Authority and motivation in situations of open conflict[☆]

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Abstract

We study the allocation of the authority to select a project in a principal–agent–model with non–transferable utility where the implementation of the project requires effort by the principal and the agent. Although it is common knowledge that the two players prefer the implementation of different projects, each player is privately informed about his flexibility. The principal wants the agent to compromise on the project choice whenever he is flexible, but delegation of the project choice comes along with a discouraging effect. The organization of work on the project affects the players' willingness to compromise and their motivation. If the agent provides effort first and the principal finalizes the project, delegation is only optimal when the principal is flexible with an intermediate probability. If the principal can design the organization of work, delegation is generally optimal despite the open conflict.

Keywords: Authority; Delegation; Motivation; Signaling; Common interest; Conflict of interest; Asymmetric information; No monetary transfers

JEL Classification: D23, D82, L22, M54

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1. Introduction

In a principal-agent relationship, it is often no secret that the two parties have conflicting interests about the direction of a common project. Yet, although it may be clear that the principal and the agent would like different projects to be implemented, the extent of their conflict may be unclear. In such a context, the allocation of the authority to select a project will have a crucial effect on each partner's motivation to provide effort. We are interested in the interaction between authority and motivation when effort provision by the principal and by the agent are both essential for the project's success and when the use of monetary incentives is either not feasible or not desirable. More specifically, we are interested in who should decide on which project to pursue, in how this is affected by the organization of work on the project, and in how the work on the selected project should be optimally organized.

As an example, think of a division manager and an engineer who can develop a product together. The engineer prefers a more innovative product which allows him to better signal his technical skills, whereas the manager prefers a less innovative product which is more profitable as it saves on development costs and can be constructed from standard components. Essential for the success of the project is a design for which both are motivated to work for.[1] Other examples include the partnership between a thesis advisor and a student, an editor and a researcher, a manager and a subordinate, a politician and a public servant, and so on. In all of these examples, the work on the project may be organized differently. For instance, the student might first do the basic work on the project before his advisor finalizes it. Or a manager might plan a strategic decision and leave its execution to his subordinate. Moreover, for some of the examples a specific organization of work is for exogenous reasons given, whereas it arises through an endogenous choice in others.

This article sheds light on how different exogenously given ways of organizing the work on a common project will affect both the project choice and the motivation of the involved parties. We show that not only the authority over project selection matters for the overall outcome, but also the mode of effort provision, as for instance the sequencing of effort provision.[2] For the case where no specific organization of work is for exogenous reasons required, we derive the optimal endogenous organization of work.

In the first part of this article, we use a simple base model with binary effort decisions and binary information to explain the crucial effects. There are two projects, p and a, and it is common knowledge that the principal prefers the implementation of project p, whereas the agent prefers the implementation of project a. The principal is however uncertain about how much the agent likes project p and the agent is uncertain about how much the principal likes project a. The selected project gets implemented if both players provide effort and it fails otherwise. Ex ante, the principal decides who has the authority to select a project and possibly how the work on the project will be organized. Afterwards, each partner learns whether he is flexible in the project choice or not and a project is selected. Finally, both partners can provide effort in an "effort provision game". To convey the basic trade–offs, it suffices—as we will show in the second part of this article—to consider simple stylized effort provision games in which one partner decides on effort first and the other partner decides on effort after observing his partner's decision.

[1] See Dessein et al. (2010) for a problem which is related to this example but which has a different focus.

[2] The sequence of effort provision is only one aspect we discuss. Other aspects of the mode of effort provision are discussed in Subsection 7.1 of our article.

What are the effects implied by the authority decision? On the one hand, delegation leads to a loss of control and it may have a discouraging effect if the effort provision game is such that the agent may waste effort, as it is for instance the case when the agent decides on effort first. The discouraging effect arises as follows: When the agent decides on effort after having chosen project a himself, he is uncertain about whether the principal is also willing to provide effort. He must thus fear that his effort will be wasted. By contrast, project selection by the principal comes along with a signaling effect which takes the fear of wasting effort away from the agent. The agent's motivation to provide effort for project a is thus stronger when this project was selected by the principal than when it was chosen by himself. On the other hand, the principal wants project p to be selected whenever the agent is flexible in the project choice and that project a is only selected if no other compromise can be reached. As this project selection behavior depends on the agent's private information, the principal may also have an incentive to delegate the project choice in order to use the agent's information.

What is the role of the effort provision game? When the agent decides on effort last instead of first, the discouraging effect of delegation disappears and the agent's motivation to provide effort improves. However, the disappearance of the discouraging effect of delegation makes it also relatively more attractive for the agent to choose project a instead of p. Therefore the stronger motivation comes along with a lower willingness to compromise on the project choice. It is thus a priori also unclear whether the principal prefers an effort provision game which induces a stronger or a weaker discouraging effect of delegation.

Our main finding is that the optimal authority decision and possibly also the choice of the effort provision game is driven by the strength of the discouraging effect of delegation when the agent decides on effort first. If this effect is of intermediate strength, delegating the project choice plus the agent providing effort first achieves always the best possible outcome for the principal. Otherwise, the principal benefits from choosing an effort provision game which induces a "discouraging effect of delegation with the right strength". This might entail undertaking measures which make this effect weaker (e.g., by sometimes warning the agent that he is about to waste effort) or stronger (e.g., by employing instruments which sometimes cause the failure of a mutually beneficial project). If the agent is not restricted in the design of the effort provision game, delegation is generally optimal despite the open conflict. If an effort provision game which induces a discouraging effect of delegation with the right strength is for exogenous reasons not feasible, it is optimal for the principal to retain control over the project choice.

The first part of this article is organized as follows: After discussing the related literature in the next section, we introduce our base model in Section 3 and we discuss the full information benchmark in Section 4. Subsequently, we analyze in Sections 5 and 6 the optimal allocation of authority for the case in which the principal decides on effort last, for the case in which the sequence of effort provision is for exogenous reasons reversed, and for the case in which the sequence is endogenously determined by the principal. This gives us a basic understanding of when the principal wants to stay in control and of when he wants to have an effort provision game which implies that delegation has a discouraging effect. The role of the second part of this article (Sections 7 and 8) is to explain why the results in the first part are robust (more general effort provision games, cheap talk communication, informed principal problem) and to demonstrate how they extend to more complicated environments (continuous effort, continuous information). We conclude in Section 9. All proofs are relegated to the Appendix.

2. Literature

Our delegation problem with two–sided effort provision after project selection is related to several strands of literature which study the allocation of decision rights and the optimal way to delegate decisions.

No effort provision. There exists an extensive literature on the optimal delegation of a decision to a systematically biased agent who is in possession of information which is payoff–relevant to the principal (see, e.g., Holmström 1984, Melumad and Shibano 1991, Dessein 2002, Martimort and Semenov 2006, Alonso and Matouschek 2008, Amador and Bagwell 2013). This literature is concerned with how to restrict the agent's discretion in order to utilize his information optimally. Motivational issues play no role. Although the agent in our model is also systematically biased, he is not in possession of any information which is directly payoff–relevant for the principal. The only reason for delegation is to induce effort by the agent. Although the principal has an indirect interest in the agent's private information through its effect on his motivation, restricting the set of admissible projects is in our setting not a useful instrument to affect the project selection behavior under delegation. Instead, the choice of the mode of effort provision can serve as such an instrument.

Effort provision before project selection. In their seminal article on formal authority (the right to decide) and real authority (the effective control over decisions), Aghion and Tirole (1997) study the interaction between authority and motivation. A principal and an agent can both provide effort to acquire information before a project is selected. The sequence of project selection and effort provision thus is reversed compared to our article and the effort decisions are strategic substitutes instead of complements. As a consequence, the implied effects differ crucially from those in our article: Delegation of the project choice has a motivating effect and communication at the project selection stage can have an important impact on the project selection behavior.[3]

One–sided effort provision after project selection. Furthermore, there is a literature in which the probability with which the selected project is successful depends on one–sided effort by the agent and in which effort and the "right" project selection are complementary. In Van den Steen (2006), an open conflict exists in the sense that principal and agent have different priors about the state of the world. As this implies that the agent believes that he is able to take better decisions than the principal, delegation has a motivating effect.[4] Landier et al. (2009) take the perspective of a third party (the organization) and explore the role of dissent between a decision–maker and an implementer. Decision–maker and implementer have intrinsic and possibly differing preferences over projects but share an interest in the project's success. The decision–maker anticipates the effect of his project choice on the implementer's motivation. If there is dissent, this can prevent the decision–maker from following his intrinsic bias and to choose the project which is more likely to be right. That is, dissent has a disciplining effect which improves the implementer's motivation to provide effort and can render a dissenting organization optimal.[5] Our model differs from this literature in

[3] Marino et al. (2010) extend the study of formal and real authority by introducing limits to authority which arise through ineffective enforcement. The agent can disobey the principal's orders at the project selection stage and the principal can punish a disobeying agent by dismissing him. Szalay (2005) introduces one–sided information acquisition by the agent in an optimal delegation problem. See also Section 3.1 in Armstrong and Vickers (2010).

[4] See also Van den Steen (2009).

[5] For the version of the model in which the decision–maker has no private information about what is the right project, the analysis in Landier et al. (2009) can also be interpreted in terms of the optimal allocation of authority. A homogeneous (resp.

two important respects. First, the nature of the projects differs. There is no objectively "right" project in our article. The difference in projects is just a matter of taste. Second, the success of the project relies on effort provision by both players. This implies different effects as each player internalizes the effect of project selection on the other player's motivation. That is, delegation and non–delegation both have a disciplining effect.

Bénabou and Tirole (2003) study the interplay between intrinsic and extrinsic motivation in a setting with an agent with imperfect self–knowledge and an informed principal. The principal's decision to delegate can signal confidence in the agent's ability and thus have a motivating effect. By contrast, in our model, a motivating signaling effect arises under non–delegation. The absence of this signaling effect under delegation implies that delegation is associated with a discouraging effect which even prevails if we consider the informed principal version of our model, as we argue in our robustness section.

One–sided implementation decision after project selection. Aghion et al. (2004) consider the allocation of decision rights for a problem with two particular features: First, after the project is selected, the principal can decide between implementing it and stopping it at "intermediate payoffs".[6] Second, the principal's optimal implementation decision depends directly on the agent's type and the agent is already informed about his type at the time the decision rights are allocated. They show that learning about the agent's type might take place in a drastically different way when decision rights are contractible (i.e., when the allocation of decision rights can be message contingent) and when decision rights are simply transferable. Besides the difference in focus, Aghion et al. abstract from a motivational problem on the agent's side.

Authority, motivation and monetary incentives. Zabojnik (2002) and Bester and Krähmer (2008) study the interaction between authority and the agent's motivation to exert implementation effort when monetary incentives are feasible. Contracts can specify monetary transfers which condition on performance but not on project selection.[7] The results depend strongly on the specifics of the considered framework.[8] In our model, we are interested in situations in which it is either not desirable or for exogenous reasons not possible to set monetary incentives. Instead, implementation requires two–sided effort and the mode of effort provision can to a certain extent be used as an instrument to manipulate incentives. This instrument has however a different flavor compared to monetary incentives as utility stays non–transferable.

heterogeneous) organization corresponds then to delegation of the implementation task to the decision–maker (resp. to an agent). Roughly speaking, they are interested in the case where the principal always selects a project but its execution can be delegated to the agent, whereas we are interested in the case where the agent is always needed for the project's execution but project selection can be delegated to the agent.

[6] See also Bester and Krähmer (2013). They introduce an exit option in a delegation problem with monetary incentives. Although the exit option is an endogenous variable, it resembles the implementation decision in Aghion et al. (2004).

[7] See Melumad and Reichelstein (1987) for the case in which project selection is contractible.

[8] Zabojnik (2002) considers a problem in which principal and agent possess independent information about what is the right project and in which the agent's implementation effort and the quality of decision–making are complementary. He shows that delegation might allow the principal to save on high–powered incentives when the agent is protected by limited liability. Delegation can thus be optimal even if the principal is better informed than the agent. See also Vidal and Möller (2013) for a mechanism design approach to project selection for a related setting with two–sided effort and contractible project selection. Bester and Krähmer (2008) consider a problem without asymmetric information. Projects differ in the private benefits that they generate in case of success and the agent can increase the success probability by exerting implementation effort. They show that the need to motivate the agent makes the principal less willing to delegate. When the agent is protected by limited liability, delegation is generally suboptimal.

3. The base model

We introduce in this section a simple base model which we later on extend into several directions. There is a principal P and an agent A who can conduct a project $k \in \{a, p\}$ together. The success of the project depends on the effort decision of the principal, $e_P \in \{0, 1\}$, and of the agent, $e_A \in \{0, 1\}$. If both players provide effort ($e_A = e_P = 1$), the selected project is implemented/successful, otherwise it fails. It is common knowledge that the principal prefers the implementation of project p whereas the agent prefers the implementation of project a. Each player is privately informed about how much he dislikes the project which the other player prefers to be implemented. First, we consider the case in which the principal decides ex ante on who has the authority to select a project and he provides effort last after observing the agent's effort choice. This corresponds to situations in which the agent is a subordinate who prepares a project which then has only to be finalized by the principal. Later on, we will also endogenize the sequencing and, more generally, the mode of effort provision.

We denote a generic player by i and his partner by $-i$. Furthermore, we denote the project which player i prefers to be implemented by $k^*(i)$. That is, $k^*(A) = a$ and $k^*(P) = p$. Player i realizes a value $B_i > 0$ from the implementation of project $k^*(i)$ whereas he realizes only a value $\alpha_i^{s_i} B_i$ with $\alpha_i^{s_i} \in (0, 1)$ from the implementation of project $k^*(-i)$. By providing effort, player i incurs a cost $c_i B_i$ with $c_i \in (0, 1)$. His payoff is thus $\pi_i = e_i(e_{-i} \cdot 1 - c_i)B_i$ if $k = k^*(i)$ and $\pi_i = e_i(e_{-i}\alpha_i^{s_i} - c_i)B_i$ if $k = k^*(-i)$. As only the proportions c_i and $\alpha_i^{s_i}$ matter for the analysis, we can without loss of generality apply the normalization $B_i = 1$. The parameter $s_i \in \{L, H\}$ is player i's private information. We assume $\alpha_i^L < c_i < \alpha_i^H$. That is, player i always obtains a positive payoff from the implementation of project $k^*(i)$, whereas it depends on his private information whether this is also the case for project $k^*(-i)$. We say player i likes (resp. dislikes) project $k^*(-i)$ if $s_i = H$ (resp. $s_i = L$). Analogously, we will say that player i always likes project $k^*(i)$. The parameters s_A and s_P are independently distributed with $\text{Prob}\{s_i = H\} = q_i \in (0, 1)$. q_i can be interpreted as the probability with which player i likes the project which the other player prefers to be implemented.

The timing of the game is as follows:

(1) *Authority decision.* The principal chooses which player $j \in \{A, P\}$ has the authority to select a project. We will refer to the resulting subgame as j–authority.

(2) *Project selection.* Each player i learns his private signal $s_i \in \{L, H\}$. Player j selects a project $k \in \{a, p\}$ and announces it to the other player.

(3) *Effort provision game.* The effort provision game is played. For the time being, this means that the agent first chooses $e_A \in \{0, 1\}$ and that the principal then chooses $e_P \in \{0, 1\}$ after observing e_A.

We employ the notion of Perfect Bayesian Equilibrium and denote the probability with which player i is believed to have signal $s_i = H$ after the project selection stage by $\mu_i \in [0, 1]$.[9]

Each play of the game ends in one of five possible outcomes $\omega \in \Omega := \{a, p, \emptyset, \emptyset_A, \emptyset_P\}$. Outcome $\omega = a$ (resp. $\omega = p$) describes the case in which project $k = a$ (resp. $k = p$) is implemented. Outcome $\omega = \emptyset_A$

[9]Although we do not introduce a specific notation for mixing behavior, we of course allow for it. For generic parameter values, optimal behavior does not rely on mixing. We will state our results only for such generic parameter values as the mixing behavior that may arise in the non–generic case provides no additional insights.

(resp. $\omega = \emptyset_P$) describes the case in which the project fails although player A (resp. player P) provides effort. Outcome $\omega = \emptyset$ describes the case in which the project fails and neither of the two players provides effort. Each player i's payoff is completely determined by the outcome of the game and his private signal. We denote this payoff by $\pi_i(\omega, s_i)$. Player i's interim preferences over outcomes are then as follows:

$$\pi_i(\emptyset_i, s_L) < \pi_i(k^*(-i), s_L) < \pi_i(\emptyset_{-i}, s_L) = \pi_i(\emptyset, s_L) = 0 < \pi_i(k^*(i), s_L) \tag{1}$$

$$\pi_i(\emptyset_i, s_H) < \pi_i(\emptyset_{-i}, s_H) = \pi_i(\emptyset, s_H) = 0 < \pi_i(k^*(-i), s_H) < \pi_i(k^*(i), s_H) \tag{2}$$

An easy way to describe all payoff–relevant information that is associated with a certain play of the game is to describe which outcome arises as a function of the players' private information, $\omega(s_P, s_A)$.

4. The full information benchmark and the role of asymmetric information

Consider first the benchmark case in which principal and agent both learn the two signals s_P and s_A at the project selection stage. The behavior in the effort provision game is then straightforward. Both players provide effort if and only if they both obtain a positive payoff from the implementation of the selected project.[10] Hence, at the project selection stage, both players want to coordinate on a project which they both like sufficiently much. If $s_A \neq s_P$, principal and agent have a *common interest* as there is a single project on which coordination is possible. Whoever has the authority to choose the project will select this project. If $s_A = s_P = L$, the project choice does not matter as no project has a chance of being implemented. However, if $s_A = s_P = H$, principal and agent face a *conflict of interest* because whatever project is chosen will be implemented. The player who has the authority to select the project will resolve this conflict in his own interest. Because the resolution of this conflict is the only difference between A–authority and P–authority, P–authority is clearly optimal for the principal under full information.

If a player's signal is his private information instead, two things change. First, the project selection behavior is affected and coordination failure may occur. The player i who selects the project is in this case uncertain about whether there is a common interest or a conflict of interest when $s_i = H$. This implies that he is no longer able to make just as many compromises on the project choice as he needs to make. That is, he can no longer choose the project which he prefers to be implemented when $s_{-i} = H$ and compromise on the project choice when $s_{-i} = L$. He has to decide between compromising either in both cases or in none of them. The former implies the project selection behavior preferred by player $-i$, whereas the latter implies that sometimes a coordination failure occurs (i.e, the implementation of the selected project would not generate a positive payoff for both players although a project exists that would achieve this). Second, motivational problems may arise. The fear that the principal does not like the selected project makes it less attractive for the agent to provide effort in the first place. It may thus happen that the selected project is not implemented although its implementation would generate a positive payoff for both players. The two differences under asymmetric information make it a priori unclear which authority structure is optimal for the principal.

[10] Suppose project k is selected. If the agent provides effort, the principal will provide effort as well if $\pi_P(k, s_P) > 0$ and he will not provide effort otherwise. As the agent knows the principal's willingness to provide effort, it is optimal for him to provide effort if $\pi(k, s_A) > 0$ and $\pi(k, s_P) > 0$.

	$s_A = L$	$s_A = H$
$s_P = L$	none	p
$s_P = H$	a	a and p

(a) Potentially implementable projects

	$s_A = L$	$s_A = H$
$s_P = L$	$\emptyset$ or $\emptyset_A$	p
$s_P = H$	a	p

(b) Best possible outcome for the principal

Table 1: Benchmark cases

5. Optimal allocation of authority when the principal decides on effort last

Even though there is asymmetric information, at the time of effort choice, each player knows the payoff that he obtains if the selected project gets implemented. As each player can ensure himself a zero payoff by not providing effort, only projects which generate a positive payoff for both players have a chance of getting implemented. We call such projects potentially implementable. Project a is potentially implementable if $s_P = H$ and project p is potentially implementable if $s_A = H$. See Table 1a. When we take into account that an outcome $k \in \{a, p\}$ cannot occur when project k is not potentially implementable, we obtain from (1) and (2) an upper bound on the principal's payoff for any given (s_P, s_A). The best that can happen for the principal is that the outcome is p if $s_A = H$, that it is a if $s_A = L$ and $s_P = H$, and that he does not waste effort if $s_A = L$ and $s_P = L$. We will henceforth refer to this as the best possible outcome for the principal. See Table 1b.

At issue is now whether the principal prefers the outcomes implied by P–authority or those implied by A–authority. Important for this is how the authority decision affects the agent's motivation to provide effort. As the choice of a project by the principal signals that the principal likes the selected project, the agent's incentive to provide effort is at least weakly larger under P–authority.

Lemma 1 (Discouraging effect of delegation) *(a) Suppose project $k = a$ is selected. Then the agent believes to get an expected payoff from providing effort which is strictly smaller when the project was selected under A–authority than when it was selected under P–authority. (b) If project $k = p$ is selected, then the agent believes to get the same expected payoff from providing effort under both authority structures.*

On the one hand, the discouraging effect of delegation speaks in favor of P–authority. The principal stays in control of the project choice, and the agent's incentive to provide effort is larger for any given project. On the other hand, the best possible outcome for the principal may only be obtained under A–authority as it requires a project selection behavior which depends on the agent's private information (see Table 1b). However, the best possible outcome for the principal is only actually obtained if the agent is willing to compromise on the project choice when $s_A = H$ and if he is willing to provide effort for project a despite the discouraging effect of delegation.

Proposition 1 *Consider A–authority. If $q_P \in (c_A, \alpha_A^H)$, the best possible outcome for the principal is obtained. If $q_P \in (\alpha_A^H, 1)$, the best possible outcome for the principal is not obtained because the agent makes too little compromises on the project choice. If $q_P \in (0, c_A)$, the best possible outcome for the principal is not obtained because the agent provides too little effort. Table 2 summarizes the outcomes implied by A–authority.*

The intuition for the result is the following: The strength of the discouraging effect of delegation is determined by how much the agent fears that the principal dislikes project a. The lower q_P, the stronger is

	$s_A = L$	$s_A = H$
$s_P = L$	$\emptyset$	p
$s_P = H$	$\emptyset$	p

(a) A too little effort problem arises $[q_P < c_A]$

	$s_A = L$	$s_A = H$
$s_P = L$	$\emptyset_A$	p
$s_P = H$	a	p

(b) The best possible outcome for the principal is obtained $[c_A < q_P < \alpha_A^H]$

	$s_A = L$	$s_A = H$
$s_P = L$	$\emptyset_A$	$\emptyset_A$
$s_P = H$	a	a

(c) A too little compromise problem arises $[\alpha_A^H < q_P]$

Table 2: Outcomes implied by A–authority

	$s_A = L$	$s_A = H$
$s_P = L$	$\emptyset$	p
$s_P = H$	a	a

(a) Probability that the agent likes project p is low $[q_A < (\alpha_P^H - c_P)/(1 - c_P)]$

	$s_A = L$	$s_A = H$
$s_P = L$	$\emptyset$	p
$s_P = H$	$\emptyset$	p

(b) Probability that the agent likes project p is high $[q_A > (\alpha_P^H - c_P)/(1 - c_P)]$

Table 3: Outcomes implied by P–authority

the discouraging effect. The strength of this effect determines whether the agent is willing to compromise on the project choice when $s_A = H$ and whether he is willing to provide effort for project a, the only project which is potentially implementable if $s_A = L$. On the one hand, a stronger discouraging effect of delegation makes choosing project p relatively more attractive to the agent as it reduces only the expected payoff he believes to get from project a. If this effect is too weak ($q_P > \alpha_A^H$), the agent is not willing to compromise on the project choice. He then always chooses project a. See Table 2c. On the other hand, if the discouraging effect of delegation is too strong ($q_P < c_A$), the agent is willing to compromise on the project choice when $s_A = H$, but he is not willing to provide effort for project a when $s_A = L$. See Table 2a. When the strength of the discouraging effect of delegation is however intermediate ($c_A < q_P < \alpha_A^H$), the agent is at the same time willing to compromise on the project choice when $s_A = H$ and willing to provide effort for project a. The best possible outcome for the principal is then obtained. See Table 2b.

The question remains which authority structure the principal prefers when A–authority does not imply the best possible outcome for him.

Proposition 2 *(a) If $q_P \in (c_A, \alpha_A^H)$, A–authority is strictly optimal for the principal. (b) If $q_P \in (0, c_A)$ or if $q_P \in (\alpha_A^H, 1)$, P–authority is at least weakly optimal for the principal. It is strictly optimal if either $q_P > \alpha_A^H$ or $q_A < (\alpha_P^H - c_P)/(1 - c_P)$.*

Because only A–authority may lead to the best possible outcome for the principal, A–authority is strictly optimal when it induces this outcome. This is the case when $q_P \in (c_A, \alpha_A^H)$. If the agent is not willing to compromise on the project choice ($q_P \in (\alpha_A^H, 1)$) or if he is not willing to provide effort for project a ($q_P \in (0, c_A)$), there is only a single project which gets implemented under A–authority (see Tables 2a and 2c). As the principal could also choose this project under P–authority and would thereby avoid the discouraging effect of delegation, P–authority must be at least weakly better for him. See Figure 1a for an illustration of Proposition 2.

Although we have already explained under which conditions P–authority is optimal, we have not discussed yet which behavior P–authority implies.[11] This behavior differs structurally from that implied by

[11] A formal derivation of this behavior is given in the last paragraph of the proof to Proposition 2.

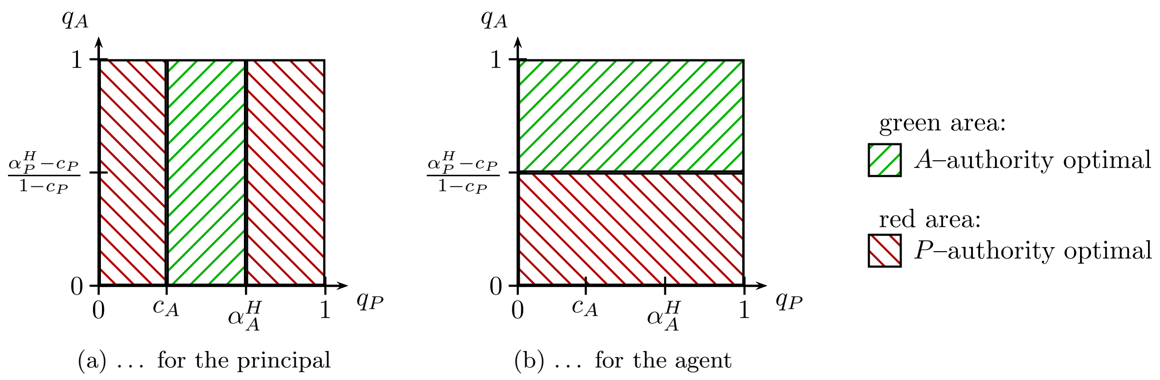


Figure 1: Optimal allocation of authority [$c_A = c_P = 0.3$, $\alpha_A^H = \alpha_P^H = 0.65$]

A–authority. The reason is that the principal does not have to fear to waste effort as he knows the agent's effort decision already when he decides on effort himself. If it is relatively likely that the agent likes project p ($q_A \in ((\alpha_P^H - c_P)/(1-c_P), 1)$), the principal is not willing to compromise on the project choice. He always chooses project p and this project gets implemented whenever the agent likes this project. See Table 3b. If it is relatively unlikely that the agent likes project p ($q_A \in (0, \alpha_P^H - c_P)/(1-c_P))$), the principal is willing to compromise on the project choice whenever $s_P = H$. As there is no motivational problem under P-authority, this implies that the best possible outcome for the agent is induced. See Table 3a.

As a by–product of this discussion, we learn also which allocation of authority the agent prefers: As P–authority implies the best possible outcome for the agent if q_A is small and as P–authority implies an outcome which the agent could also obtain under A–authority if q_A is large, we obtain the following corollary which is illustrated in Figure 1b.

Corollary 1 *If $q_A \in (0, (\alpha_P^H - c_P)/(1-c_P))$, P–authority is strictly optimal for the agent and implies the best possible outcome for him. If $q_A \in ((\alpha_P^H - c_P)/(1-c_P), 1)$, A–authority is optimal for the agent.*

6. Optimal allocation of authority and the sequencing of effort provision

It may not always be natural that the principal provides effort last. Instead, he may have to provide effort first or he may even be able to choose the sequencing of effort provision. The effort provision game in which the principal provides effort first corresponds to a situation in which the principal plans and designs the basic structure of a project, whereas the agent takes care of the details. The parameter s_A then can be interpreted as the agent's ability to finish the project which the principal prefers to be implemented. In some applications this kind of sequencing is natural (e.g., when a manager plans a strategic decision which is subsequently executed by a subordinate), whereas in others both kinds of sequencing make equally much sense (e.g., when two scholars plan to write a scientific paper).

Henceforth, we will denote a general effort provision game by Γ and the specific effort provision game in which the principal provides effort last (resp. first) by $\Gamma_{P \text{ last}}$ (resp. $\Gamma_{P \text{ first}}$). We explain in this section what changes when the sequence of effort provision is for exogenous reasons interchanged (i.e., when $\Gamma = \Gamma_{P \text{ first}}$) and when the principal can choose $\Gamma \in \{\Gamma_{P \text{ first}}, \Gamma_{P \text{ last}}\}$ together with his authority decision.

	$s_A = L$	$s_A = H$
$s_P = L$	$\emptyset$	p
$s_P = H$	a	p

(a) Probability that the principal likes project a is low $[q_P < (\alpha_A^H - c_A)/(1 - c_A)]$

	$s_A = L$	$s_A = H$
$s_P = L$	$\emptyset_P$	p
$s_P = H$	$\emptyset_P$	p

(b) Probability that the principal likes project a is high $[q_P > (\alpha_A^H - c_A)/(1 - c_A)]$

Table 4: Outcomes implied by $\Gamma = \Gamma_{P \text{ first}}$

Proposition 3 *Consider the following modification of the base model: the effort provision game is now* $\Gamma = \Gamma_{P\ first}$. *If* $q_P \in (0, (\alpha_A^H - c_A)/(1 - c_A))$, *A–authority is strictly optimal for the principal and implies the best possible outcome for him. If* $q_P \in ((\alpha_A^H - c_A)/(1 - c_A), 1)$, *P–authority is optimal for the principal. The implied outcomes are as stated in Table 4.*

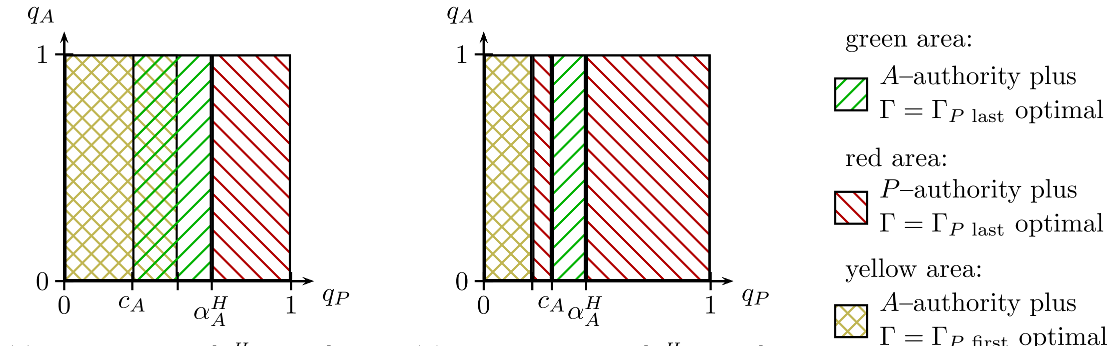
There are two differences relative to the case in which $\Gamma = \Gamma_{P \text{ last}}$. On the one hand, by providing effort first, the principal takes the fear of wasting effort away from the agent. That is, the discouraging effect of delegation disappears. As a consequence, the "too little effort" problem disappears rendering A–authority optimal for the principal whenever the probability with which he likes project a is sufficiently small. On the other hand, by taking away this fear from the agent, it becomes also relatively more attractive for the agent to choose project a instead of project p. The agent becomes thus even less willing to compromise. More formally, as $(\alpha_A^H - c_A)/(1 - c_A) < \alpha_A^H$, the interval of q_P–values for which the "too little compromise" problem arises expands. Interestingly, this implies that there exists an interval of q_P–values such that A–authority is optimal for $\Gamma = \Gamma_{P \text{ last}}$ not *despite* the discouraging effect of delegation but *because* of it. This effect is in this region essential for aligning the agent's actual project selection behavior with the principal's preferred project selection behavior.

We are now set to discuss what happens if the principal can ex ante decide between $\Gamma = \Gamma_{P \text{ last}}$ and $\Gamma = \Gamma_{P \text{ first}}$. Because the player who has to provide effort last is never at risk of wasting effort, providing effort last seems at first glance to be an advantage. However, when the agent's fear of wasting effort is so large that he is sometimes deterred from providing effort, there might nevertheless be a role for interchanging the order of effort provision.

Proposition 4 *Consider the following modification of the base model: the principal now chooses an effort provision game* $\Gamma \in \{\Gamma_{P\ first}, \Gamma_{P\ last}\}$ *together with the authority decision. If* $q_P \in (0, (\alpha_A^H - c_A)/(1 - c_A))$, *A–authority plus* $\Gamma = \Gamma_{P\ first}$ *is optimal for the principal. Otherwise,* $\Gamma = \Gamma_{P\ last}$ *plus the authority decision specified in Proposition 2 is optimal for the principal.*

Figures 2a and 2b illustrate Proposition 4 for $(\alpha_A^H - c_A)/(1 - c_A) > c_A$ and for $(\alpha_A^H - c_A)/(1 - c_A) < c_A$, respectively. What one would expect at first glance is that whenever a "too little effort" problem exists for $\Gamma = \Gamma_{P \text{ last}}$ plus A–authority, interchanging the order of effort provision avoids this problem and renders A–authority optimal. This is indeed what happens if $(\alpha_A^H - c_A)/(1 - c_A) > c_A$ (see Figure 2a). However, if $(\alpha_A^H - c_A)/(1 - c_A) < c_A$, P–authority remains optimal when $q_P \in ((\alpha_A^H - c_A)/(1 - c_A), c_A)$ (see Figure 2b). Avoiding the agent's motivational problem by interchanging the order of effort provision works in this region so well that it comes along with a "too little compromise" problem. This renders P–authority optimal again.

Reinterpretation of the model: Authority to initiate and authority to approve a project. The right to select a project can be interpreted as the authority to initiate a project, whereas the right to provide effort



(a) First structure [$\alpha_A^H = 0.65$] (b) Second structure [$\alpha_A^H = 0.45$]

Figure 2: Optimal allocation of authority for the principal [$c_A = c_P = 0.3$]

last can be interpreted as the authority to approve the selected project. By keeping the authority to initiate a project, the principal can avoid being "exploited" at the project selection stage. However, if the agent is not willing to exploit him, the principal can utilize the agent's information by giving the authority to initiate a project to the agent. Whoever has the authority to approve the project is not at risk of wasting effort, whereas the other player potentially is. Our results indicate that it is the more attractive for the principal to give away authority, the less probable it is that he likes project a. Interestingly, this means that the principal gives away more authority (first only the authority to initiate a project and then also the authority to approve the project) when the dissent between him and the agent becomes larger.

7. Robustness

So far, we have employed three extreme assumptions which may be violated in interesting applications. First, we restricted attention to two simple stylized effort provision games. Second, we did not allow for communication between the principal and the agent. Third, when taking the authority decision, the principal was completely uninformed about how much he likes the project which the agent prefers to be implemented. In this section, we discuss how our results are affected when these assumptions are relaxed.

7.1. Optimal effort provision games

The two stylized effort provision games which we have studied so far are in a certain sense focal, but they are specific. There exist many variations of these games which are interesting as well and which are possibly more realistic. Examples for such variations are the following:

Variation 1: Communication is possible in the effort provision game. For example, the principal has to decide on effort last like in $\Gamma_{P\text{ last}}$, but he has the opportunity to send the message "don't provide effort" to the agent before the agent decides on effort provision. We will refer to this effort provision game as $\Gamma_{P\text{ last + talk}}$.

Variation 2: A project might get lost/ignored. An example is the following: The agent has to decide on effort first and puts the project afterwards into a workflow system. The system delivers the project with probability δ to the principal and loses it otherwise. The principal can only provide effort if he got the project delivered. We will refer to this effort provision game as $\Gamma_{P\text{ last + ignore}}(\delta)$.

Variation 3: The project choice k affects which effort provision Γ_k game is played. The project choice may affect the sequencing or, more generally, the mode of effort provision: An example for the former is that $\Gamma_a = \Gamma_{P \text{ last}}$ is played if $k = a$ is chosen, whereas $\Gamma_p = \Gamma_{P \text{ first}}$ is played if $k = p$ is selected. That is, when the project is chosen which player i prefers to be implemented, player i has to provide effort first. An example for the latter could be $\Gamma_p = \Gamma_{P \text{ last + ignore}}(\delta')$ and $\Gamma_a = \Gamma_{P \text{ last + ignore}}(\delta'')$ with $\delta' > \delta''$. That is, it is less likely that project p is "lost on the principal's desk" than that this happens for project a.[12]

Variation 4: Effort is provided piecewise. The unit of effort which each player must provide in order to implement the selected project may also be provided piecewise. For example, the principal may decide first which share $e_{P1} \in [0,1]$ of his effort he provides in advance at cost $e_{P1}c_P$. Then the agent decides on whether he provides effort ($e_A = 1$) or does not ($e_A = 0$). Finally, the principal decides on whether he provides the remaining effort which is necessary for the implementation of the project, $e_{P2} = 1 - e_{P1}$, at cost $e_{P2}c_P$.

The aim of this subsection is to explain why the two effort provision games $\Gamma_{P \text{ last}}$ and $\Gamma_{P \text{ first}}$, despite their simplicity, imply a trade–off which is interesting from a general perspective.

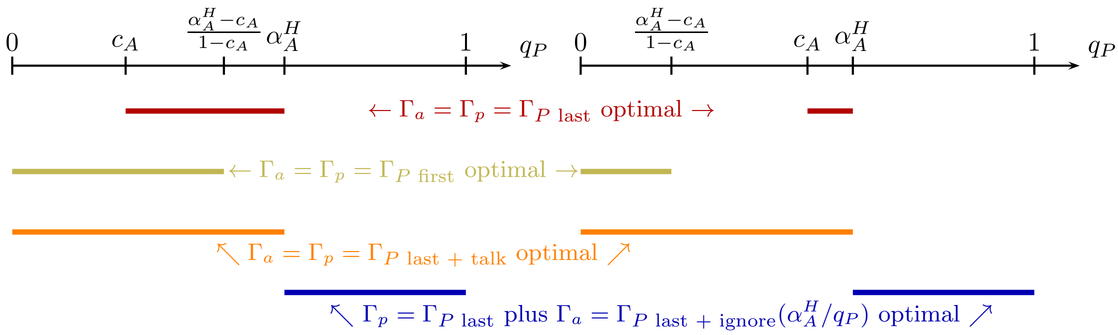
First, understanding the effects implied by $\Gamma = \Gamma_{P \text{ last}}$ and $\Gamma = \Gamma_{P \text{ first}}$ helps to better understand the effects implied by variations thereof. For example, when $\Gamma = \Gamma_{P \text{ last}}$ plus A–authority implies a "too little effort problem", communication or piecewise effort provision can help to mitigate this problem by weakening the discouraging effect of delegation. On the other hand, when $\Gamma = \Gamma_{P \text{ last}}$ plus A–authority implies a "too little compromise problem", the two examples discussed for Variation 3 make choosing project a relatively less attractive for the agent. They can thus help to align the agent's actual project selection behavior with the project selection behavior preferred by the principal. For future reference, the following two examples describe properties of the equilibrium behavior implied by two of these variations:[13]

Example 1 (Motivation through communication) *Let $q_P \leq \alpha_A^H$. There exists an equilibrium of the game implied by A–authority plus $\Gamma_p = \Gamma_a = \Gamma_{P \text{ last + talk}}$ with the following properties: (i) The agent chooses $k = p$ if $s_A = H$ and $k = a$ if $s_A = L$. (ii) If project $k = a$ is selected and $q_P \leq (\alpha_A^H - c_A)/(1 - c_A)$, the principal sends the message "don't provide effort" whenever $s_P = L$. If project $k = a$ is selected and $(\alpha_A^H - c_A)/(1 - c_A) < q_P \leq \alpha_A^H$, the principal sends the message "don't provide effort" with probability $(\alpha_A^H - q_P)/(c_A - q_P c_A) \in [0, 1)$ conditional on that $s_P = L$. (iii) The agent provides effort whenever the principal does not send the message "don't provide effort". (iv) The principal provides effort whenever the agent provided effort and $\pi_P(k, s_P) > 0$. (v) The best possible outcome for the principal is obtained.*

Example 2 (More compromise through ignorance) *Let $q_P > \alpha_A^H$. There exists an equilibrium of the game implied by A–authority plus $\Gamma_p = \Gamma_{P \text{ last}}$ and $\Gamma_a = \Gamma_{P \text{ last + ignore}}(\alpha_A^H / q_P)$ with the following properties: (i) The agent chooses $k = p$ if $s_A = H$ and $k = a$ if $s_A = L$. (ii) The agent provides effort in both cases. (iii) The principal provides effort when he gets the project delivered and $\pi_P(k, s_P) > 0$. (iv) The principal's expected payoff is given by $q_A(1 - c_P) + (1 - q_A)\alpha_A^H(\alpha_P^H - c_P)$.*

[12] Note that when the principal has many projects with different agents on his desk and he cannot work on all of them due to time constraints, such a "getting lost on the principal's desk" property can arise endogenously even if the project selection is not contractible.

[13] See Appendix A for proofs of the stated properties.



(a) First structure $[(\alpha_A^H - c_A)/(1 - c_A) > c_A]$ (b) Second structure $[(\alpha_A^H - c_A)/(1 - c_A) < c_A]$

Figure 3: The optimal effort provision game under A–authority

Second, our stylized effort provision games $\Gamma_{P \text{ last}}$ and $\Gamma_{P \text{ first}}$—or slight variations thereof which imply similar trade–offs—are often optimal within a general class of effort provision games. To prove this, we follow a design approach to effort provision games. We assume that the principal can choose any effort provision game which conditions on the selected project (i.e., he chooses two games Γ_a and Γ_p which are to be played after project $k = a$ and project $k = p$ is selected, respectively) and which satisfies the following three basic properties:

(P1) Each player can provide (in sum) at most one unit of effort.

(P2) The selected project is implemented when each player provides (in sum) one unit of effort.

(P3) When player i provides (in sum) an effort of e_i, he suffers cost $e_i c_i$. This means in particular that each player can ensure himself a payoff of zero by providing no effort.

These properties imply that the projects which are potentially implementable and that the best possible outcome for the principal are as in the original model (i.e., the reasoning in the first paragraph of Section 5 still applies). The Properties (P1), (P2) and (P3) are, for example, satisfied by all the effort provision games sketched above and by the effort provision game where both players decide on effort simultaneously. As is standard in the design literature, we assume that, besides designing an effort provision game, the principal can also pick an equilibrium which is implied by this game. We obtain then the following result.

Proposition 5 *Consider the following modification of the base model: the principal can now choose any effort provision games Γ_a and Γ_p which satisfy properties (P1), (P2) and (P3) together with the authority decision. (a) The effort provision game which is optimal in conjunction with P–authority is $\Gamma_p = \Gamma_a = \Gamma_{P \text{ last}}$. (b) Which effort provision game is optimal in conjunction with A–authority is as summarized in Figure 3. (c) A–authority is optimal.*

In Sections 5 and 6, we found that delegation has a discouraging effect when the effort provision game is $\Gamma_{P \text{ last}}$, but not when it is $\Gamma_{P \text{ first}}$. The principal's choice between $\Gamma_{P \text{ last}}$ and $\Gamma_{P \text{ first}}$ was driven by whether he wants to have this effect (in order to affect the agent's project selection behavior) or not (in order to motivate effort provision by the agent). Only when the principal found the discouraging effect of delegation either too weak or too strong, it was optimal for him not to delegate the project choice. In this section, we have shown that when the principal can choose among general effort provision games, the basic trade–off still concerns the strength of the discouraging effect. But as the principal can now fine–tune this effect by designing the effort game, delegation of the project choice turns out to be generally optimal.

In particular, if $q_P > \alpha_A^H$, the principal finds the discouraging effect of delegation that is implied by $\Gamma_{P \text{ last}}$ not strong enough. It is then optimal for him to delegate the project choice, but to choose an effort provision game which induces an even stronger discouraging effect than $\Gamma_{P \text{ last}}$ when project $k = a$ is selected. This can happen by choosing a game $\Gamma_a = \Gamma_{P \text{ last + ignore}}(\delta)$ in which the agent does not only waste effort when there exists no potentially implementable project but also sometimes when there exists one.[14] On the other hand, if $q_P \in ((\alpha_A^H - c_A)/(1 - c_A), c_A)$, the principal finds the discouraging effect implied by $\Gamma_{P \text{ last}}$ too strong and that implied by $\Gamma_{P \text{ first}}$ too weak. Delegation in conjunction with the former implied a "too little compromise" problem, whereas delegation in conjunction with the latter implied a "too little effort provision" problem. In this case, it is optimal for the principal to construct an effort provision game which exhibits a discouraging effect of intermediate strength. This can happen, for example, by choosing $\Gamma_{P \text{ last + talk}}$ and by sometimes—but not always—warning the agent when he is about to waste effort.

7.2. Cheap talk

In basically any interesting application, communication between partners/collaborators is possible. The question is however whether and about what collaborators are willing to communicate informatively. For example, Aghion and Tirole (1997) find that communication about the project choice plays an important role when partners can gather costly information before a project is selected. For us, the question arises whether communication is still important when there is an open conflict concerning the selection of the project and when partners engage in costly, complementary actions after a project is selected.

Cheap talk in the effort provision game. Communication within the effort provision game can serve as an instrument to prevent the waste of effort after a project is selected which is not potentially implementable. In the preceding subsection, we have shown however that there is only limited scope for this kind of communication. If $q_P > \alpha_A^H$, the principal does not only not want to prevent waste of effort by the agent, he is even willing to undertake measures such that the agent wastes effort in cases in which the selected project is potentially implementable. If $q_P \leq \alpha_A^H$, the principal can achieve the best possible outcome for him by choosing an effort provision game which relies on communication (in mixed strategies), but in most cases either $\Gamma_{P \text{ last}}$ or $\Gamma_{P \text{ first}}$ achieves also the best possible outcome for the principal (in pure strategies). Only if $((\alpha_A^H - c_A)/(1 - c_A), c_A)$ is non–empty, there exist q_P–values for which an effort provision game exists which relies on communication and which strictly outperforms $\Gamma_{P \text{ last}}$ and $\Gamma_{P \text{ first}}$.

Cheap talk at the project selection stage. Communication at the project selection stage can serve as an instrument to select a project which is potentially implementable. Our analysis in the preceding subsection implies however also that there is only limited scope for such communication. If $q_P \leq \alpha_A^H$, the principal can obtain the best possible outcome for him without communication at the project selection stage. This means in the language of Aghion and Tirole (1997) that formal authority corresponds to real authority when we

[14] That the commitment to ex post inefficient behavior can improve the use of information ex ante has also been shown for other settings. See, e.g., Szalay (2005), Section 3.1 in Armstrong and Vickers (2010) or Vidal and Möller (2013).

allow for communication. There may thus only be scope for communication if $q_P > \alpha_A^H$. In the proof to Proposition 5, we derive for this case an upper bound on the expected payoff that the principal can obtain when the project selection behavior is such that the agent makes just as many compromises as he is able to make (i.e., when he chooses project $k = a$ if $s_A = H$ and project $k = p$ if $s_A = L$) and we show that this upper bound can be attained without communication at the project selection stage. It follows that there is also only limited scope for communication in this case.[15]

7.3. Authority allocation by an informed principal

So far, we have considered the problem in which the principal does not know the realization of his private signal at the time he decides on the authority structure/the mode of effort provision. This problem corresponds basically to situations in which the organizational structure/mode of effort provision is designed to govern several different conflicts instead of a single specific conflict. Thus the question arises what changes if the principal designs the mode of interaction to govern a specific conflict about which he is already better informed. The following proposition states that there exists an equilibrium such that the organizational structure which optimally governs any specific conflict coincides with the organizational structure which is designed to govern several different conflicts.[16]

Proposition 6 *Consider the following modification of the base model: the principal learns his private signal already at the outset and he chooses* $\Gamma \in \{\Gamma_{P\ last}\}$ *(resp.* $\Gamma \in \{\Gamma_{P\ first}, \Gamma_{P\ last}\}$*) together with the authority decision. There exists an equilibrium in which principal and agent both behave like in the game in which the principal learns his private signal only after stage (1). That is, Proposition 2 (resp. Proposition 4) extends.*

A rough intuition is the following: First, note that the principal can only have a strict incentive to delegate when $s_P = H$. However, a separating equilibrium in which only the principal with $s_P = H$ delegates the project choice cannot exist. If it did, the agent would infer that the principal likes project a when he delegates. This implies that the agent would never be willing to compromise on the project choice which in turn would render delegation unattractive for a principal with private signal $s_P = H$. A direct consequence of this reasoning is that there always exist out–of–equilibrium beliefs which render non–delegation by both principal types stable. On the other hand, when delegation by both principal types is capable of inducing the best possible outcome for the principal, no principal type can become better off by deviating from delegation. This renders delegation by both principal types stable in this case.

8. Extensions of the model

Up to know, we employed the simplest possible environment to explain the effects in which we are interested. In this section, we demonstrate how the basic trade–offs extend to more complicated environments.

[15] More specifically, our analysis implies that there may only be a role for communication when the principal wants to induce a project selection behavior where the agent does not make as many compromises as he is able to make.

[16] Bénabou and Tirole (2003) construct an example in which the signaling effect associated with the decision to delegate is motivating. Proposition 6 basically says that the kind of signaling effect which drives the results in Bénabou and Tirole (2003) is not important for our framework, whereas the signaling effect associated with the principal's project selection behavior in case of non–delegation is. Responsible for this is the different nature of private information in our model.

8.1. Continuous effort

Modification of the model. We now present a modification of our base model in which the players' effort decisions are still complementary, but in which each player's effort choice is continuous, $e_i \in [0,1]$. By providing more effort, each player i increases the probability $e_i e_{-i}$ with which the selected project gets implemented and he incurs a higher cost $c(e_i)$. To derive the optimal effort decisions explicitly, we assume $c(e_i) = e_i^2/2$. Player i's payoff is given by $\pi_i = e_i e_{-i} - c(e_i)$ if $k = k^*(i)$ and by $\pi_i = e_i e_{-i}\alpha_i^{s_i} - c(e_i)$ if $k = k^*(-i)$. We assume $0 < \alpha_i^L < 1/2 < \alpha_i^H < 1$. Project p (resp. project a) is thus still the project which the principal (resp. the agent) prefers to be implemented. Everything else is as in the original model. In particular, we consider again the effort provision game $\Gamma = \Gamma_{P \text{ last}}$.

Optimal effort decisions. Because the two players' effort decisions are complementary besides the complementarity between effort and project value, each player has a stronger incentive to provide effort for projects which he likes more and for projects which have a better chance of getting implemented. In particular, the principal provides the more effort the more effort was provided by the agent. The principal's optimal effort decision is given by $e_P = e_A$ if $k = p$ and by $e_P = e_A\alpha_P^{s_P}$ if $k = a$. Taking this behavior as given, the agent chooses e_A to maximize

$$\begin{cases} e_A^2\left[\mu_P\alpha_P^H + (1-\mu_P)\alpha_P^L\right] - e_A^2/2 & \text{if } k = a \\ e_A^2\alpha_A^{s_A} - e_A^2/2 & \text{if } k = p \end{cases}. \tag{3}$$

As the agent's objective function is linear in e_A^2, the agent's effort provision problem has a corner solution: the agent either provides effort (i.e., $e_A = 1$) or he does not (i.e., $e_A = 0$). If $k = p$, the agent provides effort if and only if $s_A = H$. If $k = a$, whether the agent is willing to provide effort depends on the probability μ_P with which he believes that the principal likes project a.

The full information benchmark. Consider first the full information benchmark in which principal and agent learn both signals s_P and s_A at the project selection stage. This implies that $\mu_P = 1$ if $s_P = H$ and $\mu_P = 0$ if $s_P = L$. The probabilities with which project $k = p$ and $k = a$ are implemented as a function of (s_P, s_A) follow then from the discussion in the preceding paragraph and are as stated in Table 5a. If $s_P = s_A = L$, the project choice does not matter as neither project has a positive implementation probability. If $s_P \neq s_A$, principal and agent have a *common interest* at the project selection stage as there exists a single project which is implemented with a positive probability. The most interesting case arises when $s_P = s_A = H$. In this case, both projects are associated with a positive implementation probability. In contrast to the case with binary effort, the project p which the principal prefers to be implemented is however associated with a higher implementation probability (1 compared to α_P^H). Hence, the two players face only a *conflict of interest* if the probability with which project a would get implemented is sufficiently large. See Tables 5b and 5c for a description of which project is preferred by principal and agent, respectively.[17]

The effects implied by delegation. If a player's signal is his private information and $\alpha_P^H > \alpha_A^H$, a player with a high private signal is uncertain about whether there is a common interest or a conflict of interest.

[17]The case distinction arises as follows: Suppose $s_P = s_A = H$. By plugging the implementation probabilities into the principal's payoff function, we obtain $\alpha_P^H(1 - 1/2)$ for $k = a$ and $(1 - 1/2)$ for $k = p$. That is, the principal generally prefers project p. By doing this for the agent, we obtain $\alpha_P^H - 1/2$ for $k = a$ and $\alpha_A^H - 1/2$ for $k = p$. The agent prefers thus project $k = p$ if $\alpha_A^H > \alpha_P^H$, but he prefers project $k = a$ if $\alpha_A^H < \alpha_P^H$.

	$s_A = L$	$s_A = H$
$s_P = L$	0 / 0	1 / 0
$s_P = H$	0 / α_P^H	1 / α_P^H

(a) Implementation probabilities if $k = p$ / $k = a$

	$s_A = L$	$s_A = H$
$s_P = L$	– / –	p / p
$s_P = H$	a / a	p / p

(b) Project preferred by principal / agent $[\alpha_P^H < \alpha_A^H]$

	$s_A = L$	$s_A = H$
$s_P = L$	– / –	p / p
$s_P = H$	a / a	p / a

(c) Project preferred by principal / agent $[\alpha_P^H > \alpha_A^H]$

Table 5: Full information benchmark

The trade–offs implied by the version of the model with continuous effort are thus like in the version with binary effort. On the one hand, the project choice under P–authority still signals that the principal likes the selected project. The belief μ_P is thus higher when project a was selected by the principal than when it was selected by the agent. It follows that the discouraging effect of delegation (Lemma 1) which drives the effects in our version of the model with binary effort extends to the version with continuous effort. On the other hand, if the project choice is delegated to the agent, the agent always selects a project for which he is willing to provide effort when such a project exists. Hence, as in the version of the model with binary effort, the principal might want the project selection behavior to depend on the agent's private signal. This requires however delegation of the project choice.

To be more specific, consider the numerical example with $q_A = 1/2$, $\alpha_A^L = 1/3$, $\alpha_A^H = 2/3$, $\alpha_P^L = 1/4$ and $\alpha_P^H = 3/4$. We then have $\mu_P = 1$ (resp. $\mu_P = q_P$) if project a is selected under P–authority (resp. A–authority). It is straightforward to verify that A–authority is optimal if $q_P \in [1/2, 5/6]$ and that P–authority is optimal otherwise. If $q_P < 1/2$, it is not beneficial for the agent to provide effort for project $k = a$ under A–authority. If $q_P > 5/6$, the agent is not willing to compromise on the project choice under A–authority. In both cases only a single project gets implemented with positive probability.[18] It is thus optimal for the principal to choose P–authority in order to avoid the discouraging effect of delegation.

8.2. Continuous private information

Modification of the model. We present now a modification of our base model in which the players' private information is continuous. Suppose s_P and s_A are independent draws from a uniform distribution on $[0, 1]$ and suppose player i's payoff is given by $\pi_i = e_i(e_{-i} - c_i)$ if $k = k^*(i)$ and by $\pi_i = e_i(e_{-i}s_i - c_i)$ if $k = k^*(-i)$. Everything else is as in the original model. In particular, we consider again the effort provision game $\Gamma = \Gamma_{P \text{ last}}$ and binary effort $e_i \in \{0, 1\}$. We are interested in how the optimal authority structure depends for given c_A on the probability that $s_P \geq c_P$, $q_P := 1 - c_P$.

Optimal effort decisions and implied trade–offs. The principal provides effort if the agent provided effort and either $k = p$ or $s_P \geq c_P$. Taking this behavior as given, as well as the probability μ_P with which the agent believes that $s_P \geq c_P$, the agent takes his effort decision to maximize

$$\begin{cases} e_A(\mu_P - c_A) & \text{if } k = a \\ e_A(s_A - c_A) & \text{if } k = p \end{cases} .$$

The agent provides effort for project p whenever he likes this project sufficiently much (when $s_A \geq c_A$). For project a, the agent is only willing to provide effort when the belief μ_P is sufficiently high (when $\mu_P \geq c_A$).

[18]Both properties follow from (3) with $\mu_P = q_P$.

Again, the trade–offs are as in the version of the model with binary information: On the one hand, because there still is a signaling effect associated with the project choice under P–authority,[19] the discouraging effect of delegation (Lemma 1) extends also to our version of the model with continuous private information. On the other hand, the principal relies on project selection by the agent if he wants that a project is selected for which the agent is willing to provide effort whenever such a project exists.

A–authority. Consider A–authority and suppose first $q_P < c_A$. The agent's fear of wasting effort for project $k = a$ is then so strong that he is discouraged from providing effort for this project. It follows that project $k = p$ gets implemented if $s_A \geq c_A$ and that the project choice does not matter as neither project would get implemented if $s_A < c_A$. The principal's expected payoff is thus

$$\Pi_P^{A1} \quad := \quad \text{Prob}\{s_A \geq c_A\}(1 - c_P).$$

Suppose now $q_P > c_A$. In this case, there always exists a project for which the agent is willing to provide effort. The agent chooses $k = p$ if $s_A > q_P$ and $k = a$ if $s_A < q_P$. If $s_A \in (c_A, q_P)$, the agent does not compromise on the project although he would get a positive expected payoff from compromising. The higher q_P, the more likely it is that the agent does not compromise on the project choice although he could compromise. The principal's expected payoff is

$$\Pi_P^{A2} \quad := \quad \text{Prob}\{s_A < q_P\}\text{Prob}\{s_P \geq c_P\}\mathbf{E}[s_P - c_P | s_P \geq c_P] + \text{Prob}\{s_A \geq q_P\}(1 - c_P).$$

Comparison of P–authority with A–authority. By choosing $k = p$, the principal can ensure himself an expected payoff of $\text{Prob}\{q_A \geq c_A\}(1 - c_P) = (1 - c_A)(1 - c_P)$, whereas choosing $k = a$ implies an expected payoff of $\max\{s_P - c_P, 0\}$ for him. Comparing these two options implies that the principal chooses $k = p$ if $s_P < c_P + (1 - c_P)(1 - c_A)$ and $k = a$ otherwise. This gives rise to the following expected payoff:

$$\begin{aligned} \Pi_P^P \quad := \quad & \text{Prob}\{s_P < c_P + (1 - c_P)(1 - c_A)\}\text{Prob}\{s_A \geq c_A\}(1 - c_P) \\ & + \text{Prob}\{s_P > c_P + (1 - c_P)(1 - c_A)\}\mathbf{E}[s_P - c_P | s_P > c_P + (1 - c_P)(1 - c_A)]. \end{aligned}$$

By comparing the principal's expected payoff from P–authority with that from A–authority, we obtain that Proposition 1 extends also to our setting with continuous private information.

Proposition 7 *Consider the version of our base model with continuous private information. There exists $q_P' \in (c_A, 1)$ such that A–authority is strictly optimal if $q_P \in (c_A, q_P')$. Moreover, P–authority is strictly optimal if $q_P \in (0, c_A) \cup (q_P', 1)$.*

9. Conclusion

This article argues that in situations in which a strong partner (the principal) can undertake a project together with a weak partner (the agent), there is scope for delegation of the project choice even when there is an open conflict concerning which project the partners prefer to be implemented. A crucial role is played by the dissent between the principal and the agent as measured by the probability with which the principal also likes the project which the agent prefers to be implemented. When the agent does the basic work on the

[19] Note that $\mu_P = q_P$ if project $k = a$ is selected under A–authority and $\mu_P = 1$ if project $k = a$ is selected under P–authority.

project and the principal finalizes it, delegation of the project choice to the agent is optimal if the dissent is of intermediate strength. If the dissent is too strong, the fear of wasting effort sometimes discourages the agent from providing effort in the first place. If the dissent is too weak, the agent does not feel the need to compromise on the project choice. When the principal can affect also the mode of effort provision, this mode serves as an instrument to either decrease the agent's fear of wasting effort (in order to motivate effort provision) or to increase this fear (in order to increase his willingness to compromise). Delegation becomes then generally optimal.

Appendix A. Proofs

Proof of Lemma 1.

If project k is selected and the agent provided effort, the principal's payoff from providing effort as well is for any authority structure $\pi_P(k, s_P)$. Hence, $e_p = 1$ if and only if $k = p$ or if $k = a$ and $s_P = H$. Consider now the agent's incentive to provide effort taking this behavior of the principal as given.

(b) Suppose project $k = p$ is selected. The agent knows then that the principal is willing to provide effort irrespective of by whom project p was chosen. His expected payoff from providing effort is $\pi_A(p, s_A) = (\alpha_A^{s_A} - c_A)$. Hence, $e_A = 1$ if and only if $s_A = H$.

(a) If project $k = a$ is selected, it matters for the agent by whom this project was chosen. If the principal selected this project, the agent can infer by a revealed preferences argument that $s_P = H$: If the principal had chosen project p instead, the agent would have provided effort if $s_A = H$ (see (b)). Because this implies for any private signal s_P a positive expected payoff for the principal, choosing project a could have only been optimal for him when this implies a positive expected payoff for him as well. As this is however only possible when $s_P = H$, the agent can infer that $s_P = H$. Hence, $\mu_P = 1$. By contrast, if the agent selected project a, the agent can infer nothing about the principal's willingness to provide effort. Hence, $\mu_P = q_P$. As the agent's expected payoff from providing effort is given by $\mu_P \pi_A(a, s_A) + (1 - \mu_P)\pi_i(\emptyset_A, s_A) = (\mu_P - c_A)$, he always provides effort under P–authority, whereas he only provides effort under A–authority when $q_P > c_A$. q.e.d.

Proof of Proposition 1.

Consider A–authority. As argued in the proof to Lemma 1, $e_P = 1$ if and only if $k = p$ and $e_A = 1$ or if $k = a$, $s_P = H$ and $e_A = 1$. Moreover, as it is not possible for the agent to infer anything about the principal's signal, $\mu_P = q_P$. The agent has basically three options: First, by not providing effort, he obtains a payoff of 0. Second, by choosing project a and providing effort, he obtains an expected payoff of $\mu_P \pi_A(a, s_A) + (1 - \mu_P)\pi_A(\emptyset_A, s_A) = (q_P - c_A)$. Third, by choosing project p and providing effort, he obtains an expected payoff of $\pi_A(p, s_A) = (\alpha_A^{s_A} - c_A)$. By comparing these three options for $s_A = L$ and $s_A = H$, the outcomes described in Table 2 follow immediately. q.e.d.

Proof of Proposition 2.

(a) Consider $q_P \in (c_A, \alpha_A^H)$. By Proposition 1, A–authority implies for any (s_P, s_A) the best possible outcome for the principal and is therewith at least weakly optimal for him. As this outcome requires that the project choice depends non–trivially on the agent's private signal s_A, it cannot be obtained under P–authority. Hence, A–authority must be strictly optimal.

(b) Suppose $q_P \in (0, c_A)$ or $q_P \in (\alpha_A^H, 1)$. In each of these cases, a single project gets implemented under A–authority (see Tables 2a and 2c). If the principal chooses this project under P–authority, he cannot be worse off than under A–authority as the agent's incentive to provide effort is by Lemma 1 at least weakly larger under P–authority. This implies that P–authority is at least weakly better for the principal. If the principal has a strict incentive not to pursue this "imitation behavior", P–authority is by a revealed preferences argument strictly optimal for him.

We next derive the behavior that is induced under P–authority. As argued in the proof to Lemma 1, $e_P = 1$ if and only if $k = p$ and $e_A = 1$ or if $k = a$, $s_P = H$ and $e_A = 1$. Moreover, by the reasoning in the same proof, $e_A = 1$ if $k = a$ or if $k = p$ and $s_A = H$. Taking this behavior as given, the principal's expected payoff from choosing project p is $q_A \pi_P(p, s_P) = q_A(1 - c_P)$ and his expected payoff from choosing project a is $\pi_P(\emptyset, L) = 0$ if $s_P = L$ and $\pi_P(a, H) = (\alpha_P^H - c_P)$ if $s_P = H$. By comparing these two options for $s_P = L$ and $s_P = H$, the outcomes described in Table 3 follow immediately. q.e.d.

Proof of Corollary 1.

Because (1) and (2) hold also for the agent, the best possible outcome for the agent is like the best possible outcome for the principal (see Table 1b) with the roles of the two players and the two projects interchanged. Because this outcome depends non–trivially on the principal's private information, it may only be obtained under P–authority. Because this outcome is actually obtained under P–authority if $q_A < (\alpha_P^H - c_P)/(1-c_P)$ (see Table 3a), P–authority is in this case strictly optimal for the agent. Consider now $q_A > (\alpha_P^H - c_P)/(1 - c_P)$. P–authority implies then outcome p if $s_A = H$ and outcome $\emptyset$ if $s_A = L$ (see Table 3b). Because the agent can induce the same outcome also under A–authority, A–authority must be at least weakly better for him. q.e.d.

Proof of Proposition 3.

Principal and agent switch roles when the sequence of effort provision is interchanged. Proposition 3 follows therefore directly from Corollary 1 by interchanging the roles of the two players. q.e.d.

Proof of Proposition 4.

Step 1: P–authority plus $\Gamma = \Gamma_{P\ last}$ dominates P–authority plus $\Gamma = \Gamma_{P\ first}$ for the principal. Consider in the following three substeps P–authority. (1.1) Consider $\Gamma = \Gamma_{P\text{ last}}$ and suppose that the principal selects project a. The agent believes then by the reasoning in Lemma 1 that the principal likes the selected project. Hence, the agent will choose $e_A = 1$. If $s_P = H$, $e_P = 1$ is optimal for the principal such that the outcome is a. If $s_P = L$, $e_P = 0$ is optimal for the principal such that the outcome is $\emptyset_A$. Consider now $\Gamma = \Gamma_{P\text{ first}}$ and suppose that the principal selects project a. The agent will then choose $e_A = 1$ if and only if the principal chooses $e_P = 1$. If $s_P = H$, $e_P = 1$ is optimal for the principal such that the outcome is a. If $s_P = L$, $e_P = 0$ is optimal for the principal such that the outcome is $\emptyset$. It follows that choosing project a generates for both effort provision games the same expected payoff for the principal. (1.2) Consider $\Gamma = \Gamma_{P\text{ last}}$ and suppose that the principal selects project p. The outcome is then p if $s_A = H$ and $\emptyset$ if $s_A = \emptyset$. Consider now $\Gamma = \Gamma_{P\text{ first}}$ and suppose that the principal chooses project p. If the principal chooses $e_P = 1$, the outcome is p if $s_A = H$ and $\emptyset_P$ if $s_A = L$. If the principal chooses $e_P = 0$, the outcome is $\emptyset$. Hence, no matter whether $e_P = 0$ or $e_P = 1$ is optimal for the principal, choosing project p generates a strictly higher expected payoff for the principal when $\Gamma = \Gamma_{P\text{ last}}$ than when $\Gamma = \Gamma_{P\text{ first}}$. (1.3) If $\Gamma = \Gamma_{P\text{ last}}$, choosing project p is by the reasoning in the last paragraph of the proof to Proposition 2 optimal for the principal when $s_P = L$ (see Tables 3a and 3b). Hence, by this, (1.1) and (1.2), the principal's expected payoff from P–authority is strictly higher when $\Gamma = \Gamma_{P\text{ last}}$ than when $\Gamma = \Gamma_{P\text{ first}}$.

Step 2: The main argument. By Step 1, $\Gamma = \Gamma_{P\text{ first}}$ can only be optimal for the principal when he prefers A–authority over P–authority for this effort provision game. By Proposition 3, this is only the case if $q_P \in (0, (\alpha_A^H - c_A)/(1 - c_A))$. As A–authority plus $\Gamma = \Gamma_{P\text{ first}}$ implies the best possible outcome for the principal when this condition is satisfied, it is optimal for the principal. If the condition is however violated, $\Gamma = \Gamma_{P\text{ last}}$ together with the authority structure specified in Proposition 2 is strictly optimal for the principal. q.e.d.

Proof of Example 1.

	$s_A = L$	$s_A = H$
$s_P = L$	no effort by principal	project p implemented
$s_P = H$	project a implemented	project a implemented

(a) Probability that the agent likes project p is low $[q_A < (\alpha_P^H - c_P)/(1-c_P)]$

	$s_A = L$	$s_A = H$
$s_P = L$	no effort by principal	project p implemented
$s_P = H$	no effort by principal	project p implemented

(b) Probability that the agent likes project p is high $[q_A > (\alpha_P^H - c_P)/(1-c_P)]$

Table A.6: Best that can happen to the principal under P–authority

For parts (i) to (iv) we can argue backwards taking the behavior of the other player and the own behavior at later stages as given: (iv) This part is clear. (iii) The agent's expected payoff from providing effort conditional on that project $k = a$ is chosen and that the principal has not sent the message "don't provide effort" is $[q_P(1-c_A) - (1-q_P)[1-(\alpha_A^H - c_A)/(c_A - q_P c_A)]c_A]/C = [\alpha_A^H - c_A]/C$ with $C := q_P + (1-q_P)[1-(\alpha_A^H - c_A)/(c_A - q_P c_A)]$ (resp. $(1-c_A)$) if $(\alpha_A^H - c_A)/(1-c_A) < q_P \leq \alpha_A^H$ (resp. $q_P \leq (\alpha_A^H - c_A)/(1-c_A)$). As this is non–negative when the supposition $q_P \leq \alpha_A^H$ holds, it is indeed optimal for the agent to provide effort in this case. Moreover, it is straightforward that not providing effort is optimal when the message "don't provide effort" is sent and that providing effort is optimal when $s_A = H$ and $k = p$. (ii) As sending the message "don't provide effort" does not affect the principal's payoff conditional on that project $k = a$ is chosen and that $s_P = L$, any probability of sending this message is optimal for the principal in this case. In all other cases, it is strictly optimal for the principal not to send this message. (i) Suppose first $(\alpha_A^H - c_A)/(1-c_A) < q_P \leq \alpha_A^H$. The agent's expected payoff from selecting project $k = a$ is $\alpha_A^H - c_A$, whereas his expected payoff from selecting project $k = p$ is $\alpha_A^{s_A} - c_A$. It follows that $k = a$ is strictly optimal if $s_A = L$ and that $k = p$ is weakly optimal if $s_A = H$. Suppose now $q_P \leq (\alpha_A^H - c_A)/(1-c_A)$. The agent's expected payoff from selecting project $k = a$ is then $q_P(1-c_A)$, whereas his expected payoff from selecting project $k = p$ is $\alpha_A^{s_A} - c_A$. It is obvious that $k = a$ is strictly optimal if $s_A = L$ and it follows from the supposition that $k = p$ is optimal if $s_A = H$. (v) This follows from comparing the outcomes implied by the equilibrium behavior with those in Table 1b. q.e.d.

Proof of Example 2.

For parts (i) and (iii) we can argue backwards taking the behavior of the other player and the own behavior at later stages as given: (iii) This part is clear. (ii) Suppose first $k = p$. As providing effort implies a payoff of $\alpha_A^{s_A} - c_A > 0$, providing effort is optimal if and only if $s_A = H$. Suppose now $k = a$. Providing effort is optimal as it implies a payoff $(\alpha_A^H/q_P)q_P - c_A = \alpha_A^H - c_A > 0$. (i) By (ii), $k = a$ is strictly optimal if $s_A = L$ and $k = p$ is weakly optimal if $s_A = H$. (iv) This follows directly from the described equilibrium behavior. q.e.d.

Proof of Proposition 5.

We prove parts (a) and (c) before we prove part (b).

(a) Because the projects which are potentially implementable are still as described in Table 1a, it is straightforward to verify that the best that can happen to the principal conditional on that the project choice conditions only on s_P is what is stated in Table A.6. As this is what happens under P–authority when the effort provision game is $\Gamma = \Gamma_{P \text{ last}}$ (compare with Table 3), $\Gamma = \Gamma_{P \text{ last}}$ is optimal under P–authority.

(c) Consider first $q_P \leq (\alpha_A^H - c_A)/(1-c_A)$. By (a), the best possible outcome for the principal cannot be obtained under P–authority (compare Table A.6 with Table 1b). As the best possible outcome for the principal can by Example 1 (v) however be obtained under A–authority, we obtain the result. Consider now $q_P > (\alpha_A^H - c_A)/(1-c_A)$. By (a), $q_A(1-c_P)$ is the highest expected payoff that the principal can obtain under P–authority. As this is by Example 2 (iv) strictly less than what he can obtain under A–authority, we obtain again the result.

(b) Consider first $q_P \leq (\alpha_A^H - c_A)/(1-c_A)$. Optimality of $\Gamma_a = \Gamma_p = \Gamma_{P \text{ last + talk}}$ follows from Example 1. By Proposition 1, also $\Gamma_a = \Gamma_p = \Gamma_{P \text{ last}}$ is optimal if $q_P \in (c_A, \alpha_A^H)$. By Proposition 3, also $\Gamma_a = \Gamma_p = \Gamma_{P \text{ first}}$ is optimal if $q_P \in (0, (\alpha_A^H - c_A)/(1-c_A))$. It remains thus to argue that $\Gamma_p = \Gamma_{P \text{ last}}$ plus $\Gamma_a = \Gamma_{P \text{ last + ignore}}(\alpha_A^H/q_P)$ is optimal if $q_P > \alpha_A^H$. We will first derive an upper bound on the expected payoff that the principal can obtain under A–authority and argue then that this upper bound is obtained by the effort provision games Γ_a and Γ_p which we claim to be optimal.

For a given project k that is selected and for a given probability μ_A^k with which the principal believes that $s_A = H$ after he observes that project k is selected, the effort provision game Γ_k determines two things: the function $y^k : \{L,H\}^2 \to [0,1]$ which describes the probability $y^k(s_P, s_A)$ with which the selected project is implemented and for each player i the function $w_i^k : \{L,H\}^2 \to [0,1]$ which determine this player's expected cost of wasted effort, $w_i^k(s_P, s_A)c_i$.[20] Note first that the effort provision games Γ_a and Γ_p affect the principal and the agent only through the functions y^a, w_A^a, w_P^a, y^p, w_A^p and w_P^p which are implied by them. Second, note that the belief μ_A^k may affect the functions y^k, w_A^k and w_P^k which are implied by a specific effort provision game, but that μ_A^k does not matter apart from that. That is, once we know the functions y^k, w_A^k and w_P^k, we don't have to care about the belief μ_A^k anymore.

It follows from (a) and (c) that the optimal functions y^a, w_A^a, w_P^a, y^p, w_A^p and w_P^p imply a project selection behavior which depends non–trivially on s_A. By using the notation $\overline{y}^k(s_A) := q_P y^k(H, s_A) + (1-q_P) y^k(L, s_A)$ and $\overline{w}_A^k(s_A) := q_P w_A^k(H, s_A) + (1-q_P) w_A^k(L, s_A)$, we can write the agent's expected payoff from selecting project k when his private signal is s_A as

$$\Pi_A^k(s_A|\overline{y}^k, \overline{w}_A^k) := \begin{cases} \overline{y}^a(s_A)(1-c_A) - \overline{w}_A^a(s_A)c_A & \text{if } k = a \\ \overline{y}^p(s_A)(\alpha_A^{s_A} - c_A) - \overline{w}_A^p(s_A)c_A & \text{if } k = p \end{cases}. \tag{A.1}$$

Necessary for a project selection behavior where the agent chooses project $k = p$ (with positive probability) when $s_A = H$ and project $k = a$ (with positive probability) when $s_A = L$ is

$$\Pi_A^p(H|\overline{y}^p, \overline{w}_A^p) \geq \Pi_A^a(H|\overline{y}^a, \overline{w}_A^a). \tag{A.2}$$

Further, we obtain two conditions which must be satisfied by any functions y^a, w_A^a, w_P^a, y^p, w_A^p and w_P^p which are implied by some effort provision games Γ_a and Γ_p. First, as the agent can by Property (P1) provide effort at most once, how much effort he can waste is constricted by the implementation probability:

$$\overline{w}_A^p(H) \in [0, 1-\overline{y}^p(H)] \text{ and } \overline{w}_A^a(L) \in [0, 1-\overline{y}^a(L)]. \tag{A.3}$$

Second, as the agent's payoff does not directly depend on s_A when project $k = a$ is selected (see (A.1)), he must for $s_A = H$ and for $s_A = L$ get the same expected payoff from the equilibrium play of Γ_a:

$$\Pi_A^a(H|\overline{y}^a, \overline{w}_A^a) = \Pi_A^a(L|\overline{y}^a, \overline{w}_A^a). \tag{A.4}$$

By using (A.4), we can rewrite (A.2) as $\Pi_A^p(H|\overline{y}^p, \overline{w}_A^p) \geq \Pi_A^a(L|\overline{y}^a, \overline{w}_A^a)$. By using (A.1), we can rewrite this inequality as $\overline{y}^p(H)(\alpha_A^H - c_A) - \overline{w}_A^p(H)c_A \geq \overline{y}^a(L)(1-c_A) - \overline{w}_A^a(L)c_A$. As (A.3) implies $\overline{w}_A^p(H) \geq 0$ and $\overline{w}_A^a(L) \leq 1 - \overline{y}^a(L)$, necessary for (A.2) is

$$\overline{y}^p(H)(\alpha_A^H - c_A) \geq \overline{y}^a(L) - c_A. \tag{A.5}$$

We can now pose an auxiliary problem whose maximum provides us with an upper bound on the principal's expected payoff: Suppose that the principal chooses the functions y^a, w_A^a, w_P^a, y^p, w_A^p and w_P^p directly

[20] "Wasted effort" is effort that is spent in cases in which the project does not get implemented. There are two ways how a player i can waste effort. First, he wastes effort if he provides effort but the other player does not. Second, he definitely wastes effort if he spends only a part of the unit effort which is necessary for the implementation of the project. An expected effort waste of $1/2c_i$ may thus either arise because player i provides with probability $1/2$ effort while player $-i$ does not, or because player i spends only half of the effort which is necessary for implementation.

(instead of that he designs the two effort provision provision games Γ_a and Γ_p which imply these functions) to maximize his expected payoff subject to the constraint (A.5). Note that inducing mixing at the project selection stage can be used as an instrument to affect the belief which the principal has about the agent's private signal. This belief matters however only in so far for the principal as it imposes additional constraints regarding which functions y^a, w^a_A, w^a_P, y^p, w^p_A and w^p_P can be induced. As we ignore such constraints in our auxiliary problem, the principal cannot benefit strictly from inducing mixing behavior at the project selection stage. It follows that in order to derive an upper bound on the principal's expected payoff, it is without loss of generality to restrict attention to the case in which $k = p$ is chosen with probability 1 if $s_A = H$ and in which $k = a$ is chosen with probability 1 if $s_A = L$. Formally, this gives rise to the following auxiliary problem:

$$\begin{array}{ll} \max_{y^a, w^a_A, w^a_P, y^p, w^p_A, p^p_P} & q_A q_P \ (y^p(H,H)(1-c_P) - w^p_P(H,H)c_P) \\ & + \ q_A(1-q_P) \ (y^p(L,H)(1-c_P) - w^p_P(L,H)c_P) \\ & + \ (1-q_A)q_P \ (y^a(H,L)(\alpha^H_P - c_P) - w^p_P(H,L)c_P) \\ & + \ (1-q_A)(1-q_P) \ (y^a(L,L)(\alpha^L_P - c_P) - w^p_P(L,L)c_P) \\ \text{subject to} & \overline{y}^p(H)(\alpha^H_A - c_A) \geq \overline{y}^a(L) - c_A \end{array} \quad \text{(A.6)}$$

$w^k_P(s_P, s_A) = 0$ is clearly optimal for the auxiliary problem as $w^k_P(s_P, s_A)$ does not enter the constraint. Because the objective function is increasing in $\overline{y}^p(H)$ and because a higher $\overline{y}^p(H)$ relaxes the constraint, $\overline{y}^p(H) = 1$ is clearly optimal. Similarly, because the objective function is decreasing in $y^a(L,L)$ and because a lower $y^a(L,L)$ relaxes the constraint, $y^a(L,L) = 0$ is clearly optimal. These two properties imply that the maximum of (A.6) is the maximum of $q_A(1-c_P)+(1-q_A)q_P y^a(H,L)(\alpha^H_P - c_P)$ subject to $\alpha^H_A \geq q_P y^a(H,L)$. Under our supposition that $q_P > \alpha^H_A$, this problem is maximized by $y^a(H,L) = \alpha^H_A/q_P$. It follows that $q_A(1-c_P) + (1-q_A)\alpha^H_A(\alpha^H_P - c_P)$ is an upper bound on the maximum of the auxiliary problem. As it follows from Example 2 that this upper bound is attained by $\Gamma_p = \Gamma_{P \text{ last}}$ plus $\Gamma_a = \Gamma_{P \text{ last + ignore}}(\alpha^H_A/q_P)$, we obtain our result. q.e.d.

Proof of Proposition 6.

The informed principal problem exhibits two differences relative to the uninformed principal problem which we have considered in Proposition 2 (resp. Proposition 4). First, the principal knows already the realization of s_P when he takes the decisions at stage 1. Second, the agent can use the observation of these decisions to update his belief about the principal's signal. Roughly speaking, we know that the stage 1 behavior specified in Proposition 2 (resp. Proposition 4) maximizes the principal's expected payoff when he cannot condition this behavior on s_P. What we have to show is that there exist out–of–equilibrium path beliefs such that the principal has for neither private signal s_P a strict incentive to deviate from this "pooling behavior" when the on–the–equilibrium path belief is the prior.

Reference case. By a reasoning like that at the beginning of Section 5, we have the following: The best possible outcome for a principal with private signal $s_P = L$ is $\omega \in \{\emptyset, \emptyset_A\}$ if $s_A = L$ and $\omega = p$ if $s_A = H$. The best possible outcome for a principal with private signal $s_P = H$ is $\omega = a$ if $s_A = L$ and $\omega = p$ if $s_A = H$.

Case 1: Suppose the primitives of the model are such that A–authority is optimal in Proposition 2 (resp. Proposition 4). As non–deviation from this behavior implies the best possible outcome for a principal with private signal $s_P = L$ and simultaneously the best possible outcome for a principal with private signal $s_P = H$, the principal can for neither private signal have a strict incentive to deviate from this behavior.

Case 2.: Suppose the primitives of the model are such that P–authority plus $\Gamma = \Gamma_{P\ last}$ is optimal in Proposition 2 (resp. Proposition 4). As behaving like this implies still the best possible outcome for a principal with private signal $s_P = L$ (see Tables 3a and 3b), a principal with this private signal can still not have a strict incentive to deviate. It remains thus only to argue that also a principal with private signal $s_P = H$ has no incentive to deviate. When this principal chooses P–authority plus $\Gamma = \Gamma_{P \text{ last}}$, it depends on the primitives of the model which outcome is induced. If $q_A < (\alpha^H_P - c_p)/(1-c_P)$, the outcome is $\omega = a$

irrespective of s_A (see Table 3a). If $q_A > (\alpha_P^H - c_P)/(1-P)$, the outcome is $\omega = \emptyset$ if $s_A = L$ and $\omega = p$ if $s_A = H$ (see Table 3b). In each case, the induced combination of outcomes maximizes the principal's interim expected payoff conditional on that the project choice does not condition on s_A and conditional on that a project can only be implemented if it is potentially implementable. This implies that the principal cannot have a strict incentive to deviate to P–authority plus $\Gamma = \Gamma_{P \text{ first}}$. Hence, it remains only to argue that there exist out–of–equilibrium path beliefs such that a principal with $s_P = H$ has also no strict incentive to deviate to A–authority. When the agent's out–of–equilibrium path belief corresponds to the prior, we obtain however by the supposition of Case 2 and by the reasoning in Proposition 2 (resp. Proposition 4) that only a single project is implemented under A–authority plus $\Gamma \in \{\Gamma_{P \text{ first}}, \Gamma_{P \text{ last}}\}$. As this immediately implies that the principal with $s_P = H$ can also not have a strict incentive to deviate to A–authority plus $\Gamma \in \{\Gamma_{P \text{ first}}, \Gamma_{P \text{ last}}\}$, we are done. q.e.d.

Proof of Proposition 7.

Consider $q_p < c_A$. Because $\mathbf{E}[s_P - c_P | s_P > c_P + (1-c_P)(1-c_A)] > (1-c_P)(1-c_A) = \text{Prob}\{s_A \geq c_P\}(1-c_A)$, it immediately follows $\Pi_P^P > \Pi_P^{A2}$. Consider now $q_P > c_A$. By using that $c_P = 1 - q_P$ and by simplifying, we obtain $\Pi_P^{A2} = q_P^3/2 + q_P - q_P^2$ and $\Pi_P^P = q_P - q_P c_A + q_P^2 c_A^2/2$. Define $\xi(q_P) := (\Pi_P^P - \Pi_P^{A2})/(1-c_P)$. By simplifying, we obtain $\xi(q_P) = (q_P - c_A) + q_P(c_A^2 - q_P)/2$. The function ξ has the following three properties: First, $\lim_{q_P \downarrow c_A} = -c_A^2(1-c_A)/2 < 0$. Second, $\lim_{q_P \uparrow 1} = (1-c_A)^2/2 > 0$. Third, $\xi'(q_P) = (1-q_P) + c_A^2/2 > 0$. The first (resp. second) property implies that A–authority (resp. P–authority) is optimal for q_P close to c_A (resp. close to 1). The third property implies that there exists a threshold $q_P' > c_A$ such that A–authority is optimal for $q_P \in (c_A, q_P')$, whereas P–authority is optimal for $q_P \in (q_P', 1)$. Moreover, the threshold is implicitly defined by $\xi(q_P') = 0$. By solving this equation, we obtain that the threshold is given by $q_P' = 1 + c_A^2/2 - \sqrt{4 + 4c_A^2 + c_A^4 - 8c_A}/2$. q.e.d.

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