generates a *commitment effect*.

Ideally, the principal would use this commitment effect by setting *ex ante* a bonus that forces him *ex post* to select the first-best project d^*. This, however, is possible only if the agent's effort cost is sufficiently low. If this cost rises, then the bonus must also rise. This increases expected wages and raises the principal's incentive to choose d_P rather than d^* *ex post* so that ultimately the second condition of Lemma 1 will be violated. Accordingly, for some intermediate level of the effort cost c, the commitment effect becomes weaker and under the optimal contract the critical project d moves away from the first-best project closer to d_P. Of course, if c becomes too large then it is no longer optimal to implement high effort and so the principal optimally implements (d_P, e_L) by setting the bonus to zero.

To describe how the optimal contract under P-authority depends on the effort cost c, we define

$$\begin{aligned} \bar{c}_{II} &\equiv 2(p_H - p_L) - (d_A - d_P)^2 \frac{(p_H - p_L)k_A k_P^2 + p_H k_A^2 k_P}{(k_A + k_P)^2}, \\ \bar{c}_{III} &\equiv 2(p_H - p_L) - (d_A - d_P)^2 \frac{(p_H - p_L)p_H k_A k_P}{(p_H - p_L)k_A + p_H k_P}. \end{aligned} \tag{11}$$

The critical value $\bar{c}_{II}$ represents the highest value of the agent's effort cost c so that d^* satisfies the conditions of Lemma 1. That is, the first-best project is implementable under P-authority only if $c \leq \bar{c}_{II}$. Similarly, $\bar{c}_{III}$ is the highest value of c such that some $d > d_P$ satisfies the conditions of Lemma 1. In other words, if $c > \bar{c}_{III}$ the principal can no longer exploit the commitment effect and so under his authority only d_P can be implemented.

Note that $\bar{c}_{II} < \bar{c}_{III}$. Both $\bar{c}_{II}$ and $\bar{c}_{III}$ are strictly decreasing in k_P and k_A. This is so because the surplus from a project $d \in (d_P, d_A)$ decreases when the parties put more weight on the utility loss from not realizing their ideal projects. Further, we have $\bar{c}_I = \bar{c}_{II} = \bar{c}_{III}$ in the limit as k_P tends to zero.

Proposition 2. The optimal project-effort combination under P-authority has the following properties:

(i) If $c \leq \bar{c}_{II}$, then d^* and e_H are implemented.
(ii) If $c \in (\bar{c}_{II}, \bar{c}_{III}]$, then some $d \in (d_P, d^*)$ and e_H are implemented.
(iii) If $c > \bar{c}_{III}$, then d_P and e_L are implemented.

FIGURE 3

PROJECT-EFFORT COMBINATIONS UNDER P-AUTHORITY

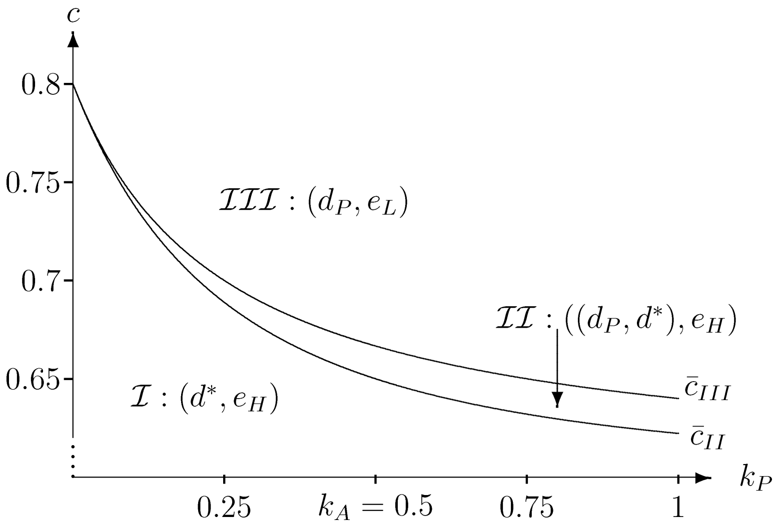


Figure 3 illustrates Proposition 2 by showing how the optimal project-effort combination under P-authority depends on the parameters k_P and c. The borderline between regions $\mathcal{I}$ and $\mathcal{II}$ is defined by $c = \bar{c}_{II}$. Thus, in region $\mathcal{I}$, where the agent's effort cost is rather low, the principal optimally implements the first-best decision d^*, which in combination with the wage schedule induces the agent to select high effort. High effort is also induced for intermediate effort costs in region $\mathcal{II}$, but here the principal selects a decision $d \in (d_P, d^*)$. Finally, in region $\mathcal{III}$, which lies above the $c = \bar{c}_{III}$ schedule, implementing high effort is too costly, so the principal chooses his ideal project d_P and provides no effort incentives by a flat wage schedule with $w_S = w_F$.

By comparing the expected surplus in (8) from the optimal project-effort combinations in Propositions 1 and 2, we can now determine whether maintaining the decision rightor delegating authority to the agent is optimal for the principal. We begin by identifying the intersection of the curves $\bar{c}_I$ and $\bar{c}_{III}$. From (10) and (11) it follows that these curves intersect at the point where

$$\frac{k_P}{k_A} = \frac{p_L}{p_H}. \tag{12}$$

If $k_P/k_A < p_L/p_H$ then $\bar{c}_I > \bar{c}_{III}$, and if $k_P/k_A > p_L/p_H$ then $\bar{c}_I < \bar{c}_{III}$. This is illustrated in Figure 4 where (12) holds for $k_P = 0.25$.[13] The next proposition characterizes the optimal allocation of authority.

Proposition 3. In the absence of limited liability restrictions, the optimal allocation of authority has the following properties:

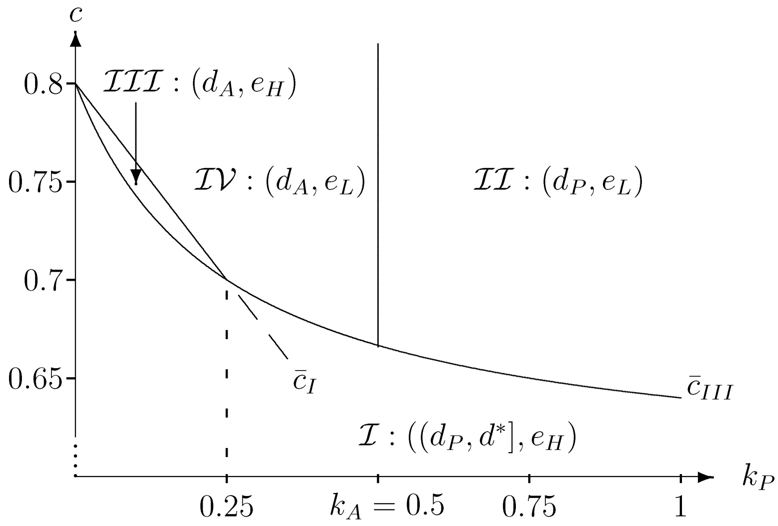
(i) If $c < \bar{c}_{III}$, then P-authority is uniquely optimal.
(ii) If $c > \bar{c}_{III}$ and $k_P > k_A$, then P-authority is uniquely optimal.
(iii) If $c > \bar{c}_{III}$ and $k_A < k_P$, then A-authority is uniquely optimal.

Figure 4 summarizes Proposition 3 for our example: in regions $\mathcal{I}$ and $\mathcal{II}$ the optimal contract entails P-authority; high effort is implemented in region $\mathcal{I}$ and low effort in region $\mathcal{II}$. Delegating

[13] Note that (12) implies $k_P < k_A$ at the intersection point, because $p_L < p_H$.

FIGURE 4

OPTIMAL ALLOCATION OF AUTHORITY



authority to the agent is optimal in regions $\mathcal{III}$ and $\mathcal{IV}$; in region $\mathcal{III}$ high effort and in region $\mathcal{IV}$ low effort is implemented.

Proposition 3 captures the main insight of our article: when effort considerations matter, there is less delegation relative to the benchmark with contractually fixed effort. Indeed, in region $\mathcal{I}$, the principal maintains authority even if he cares less about the decision than the agent, that is, if $k_P < k_A$. The reason is the commitment effect, which by Proposition 2 enables the principal to commit himself not to select his ideal project d_P but some $d \in (d_P, d^*]$ in order to motivate the agent to exert effort. The principal's choice d in region $\mathcal{I}$ generates a higher surplus than d_A, which the agent would select under delegation. Therefore, even if high effort could be implemented under A-authority, the commitment effect favors P-authority. Perhaps surprisingly, this happens even when the principal becomes less and less concerned about the choice of project as k_P tends to zero. The explanation is that both his choice d and d^* converge to d_A in the limit $k_P \to 0$.

Implementing high effort under A-authority is optimal only for parameter values in region $\mathcal{III}$. As Proposition 2 shows, here P-authority would lead to the project-effort combination (d_P, e_L). This is inefficient because d_A, which is selected under delegation, generates a higher surplus than d_P because $k_A > k_P$ in region $\mathcal{III}$. Indeed, the surplus generated under A-authority is sufficiently high to make implementing high effort efficient.

Finally, consider regions $\mathcal{II}$ and $\mathcal{IV}$ where low effort is implemented. In these regions, there is no commitment effect under P-authority, and whichever party has authority chooses its ideal project. Hence, under these parameter constellations, the logic is the same as in the benchmark case where authority is optimally assigned to the party who cares more about the decision.

An interesting comparative statics insight can be obtained by looking at how an increase in the parameter p_H affects the regions in Figure 4. A higher value of p_H indicates a higher productivity of effort, which makes the provision of incentives more important. It is straightforward to show from (11) that the curve $\bar{c}_{III}$ shifts upward as p_H increases. Thus, the range in which P-authority is optimal becomes larger as effort productivity increases. This observation supports our main result that incentive concerns give rise to less delegation.

4. Limited liability

■ We now turn to the case in which the agent is protected by limited liability. Thus, the principal's problem is to find a contract that maximizes his expected payoff $U_P(d, e, w)$, as defined in (3), subject to the constraints (4)–(6), and the additional nonnegativity constraints on transfers

$$w_S \geq 0, \quad w_F \geq 0. \tag{13}$$

As the following lemma reveals, this restriction has two important implications for the principal's problem.

Lemma 2. With limited liability, the principal's problem has the following properties:

(i) The agent's participation constraint (4) is never binding.
(ii) The decision incentive constraint (6) is redundant under P-authority.

The first observation of the lemma follows simply from the fact that the agent always has the option to exert low effort. In this way he can ensure himself a nonnegative expected payoff, because $u_A(d) > 0$ and $c(e_L) = 0$. With limited liability, his participation constraint is already implied by the effort incentive constraint (5) and so the principal will optimally set $w_F = 0$.

The intuition for the second observation in Lemma 2 is that under limited liability the *ex ante* and *ex post* interests of the principal coincide. Because he cannot extract the agent's surplus, the principal does not seek to maximize total surplus *ex ante*. *Ex ante* as well as *ex post*, his objective is to select the project which maximizes his expected private benefits net of expected wage payments. In other words, if (d, e, w) maximizes the principal's *ex ante* expected payoff subject to the effort incentive constraint (6), then implementing (d, e) must also be optimal for him *ex post* at the project selection stage, where the only difference is that w is already given. Thus, under P-authority, the decision incentive constraint (6) can be ignored in the principal's problem because it will be satisfied automatically.

The next proposition describes the allocation of authority under the optimal contract.

Proposition 4. Under limited liability, P-authority is always uniquely optimal.

For the case where implementing low effort is optimal, this result simply follows from the fact that neither the participation nor the effort incentive constraint restricts the principal's choice of contract. Therefore, he implements his ideal project d_P and sets $w_S = w_F = 0$. This generates a higher payoff than delegation, which would lead to the choice of project d_A.

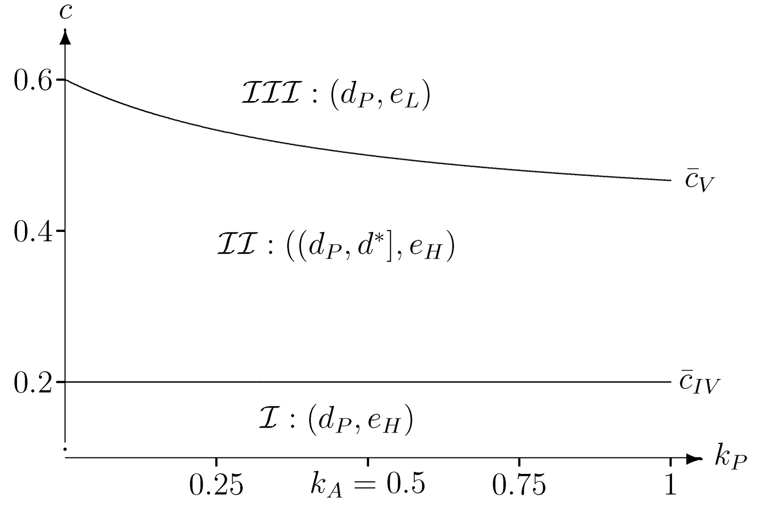
When inducing high effort is optimal, it follows from part (ii) of Lemma 2 that the principal cannot gain by delegation. Indeed, if A-authority is optimal *ex ante*, then implementing the agent's ideal project d_A must be optimal also *ex post*. Therefore, if the principal instead of the agent had the decision right, the principal would also choose d_A *ex post*. Thus, if a contract with $h = A$ is optimal, it can be replicated by a contract with $h = P$. The proof of Proposition 4 actually shows that the principal can always do better than implementing d_A. In fact, under an optimal contract he never chooses a $d > d^*$. Because the principal's marginal loss from raising d is increasing, beyond d^* it becomes more efficient to motivate the agent by the bonus payment rather than by his private benefit. Thus P-authority is *uniquely* optimal.

To put this result into context, we compare it with our benchmark case. Because P-authority is always uniquely optimal when effort is not contractible, we do not fully characterize the case when effort is contracted upon. Instead, to show that incentive effects give rise to *less* delegation, we content ourselves with identifying a constellation in which delegation is uniquely optimal when effort is contracted upon.

Suppose effort is contractually fixed. Then the decision incentive constraint (7) implies $d = d_A$ under A-authority and $d = d_P$ under P-authority. In contrast with the case where effort is not observable, the participation constraint may be binding. Indeed, if $p_H u_A(d_A) < c$, the participation

FIGURE 5

P-AUTHORITY AND LIMITED LIABLITY



constraint (4) must be binding whenever the contract obliges the agent to exert high effort. Accordingly, as in the situation without limited liability, the principal's expected payoff from a contract with $e = e_H$ is equal to the expected surplus

$$p_H[u_P(d_h) + u_A(d_h)] - c, \quad h \in \{P, A\}. \tag{14}$$

Using the same argument as for Observation 1 in Section 3, we thus obtain for the case of limited liability the following.[14]

Observation 2. Assume $p_H u_A(d_A) < c$. If effort is contractually fixed to $e = e_H$, then *A*-authority is uniquely optimal if and only if $k_A > k_P$.

We conclude this section by analyzing the projects and effort levels implemented by the optimal contract with noncontractible effort. To describe the project-effort combinations under the optimal contract, we define

$$\begin{aligned} \bar{c}_{IV} &\equiv (p_H - p_L)[1 - k_A(d_A - d_P)^2], \\ \bar{c}_V &\equiv (p_H - p_L)[(2p_H - p_L)(k_A + k_P) - p_H k_A k_P (d_A - d_P)^2]/[p_H(k_A + k_P)]. \end{aligned} \tag{15}$$

It is straightforward to show that $\bar{c}_{IV} < \bar{c}_V$ as depicted in Figure 5.

Proposition 5. With limited liability the optimal project-effort combination under *P*-authority has the following properties:

(i) If $c \leq \bar{c}_{IV}$, then d_P and e_H are implemented.
(ii) If $c \in (\bar{c}_{IV}, \bar{c}_V]$, then some $d \in (d_P, d^*]$ and e_H are implemented.
(iii) If $c > \bar{c}_V$, then d_P and e_L are implemented.

Because the principal's *ex ante* and *ex post* interests are aligned, he simply trades off higher effort against higher wage payments. If the effort cost is very small (part (i)), the agent will provide high effort even if the bonus is small, and so the principal maximizes his payoff by choosing his

[14] The principal's expected payoff from a contract with $e = e_L$ is $p_L u_P(d_P)$, because $h = P$ is optimal when the participation constraint is not binding. Therefore, setting $e = e_H$ and $h = A$ is uniquely optimal whenever $p_H u_A(d_A) < c$, $p_H[u_P(d_A) + u_A(d_A)] - c > p_L u_P(d_P)$, and $k_A > k_P$. In our numerical example, this parameter constellation is equivalent to $0.8 < c < 1.2 - 0.8\ k_P$.

ideal project. In Figure 5, this is the case for parameter constellations in region $\mathcal{I}$. The principal chooses his ideal project also in region $\mathcal{III}$, which corresponds to part (iii) of the proposition. Here inducing high effort is not attractive for the principal because this would require a rather high bonus w_S. If costs are moderate (part (ii)), high effort is desirable. In principle, the principal could induce high effort along with his ideal project by paying a large bonus. Yet, in region $\mathcal{II}$ of Figure 5, it turns out that it is more profitable to provide effort incentives by paying a moderate bonus and selecting a project which is closer to the agent's ideal project.

5. An extension

■ In this section, we show that the main tenet of our analysis extends beyond our model's simplifications, which were indicated at the end of Section 2. We consider a more general specification of payoffs and performance measures and show that incentive considerations do not induce more delegation relative to our benchmark.

Let project-effort combination (d, e), with $e \in \{e_L, e_H\}$ and $d \in D$, generate the *expected* unverifiable gross benefits $v_P(d, e) \geq 0$ for the principal and $v_A(d, e) \geq 0$ for the agent. We assume that more effort on the part of the agent increases the expected gross benefits of both parties, that is,

$$v_P(d, e_H) > v_P(d, e_L), \quad v_A(d, e_H) > v_A(d, e_L) \quad \text{for all } d \in D. \tag{16}$$

Otherwise we impose no restrictions on the interaction between project and effort.

Although perfect observation of the agent's effort is precluded, we allow the principal to make his payment contingent on the realization of a publicly observable signal or performance measure $x_s \in \{x_1, \ldots, x_N\}$, which may result from monitoring the agent's effort. The probability of signal x_s occurring after the agent has chosen e is $p_s(e) > 0$, with $\sum_s p_s(e) = 1$. As is standard in the principal-agent literature, we assume that the Monotone Likelihood Ratio Property is satisfied so that

$$\frac{p_s(e_L)}{p_s(e_H)} > \frac{p_{s+1}(e_L)}{p_{s+1}(e_H)} \tag{17}$$

for all $s < N$. The agent's remuneration is $w = (w_1, \ldots, w_s, \ldots, w_N)$, where w_s is his wage in the event that signal x_s is observed. The *ex ante* expected payoffs of the principal and the agent are then

$$\begin{aligned} U_P(d, e, w) &\equiv v_P(d, e) - \sum\nolimits_s p_s(e) w_s, \\ U_A(d, e, w) &\equiv v_A(d, e) + \sum\nolimits_s p_s(e) w_s - c(e), \end{aligned} \tag{18}$$

where the agent's effort cost satisfies $c(e_H) = c > c(e_L) = 0$. Clearly, this framework contains the model of Section 2 as a special case.

The following result holds both without and with limited liability:

Proposition 6. If a contract with $h = P$ is optimal when effort is contracted upon, then a contract with $h = P$ is also optimal when effort is noncontractible.

When incentives matter because effort is not contractually specified, the principal will not become more inclined to delegate the choice of project to the agent. For the limited liability case this result follows immediately from Lemma 2, which remains valid for the specification of payoffs in (18). For the case without limited liability restrictions, the proof of Proposition 6 is based on two insights: first, under A-authority, any (d, e) that can be implemented with noncontractible effort, is also implementable when effort can be contractually specified. This means that noncontractibility cannot increase the principal's payoff under delegation. Second, if (d, e) can be implemented under P-authority when effort is contractually fixed, then the commitment effect enables the principal to replicate (d, e) by maintaining authority and providing effort incentives also when effort is not observable. Therefore, P-authority with noncontractible effort allows the principal to obtain at least the same payoff as in a situation where effort is contracted upon.

6. Conclusion

■ Organizational decisions affect the various members of the organization in different ways. Thus, when decisions are noncontractible, the allocation of decision rights becomes a central issue for optimal organizational design. In this article, we investigate how the allocation of the right to control organizational projects interacts with the incentives of an agent who has to work on these projects. When decisions are not contractible and the principal has the decision right, he lacks commitment not to opportunistically abuse his authority once the contract is signed. The main insight of this article is that the principal's commitment problem is less pronounced in the presence than in the absence of effort concerns. The reason is that when effort incentives matter, the principal takes the effect of his project choice on the agent's effort into account, leading him to choose less opportunistically. As a result, we find that the consideration of effort incentives makes the principal *less* likely to delegate the authority over projects to the agent relative to the case in which effort is contracted upon.

As noted in the Introduction, previous research has argued that delegation creates information revelation incentives when the agent possesses decision-relevant private information. This is so because delegation protects the agent from the principal's opportunism once the information is revealed. The commitment effect discussed in this article suggests that when the principal needs the agent to exert effort *ex post*, the principal can credibly promise not to abuse the information revealed even ifhe keeps authority. A full analysis of this issue is the subject of future research.

Appendix

■ We denote by

$$V(d, e) \equiv p(e)[u_P(d) + u_A(d)] - c(e) \tag{A1}$$

the expected surplus in the absence of limited liability constraints.

Proof of Proposition 1. Under A-authority, the agent always chooses project d_A. Hence, if the principal chooses w so that high effort is induced, he obtains $V(d_A, e_H) = p_H\,[2 - k_P(d_P - d_A)^2] - c$. If the principal induces low effort, he obtains $V(d_A, e_L) = p_L\,[2 - k_P(d_P - d_A)^2]$. Comparison of the two expressions yields that high effort is optimally implemented if and only if $c \leq \bar{c}_I$. *Q.E.D.*

Proof of Lemma 1. We first show that implementability implies the conditions of the lemma. Let (d, e_H) with $d > d_P$ be implementable under P-authority so that by (5) and (6)

$$U_A(d, e_H, w) \geq U_A(d, e_L, w), \tag{A2}$$

$$U_P(d, e_H, w) \geq U_P(d', \tilde{e}(d', w), w) \quad \text{for all } d' \in D. \tag{A3}$$

Because $d > d_P$ and U_P is increasing in e and decreasing in d, (A3) implies for $d' = d_P$ that $\tilde{e}(d_P, w) = e_L$. Using this in (A3) yields the second condition of Lemma 1. To see the first condition of Lemma 1, suppose to the contrary that it is violated. Then (A2) implies that $U_A(d, e_H, w) > U_A(d, e_L, w)$. Because $d > d_P$ and by continuity, this implies that there is an $\varepsilon > 0$ such that $\tilde{e}(d - \varepsilon, w) = e_H$. Because U_P is strictly decreasing in d, it follows that $U_P(d, e_H, w) < U_P(d - \varepsilon, \tilde{e}(d - \varepsilon, w), w)$, a contradiction to (A3).

To prove the converse, suppose the two conditions of Lemma 1 hold for $d > d_P$. We have to show (A2) and (A3). Equation (A2) is trivially implied by the first condition of Lemma 1. To see (A3), note that because $U_A(d, e_H, w) = U_A(d, e_L, w)$ and because the agent's effort incentive is strictly increasing in d, it follows that $\tilde{e}(d', w) = e_L$ for all $d' < d$ and $\tilde{e}(d', w) = e_H$ for all $d' \geq d$. The latter implies that (A3) holds for all $d' \geq d$ because U_P is decreasing in d. For $d' < d$, note that $U_P(d_P, e_L, w) > U_P(d', e_L, w)$. Hence, the second condition of Lemma 1 implies (A3) for all $d' < d$. *Q.E.D.*

Proof of Proposition 2. In the absence of limited liability restrictions, the principal's objective is to choose *(d,e)* so as to maximize *V(d,e)* subject to *(d,e)* being implementable under P-authority. We begin with three auxiliary steps.

Step 1. (d, e_H), $d > d_P$ is implementable under P-authority if and only if

$$\varphi(d) \equiv V(d, e_H) - p_L[u_P(d_P) + u_A(d)] \geq 0. \tag{A4}$$

Indeed, the first condition of Lemma 1 is equivalent to

$$(p_H - p_L)[u_A(d) + w_S - w_F] - c = 0, \tag{A5}$$

and the second condition of Lemma 1 is equivalent to

$$p_H u_P(d) - p_L u_P(d_P) - (p_H - p_L)(w_S - w_F) \geq 0. \tag{A6}$$

Inserting (A5) into (A6) gives $\varphi(d) \geq 0$, as desired.

Step 2. If (d, e_H) with $d > d_P$ is implementable under P-authority, implementing e_L under P-authority is strictly suboptimal. To see this, observe first that e_L can only be implemented along with $d = d_P$. Suppose to the contrary that $d' \neq d_P$ could be implemented along with e_L. Then the principal would *ex post* be better off by selecting d_p rather than d', violating the decision incentive constraint. Therefore, implementing e_L yields $V(d_P, e_L)$. Yet, because (d, e_H) with $d > d_P$ is implementable, Step 1 implies that

$$V(d, e_H) \geq p_L[u_P(d_P) + u_A(d)] > p_L[u_P(d_P) + u_A(d_P)] = V(d_P, e_L), \tag{A7}$$

where the second inequality holds, as $u_A(d) > u_A(d_P)$ for $d > d_P$. This completes Step 2.

Step 3. Implementing (d_P, e_H) is strictly suboptimal under P-authority. To see this, note first that if (d, e_H), $d > d_P$ is implementable, then (d, e_H) gives the principal a strictly higher payoff than (d_P, e_H). This is so because $V(\cdot, e_H)$ is strictly increasing in the range $d \in [d_P, d^*]$. Next, consider the case in which for all $d > d_P$, (d, e_H) is not implementable. By Step 1 it thus follows that $\varphi(d) < 0$ for all $d > d_P$. Now note that φ is strictly increasing in a small neighborhood around d_P. Hence $\varphi(d) < 0$ for all $d > d_P$ implies that $\varphi(d_P) < 0$. But this is equivalent to

$$V(d_P, e_H) < p_L[u_P(d_P) + u_A(d_P)] = V(d_P, e_L). \tag{A8}$$

Thus, implementing (d_P, e_L) is strictly better than implementing (d_P, e_H), and this completes Step 3.

Steps 1–3 imply that the principal optimally implements (d, e_H) for some $d > d_P$ if there is a $d' > d_P$ with $\varphi(d') \geq 0$, and he optimally implements (d_P, e_L) if $\varphi(d) < 0$ for all $d > d_P$. Now note that φ is strictly concave and that the first-order condition $\varphi'(d) = 0$ yields

$$d^0 \equiv \operatorname*{argmax}_{d \in D} \varphi(d) = \frac{p_H k_P\, d_P + (p_H - p_L)k_A\, d_A}{p_H k_P + (p_H - p_L)k_A}. \tag{A9}$$

Thus, $\varphi(d) < 0$ for all $d > d_P$ if and only if $\varphi(d^0) < 0$. A straightforward but tedious calculation reveals that $\varphi(d^0) < 0$ if and only if $c > \bar{c}_{III}$. This establishes part (iii) of Proposition 2.

If $\varphi(d^0) \geq 0$, then the principal optimally implements the decision d that maximizes $V(d, e_H)$ subject to $\varphi(d) \geq 0$. Hence, if $\varphi(d^*) \geq 0$, d^* is implemented. If $\varphi(d^*) < 0$, then we also have that $\varphi(d) < 0$ for all $d \geq d^*$. This is so because by (9) $d^0 < d^*$, which implies that φ is decreasing for all $d \geq d^*$. Hence, some $d \in (d_P, d^*)$ is implemented. A straightforward calculation delivers that $\varphi(d^*) \geq 0$ if and only if $c \leq \bar{c}_{II}$. This establishes parts (i) and (ii) of Proposition 2. *Q.E.D.*

Proof of Proposition 3. As for (i): recall the definition of d^0 in (A9). The proof of Proposition 2 implies that if c is strictly smaller than $\bar{c}_{III}$, then a decision $d > d^0$ together with e_H is implemented under P-authority and yields the principal the payoff $V(d, e_H)$. $d > d^0$ implies $V(d, e_H) > V(d^0, e_H)$. To establish (i), it is thus sufficient to show that $V(d^0, e_H)$ is weakly larger than $\max\{V(d_A, e_H), V(d_A, e_L)\}$, the principal's payoff under A-authority.

To demonstrate this, let $S(d) \equiv u_P(d) + u_A(d)$. We show below that $S(d^0) \geq S(d_A)$. Thus, $V(d^0, e_H) = p_H S(d^0) - c \geq p_H S(d_A) - c = V(d_A, e_H)$. Moreover, by the definition of $\bar{c}_{III}$ in the proof of Proposition 2, we have that $c < \bar{c}_{III}$ is equivalent to $\varphi(d^0) > 0$, or, $V(d^0, e_H) > p_L[u_P(d_P) + u_A(d^0)]$. Because $p_L[u_P(d_P) + u_A(d^0)] > p_L S(d^0)$, it follows that $V(d^0, e_H) > p_L S(d^0) \geq p_L S(d_A) = V(d_A, e_L)$, which is what we sought to prove.

To complete (i), we need to show that $S(d^0) \geq S(d_A)$. A tedious but standard calculation shows that

$$S(d^0) - S(d_A) = \frac{p_H k_P^2 (d_A - d_P)^2 [k_A(p_H - 2p_L) + k_P p_H]}{(p_H k_P + (p_H - p_L)k_A)^2} > 0, \tag{A10}$$

where the inequality holds by our assumption $(p_H - p_L)/p_L \geq 1$.

As for (ii): as is argued in the paragraph preceding Proposition 3, if $c > \bar{c}_{III}$ and $k_P > k_A$, then $c > \bar{c}_I$. Hence, Proposition 1 implies that (d_A, e_L) is implemented under A-authority. Proposition 2 implies that (d_P, e_L) is implemented under P-authority. Thus, we have to show that $V(d_P, e_L) > V(d_A, e_L)$. But this is a direct implication of $k_P > k_A$.

As for (iii): Because $c > \bar{c}_{III}$, Proposition 2 implies that (d_P, e_L) is implemented under P-authority, and the principal receives $V(d_P, e_L)$. Because $k_P < k_A$, we have that $S(d_P) < S(d_A)$. Thus, $V(d_P, e_L) = p_L S(d_P) < p_L S(d_A) \leq \max\{p_L S(d_A), p_H S(d_A) - c\}$. Because the last term equals the principal's payoff under A-authority, A-authority is uniquely optimal, and this completes the proof.

Proof of Lemma 2. As for (i): clearly, for any $d \in D$ and $w_S \geq 0$, $w_F \geq 0$, it holds that $U_A(d, e_L, w) \geq 0$. Thus, if the optimal contract implements low effort, then $w_S \geq 0$, $w_F \geq 0$ trivially implies the participation constraint (4). If the optimal contract implements high effort, then it follows from the effort incentive constraint that $U_A(d, e_H, w) \geq U_A(d, e_L, w)$. Because $U_A(d, e_L, w) \geq 0$, this implies (4).

As for (ii): by (i), (4) is never binding. So the principal's *ex ante* problem is: max $_{d,e,w}$ $U_P(d, e, w)$ subject to the effort incentive constraint (5), the decision incentive constraint (6) (for $h = P$), and the limited liability constraint (13). Call this problem $\mathcal{P}$. Now, let $(\bar{d}, \bar{e}, \bar{w})$ be a solution to the relaxed problem $\mathcal{P}'$: $\max_{d,e,w} U_P(d, e, w)$ subject to (5) and (13). Because the limited liability constraint (13) is independent of d and e, $(\bar{d}, \bar{e})$ satisfies

$$(\bar{d}, \bar{e}) \in \underset{(d,e)}{\operatorname{argmax}}\, U_P(d, e, \bar{w}) \quad \text{s.t. } (5). \tag{A11}$$

But this is precisely the decision incentive constraint (6). Thus, $(\bar{d}, \bar{e}, \bar{w})$ is also a solution to the problem $\mathcal{P}$ and hence (6) is redundant in $\mathcal{P}$. *Q.E.D.*

Proof of Proposition 4. We show that whatever is optimally implemented under A-authority, the principal can do strictly better under P-authority. Consider first implementing e_L under A-authority. Wages are then optimally set to $w_S = w_F = 0$. Because the agent selects d_A, the principal's payoff is $p_L u_P(d_A)$. If under P-authority wages are $w_S = w_F = 0$, the principal will select d_P, and the agent will choose e_L. This yields the principal the payoff $p_L u_P(d_P) > p_L u_P(d_A)$. So implementing e_L under A-authority is strictly dominated by implementing e_L under P-authority.

Consider next implementing e_H. In this case, it is optimal to set $w_F = 0$ because the agent's participation constraint is not binding. By Lemma 2, under P-authority the decision incentive constraint (6) is also not binding so that the principal's problem reduces to

$$\max_{(d, w_S)} \; p_H[u_P(d) - w_S] \quad \text{s.t. } p_H[u_A(d) + w_S] - c \geq p_L[u_A(d) + w_S], \tag{A12}$$

and $w_S \geq 0$. Because under A-authority the principal faces the additional decision incentive constraint $d = d_A$, P-authority at least weakly yields him a higher payoff than A-authority.

To complete the proof, we show that implementing (d_A, e_H) is not optimal under P-authority. Let (d, w_S) solve problem (A12). Then there exists a multiplier $\mu \geq 0$ for the constraint in (A12) such that (d, w_S) satisfies the first-order conditions

$$p_H u'_P(d) + \mu(p_H - p_L)u'_A(d) = 0, \quad -p_H + \mu(p_H - p_L) \leq 0, \tag{A13}$$

with the equality holding in the second condition if $w_S > 0$. Combining these conditions implies $u'_P(d) + u'_A(d) \geq 0$. Because $u_P(d) + u_A(d)$ is strictly concave and has its maximum at d^* this proves that $d \leq d^* < d_A$. *Q.E.D.*

Proof of Proposition 5. If implementing e_L is optimal, the principal is only constrained by the limited liability constraint (13). Therefore, $w_S = w_F = 0$ and $d = d_P$. Thus the principal's expected payoff is $p_L u_P(d_P)$.

Now consider the case where e_H is implemented. By Lemma 2, the principal is constrained only by the effort incentive constraint (5) and the limited liability constraint (13). His problem is thus to choose d and w to maximize

$$p_H[u_P(d) - w_S] - (1 - p_H)w_F \tag{A14}$$

subject to

$$(p_H - p_L)[u_A(d) + w_S - w_F] \geq c, \tag{A15}$$

and $w_S \geq 0$, $w_F \geq 0$. Obviously, the solution satisfies $w_F = 0$.

If (A15) is not binding, then the solution is $d = d_P$ and $w_S = 0$. Thus (A15) is indeed not binding if $c \leq (p_H - p_L)$ $u_A(d_P)$, which by the definition of $\bar{c}_{IV}$ in (15) is equivalent to $c \leq \bar{c}_{IV}$. Because the solution satisfies $p_H u_P(d) > p_L u_P(d_P)$, implementing e_H is optimal. This proves claim (i).

If $c > \bar{c}_{IV}$, then (A15) is binding. Thus, there is a $\mu > 0$ such that the solution (d, w_S) satisfies the first-order conditions

$$p_H u'_P(d) + \mu(p_H - p_L)u'_A(d) = 0, \quad -p_H + \mu(p_H - p_L) \leq 0, \tag{A16}$$

with the equality holding in the second condition when $w_S > 0$. First, consider the case where $w_S = 0$. Then combining the two conditions in (A16) and using the fact that (A15) is binding yields

$$u'_P(d) + u'_A(d) \geq 0 \quad \text{and} \quad (p_H - p_L)u_A(d) = c. \tag{A17}$$

The first inequality implies $d \leq d^*$. Because $u'_A(d) > 0$ for all $d < d^*$, we have $p_H u'_P(d) < 0$ by (A16). Therefore $d > d_P$. Now consider the case where $w_S > 0$. Then (A15) and (A16) imply

$$u'_P(d) + u'_A(d) = 0 \quad \text{and} \quad (p_H - p_L)u_A(d) < c, \tag{A18}$$

and so $d = d^*$.

The above arguments show that for $c \in (\bar{c}_{IV}, (p_H - p_L)u_A(d^*))$, the principal implements some $d \in (d_P, d^*)$ and pays $w_S = 0$ so that his payoff is $p_H u_P(d)$. We have

$$p_H u_P(d) - p_L u_P(d_P) > p_H u_P(d^*) - p_L u_P(d_P), \tag{A19}$$

because $d \in (d_P, d^*)$. Further, by (1) and (9),

$$p_H u_P(d^*) - p_L u_P(d_P) = \frac{(p_H - p_L)(k_P + k_A)^2 - p_H k_A^2 k_P (d_A - d_P)^2}{(k_P + k_A)^2}$$
$$> \frac{(p_H - p_L)(k_P + k_A)^2 - p_H k_A k_P}{(k_P + k_A)^2} \geq p_H \frac{(k_P + k_A)^2 - 2k_A k_P}{2(k_P + k_A)^2} > 0, \quad \text{(A20)}$$

where the first inequality holds because $k_A < 1$ and $(d_A - d_P)^2 \leq 1$, and the second inequality holds because $2\ p_L \leq p_H$. By (A19) and (A20), $p_H u_P(d) > p_L u_P(d_P)$. Thus for $c \in (\bar{c}_{IV}, (p_H - p_L)u_A(d^*))$, the principal optimally implements effort e_H.

For $c > (p_H - p_L)\ u_A(d^*)$, the solution of (A14) and (A15) satisfies $d = d^*$ and $(p_H - p_L)[u_A(d^*) + w_S] = c$. Therefore implementing e_H rather than e_L is optimal as long as

$$p_H[u_P(d^*) - w_S] = p_H[u_P(d^*) + u_A(d^*)] - \frac{p_H}{p_H - p_L} c \geq p_L u_P(d_P). \quad \text{(A21)}$$

By (1) and (15), this condition is equivalent to $c \leq \bar{c}_V$. This proves claim (ii). Finally, claim (iii) follows from the fact that for $c > \bar{c}_V$ implementing e_L is optimal, which implies that $d = d_P$. *Q.E.D.*

Proof of Proposition 6. First consider the case without limited liability. Recall that, by the argument in the beginning of Section 3, the participation constraint can be substituted into the principal's objective function so that his problem becomes to maximize $v_P(d, e) + v_A(d, e) - c(e)$ subject to the decision incentive constraint and, in the case of noncontractible effort, the effort incentive constraint. Let (d', e', w') solve the principal's problem for noncontractible effort under A-authority. Then by (5) and (6),

$$(d', e') \in \operatorname*{argmax}_{d,e} U_A(d, e, w'). \quad \text{(A22)}$$

Obviously, the principal can also implement (d', e') under A-authority if effort is contracted upon simply by setting $e = e'$, and $w = w'$. Indeed, the decision incentive constraint (7) is satisfied because by (A22) d' maximizes $U_A(d, e', w')$. This proves that under A-authority the principal can achieve at least the same payoff when effort can be contractually fixed as with noncontractible effort.

Now let (d', e') be implemented under P-authority when effort is contracted upon. Then by (7),

$$d' \in \operatorname*{argmax}_{d}\ v_P(d, e'). \quad \text{(A23)}$$

Independently of whether $e' = e_L$ or $e' = e_H$, assumption (17) guarantees that there is a w such that

$$e' = \tilde{e}(d, w) \equiv \operatorname*{argmax}_{e \in \{e_L, e_H\}} U_A(d, e, w) \quad \text{for all } d \in D. \quad \text{(A24)}$$

By (A23) this implies

$$d' \in \operatorname*{argmax}_{d}\ v_P(d, e') = \operatorname*{argmax}_{d}\ v_P(d, \tilde{e}(d, w)) = \operatorname*{argmax}_{d}\ U_P(d, \tilde{e}(d, w), w). \quad \text{(A25)}$$

By (A24) and (A25), (d', e') satisfies the constraints (5) and (6) so that it can be implemented also under P-authority with noncontractible effort. This proves that under P-authority the principal can achieve at least the same payoff with noncontractible effort as in the case when effort is contractually fixed.

We have thus shown that noncontractibility of effort (weakly) reduces the principal's payoff under A-authority, whereas it (weakly) increases his payoff under P-authority. This proves the proposition for the case without limited liability.

To complete the proof, consider the case with limited liability. In this case, the argument of Lemma 2 applies also to the specification of payoffs in (18). Because the principal has to satisfy the decision incentive constraint only under A-authority, P-authority always gives him at least the same payoff. Therefore, P-authority is always optimal with limited liability and noncontractible effort. *Q.E.D.*

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