Delegation and Information Revelation

by
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This paper analyzes, in a set-up where only the control over actions is contractible, the rationale for delegation. An organization must take two decisions. The payoffs are affected by a random parameter and only the agent knows its realization. If the principal delegates the control over the first decision to the agent, his choice may indicate the information that he possesses. If the principal retains control over the second decision, discovering this information is valuable. Hence, this paper provides a new rationale for delegation: A transfer of control to the informed party can be used to discover the private information. (JEL: D23, D82, L22 , M41)

1 *Introduction*

This paper studies the problem of information transmission within an organization. We consider a repeated relationship between a better informed agent and a principal (for convenience from here on, we will refer to the principal as "she" and the agent as "he"). The organization must choose two projects, decisions or actions, in sequence whose payoffs are affected by a single random parameter. Initially, there is asymmetric information between the principal and the agent. The agent knows the realization of the

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parameter, while the principal does not. They also have diverging interests; i.e., they do not agree on the optimal projects.

In a complete contracting set-up, the principal designs a revelation contract that specifies the actions that the agent should take, and the corresponding payments as a function of these. In this paper, we adopt the incomplete contracting view of organizations and assume the projects, and the underlying economic environment (the "state of the world"), cannot be contracted upon, neither ex-ante nor ex-post. In the terminology of incomplete contract theory, we consider the case of observable, but non-verifiable, decisions. However we assume that control over projects can be contracted upon. In our setting, the only feasible contracts are the ones stipulating who is in charge of each project. At the beginning of the game, the principal allocates the right to undertake project(s) either to herself or to the agent.[1]

In the absence of performance-based payments, the governance of the decision-making process is crucial for the overall performance of an organization. The informational asymmetry can be overcome either directly (with a message sent by the agent to the principal who then decides) or indirectly (the actions of the agent allow the principal to discover the private information which he possesses).

In our set-up these two alternatives are associated with two different organizational structures: "centralization" and "partial delegation". This paper compares these two organizational structures. It shows that the information transfers are different in each case. In partial delegation, the principal can learn the state parameter by observing the agent's action while with centralization the principal may remain imperfectly informed. Information transfer is valuable for the principal if the relationship is a repeated one. Thus the principal could prefer partial delegation to an agent with different preferences rather than centralization because it enables her to discover the agent's private information.

In the case of *centralization*, the principal chooses both projects, and the agent may transmit a message containing information about the actual state of the world (for instance, the agent can be asked to advise the principal). Given that the principal cannot build a revelation contract, the agent's choice of communication is strategic. He does not necessarily want to communicate the true information. Instead he will communicate the information that best

[1]This kind of contract is called partial contracting by Aghion, Dewatripont and Rey [2002].

fits his interests when the principal selects the projects. Communication under centralization is a cheap-talk game and, as shown by Crawford and Sobel [1982], this kind of communication is noisy.

In the case of *partial delegation*, the principal delegates the choice of some projects to the agent. By observing the agent's choice in the first period, she may acquire (part of) the agent's superior information. The acquisition of information is valuable for her only if she can use it to decide in the second period and, therefore, delegation must be only partial. The principal gives up control over the first period project, but keeps control over the second period one.[2] The delegation mechanism is costly for her. When she gives up the right to decide, the agent does not implement her preferred decision. Diverging interests between the parties create losses due to her lack of control when she delegates. The principal's lack of commitment means that the agent cannot be punished for this.[3]

Our main result is that (partial) delegation is a mechanism to induce full revelation by the better informed agent. We establish this result using an appropriate equilibrium refinement, i.e., Cho and Kreps [1987] intuitive criterion. When the principal cannot elicit the agent's information through communication, she can do it by giving up control over the first project. Unlike in the complete contract framework, where the principal can control the rents she leaves to the agent, in our mechanism there is loss of control as soon as the principal gives power to the agent.[4]

Partial delegation can also be the optimal organizational structure. This is true when information is not revealed in the message game and the losses due to the lack of control are relatively small when compared to the benefits of acquiring information. Hence the principal's decision to choose either centralized decision-making process or the one where the agent partially has control depends on the value of the agent's private information and the divergence of interests between the two parties.

The work in this paper is based on the assumption that the decisions (projects) cannot be described in a completely comprehensive contract. It

[2]Partial delegation is then a signaling game (Spence, [1973]).

[3]Roider [2006] shows that delegation could be optimal in a hold-up framework, in which the information between parties is symmetric.

[4]With partial delegation, the principal learns the agent's private information by giving him control in the first period. This is in sharp contrast with the complete contract literature result that information revelation could be delayed (the so-called ratchet effect), see Freixas, Guesnerie and Tirole [1985], Laffont and Tirole [1988].

may be applicable to various forms of organizations and relationships. The literature on strategic communication provides examples of relationships between parties with different information in which projects cannot be contracted. OTTAVIANI [2000] studies the relationship between a better informed financial advisor and an investor. DESSEIN [2002] and MORRIS [2001] illustrate their models with examples from political science. To be precise, one of Morris's examples concerns a repeated relationship between a social scientist (advisor) and a politician (decision-maker). The social scientist has better knowledge of the state of the world and he is repeatedly asked to advise the politician. We consider an alternative decision-making process in which the scientist is asked by the politician to completely design a project in his field of expertise. The politician then implements the project. In this case, the scientist has the real authority over the decision even though he does not have the formal authority.[5] By delegating the project design to the social scientist, the politician improves her knowledge of the field and she can use it to take subsequent decisions. AGHION AND TIROLE [1997] also study relationships in a context of asymmetric information where the allocation of power is the only tool available. Clearly, all these examples could fit our model.

In the literature the choice between delegation and centralization is often a simple trade-off between losses due to the lack of control associated with delegation and informational benefits, in cases where the delegate is better informed than his supervisor. The benefits of a delegated structure may include better communication (MELUMAD, MOOKHERJEE AND REICHELSTEIN [1992]), better ability to prevent collusion (LAFFONT AND MARTIMORT [1998] and FELLI [1996]), an informed decision-maker (LEGROS [1993], DESSEIN [2002], OTTAVIANI [2000]) or increased incentives provided to the agent (AGHION AND TIROLE [1997]).

Most of these papers compare delegation and centralization, but they do not consider delegation as a tool for transmitting information from the better informed agent to his supervisor. DESSEIN [2002], OTTAVIANI [2000], and KRÄHMER [2006] consider a one period game where the principal can either delegate the project choice to a better informed agent with biased preferences or take the decision herself and use the agent's advice to improve her knowledge of his private information. As in our framework, communication under centralization is not fully informative. The decision to delegate, or not

[5] AGHION AND TIROLE [1997].

to, depends on the trade-off between loss of control and loss of information. Losses due to the lack of control occur when an informed agent has control, losses due to the lack of information occur when the informed agent advises the principal, who then chooses the project.[6] Our paper introduces a second period in this model, so that delegation becomes an instrument for obtaining the agent's hidden information. LEGROS [1993] integrates this dimension. In his two period model, the principal delegates the first project choice to a better informed agent chosen at random from a given set of agents. In the second period, the principal can either re-select the same agent and let him choose the second project or she can hire a new agent, chosen at random, to implement the second decision. In this model, the first period decision does not signal the agent's private information (i.e., its type) perfectly to the principal. This result differs from ours because in Legros's model the agent trades off the immediate benefit of implementing his preferred policy (revealing his private information) against the probability of being re-selected, which increases when he can convince the principal that his preferences are close to hers. Hence, the first period decision is a not a perfect signal of the agent's type of information.

The paper is organized as follows: The model is presented in section 2. The outcomes under delegation and centralization are described in sections 3 and 4. Section 5 compares the two organizational structures. The main conclusions are in section 6.

2 The Model

Consider an organization composed of one principal and one agent. The organization chooses two projects d_1 and d_2 at period $t = 1$ and $t = 2$, respectively. The selection of a project affects the welfare of the principal and the agent. Their utility levels are also affected by a common environmental

[6] KRÄHMER [2006] shows that message-contingent delegation creates incentives for the agent to disclose his private information in a context where the actions are not contractible.

parameter, θ, which realizes before any choice is made.[7,8]

Environmental parameter The payoff of the project depends on the economic environment. For simplicity, we assume that a state of the world is fully described by a parameter, $\theta \in \Theta = \{\theta_L, \theta_H\}$, with $\theta_H > \theta_L$. The agent knows the realization θ. The principal only knows Θ and the (common knowledge) distribution $F(\theta)$. Then let v_L be the probability of $\theta = \theta_L$ and let $v_H = (1 - v_L)$. Moreover, let $\Delta\theta = (\theta_H - \theta_L)$. We briefly discuss the extension to $N > 2$ states of the world in the conclusion.

Projects At each period t, the decision, d_t, is the choice of a project to be implemented by the organization, with $d_t \in (0, +\infty)$.

Allocation of the rights to choose the projects We assume that projects can be observed by both parties, but cannot be contracted (using the terminology of Tirole [1999], they are observable, but not verifiable). As in Dessein [2002], the realization of θ cannot be contracted. Hence the only variable agents can contract upon is the right to choose the projects d_1 and d_2. These control rights are allocated by the principal either to herself (centralization) or to the agent (delegation).[9]

These contractual restrictions are consistent with the incomplete contract view of organizations: To give authority to a subordinate agent means to give him the right to make a decision within an allowed set (see, Simon [1958], Grossman and Hart [1986], Hart and Moore [1988], Aghion and Tirole [1997]).

There are four possible allocations of decision rights: The principal keeps control over both projects (centralization), she delegates both choices, or the

[7] This is a simplification. Alternatively, we could assume that the state of the world changes over periods and that there is some correlation between the states of the world in the two periods. The results of the paper would remain qualitatively the same. The important assumption is that the observation of the first decision (under delegation) improves the information about the state of the world in the second period.

[8] This is a common assumption in dynamic models of incentive contracts. See, e.g., Laffont and Tirole [1988].

[9] The fact that the principal initially possesses decision rights over both projects can be justified by her owning the physical assets which give her the right to decide about their use (Grossman and Hart [1986]), or by institutional agreement, as in political decisions (Aghion and Tirole [1997]).

control rights are split between principal and agent (either d_1 or d_2 is delegated). *Partial delegation* is when the better informed agent receives control over d_1 but not over d_2. In our model, we concentrate mainly on centralization and partial delegation. Complete delegation and partial delegation of d_2 will be discussed at the end of the paper.

Message Game After observing the state of the world, the agent may reveal information by sending a message to the principal. This message may cause the principal to update her prior beliefs and thus may affect her choice of the projects.[10] We allow A to send a message before each decision taken by P. In cases of partial delegation we do not allow the agent to communicate.

Timing of the events

1. The principal (denoted by P) chooses between centralization and partial delegation of d_1.
2. The agent (denoted by A) observes the state of the world, θ.
3. Under Partial delegation,
   (a) chooses d_1, which is observed by P.
   (b) P chooses d_2.
3. Under centralization,
   (a) A sends a message to P.
   (b) P chooses d_1.
   (c) A sends a message to P.
   (d) P chooses d_2.

[10]It makes no difference whether messages are verifiable or unverifiable, because we do not consider the case where the allocation of control rights could depend on messages (see Krähmer [2006] for the analysis of this case in a one-period model).

Preferences P and A derive private benefits from each project. The payoffs of player P and A are represented by a quasi-concave Von Neumann-Morgenstern utility function $U^P(d_1, d_2, \theta)$ and $U^A(d_1, d_2, \theta)$. We assume that utility functions satisfy:

A1: Time-separability: For $K = P, A$:

$$U^K(d_1, d_2, \theta) = U_1^K(d_1, \theta) + U_2^K(d_2, \theta).$$

A2: Single peakedness: For $t = 1, 2$ and $K = P, A$, there exists a unique $\hat{d}_t^K(\theta) \equiv \text{argmax}_{d_t} U^K(d_t, \theta)$.

A3: Divergence of interests: For $t = 1, 2$: $\hat{d}_t^A(\theta) \neq \hat{d}_t^P(\theta)$.

A4: Systematic bias:

$$Sign\left(\hat{d}_t^A(\theta_L) - \hat{d}_t^P(\theta_L)\right) = Sign\left(\hat{d}_t^A(\theta_H) - \hat{d}_t^P(\theta_H)\right).$$

If the sign of these differences is positive (resp. negative), it means that at period t, the agent systematically prefers a larger (resp. lower) project than the principal.

A5: Increasing difference (ID): For $t = 1, 2$ and $K = P, A$: $\Delta U_t^K(d_t) = U_t^K(d_t, \theta_H) - U_t^K(d_t, \theta_L)$ increases in d_t. This assumption is a standard sorting condition in a framework with two states of the world.

LEMMA 1 ***A2*** *and* ***A5*** *imply that for* $t = 1, 2$ *and* $K = A, P$, $\hat{d}_t^K(\theta_H) > \hat{d}_t^K(\theta_L)$.

PROOF Single-peakedness implies that:

$$(1) \qquad U_t^K(\hat{d}_t^K(\theta_H), \theta_H) > U_t^K(\hat{d}_t^K(\theta_L), \theta_H),$$

$$(2) \qquad U_t^K(\hat{d}_t^K(\theta_L), \theta_L) > U_t^K(\hat{d}_t^K(\theta_H), \theta_L).$$

From these conditions, one immediatly obtains:

$$(3) \quad U_t^K(\hat{d}_t^K(\theta_H), \theta_H) - U_t^K(\hat{d}_t^K(\theta_H), \theta_L) > U_t^K(\hat{d}_t^K(\theta_L), \theta_H) - U_t^K(\hat{d}_t^K(\theta_L), \theta_L),$$

or equivalently that: $\Delta U_t^K(\hat{d}_t^K(\theta_H)) > \Delta U_t^K(\hat{d}_t^K(\theta_L))$. By **A5**, this implies that $\hat{d}_t^K(\theta_H) > \hat{d}_t^K(\theta_L)$. *Q.E.D.*

In our set-up, there is a unique state-contingent preferred project for P and A at each period t. However P and A disagree about which project is the best one.

Liquidity constraints We assume that the agent is liquidity constrained. We can interpret this assumption as follows: The agent is liquidity constrained because of imperfect capital markets and so he cannot buy the organization with a pay-cut at the beginning of the relationship. Without this hypothesis the problem has an easy solution: P is weakly better off if both A and P can agree on an appropriate pay-cut and let A make both decisions. This assumption is quite realistic, and is fairly common in the literature (see, ZABOJNIK [2002] and SAPPINGTON [1983]). Our Proposition 4 shows how and when an agent who is not liquidity constrained can improve the preferred organizational structure of the principal.

3 Partial delegation

This section describes the projects chosen by the agent and the principal when d_1 is delegated and d_2 is not. Under partial delegation, P observes A's decision before choosing d_2. Given that A is better informed, his choice of d_1 may provide information to P. So P then revises her prior beliefs before choosing the period 2 project and A will take this into account.

We adopt the standard equilibrium concept used in signalling games, i.e., the Bayesian-Nash equilibrium (BNE).

Let $BR^A(d_2)$ and $BR^P(d_1)$ be the best response correspondences of the two players.

Definition 1 A Bayesian-Nash equilibrium (BNE) is a strategy profile for each player, $(d_1^*(.), d_2^*(.))$, such that

$$\forall \theta, d_1^*(.) \in BR^A(d_2^*) \equiv \underset{d_1}{\operatorname{argmax}}\, U_1^A(d_1, \theta) + U_2^A(d_2^*, \theta),$$

$$d_2^*(.) \in BR(d_1^*, \Theta) \equiv \underset{d_2}{\operatorname{argmax}} \sum_{i=L,H} \mu^*(\theta_i | d_1^*) U_2^P(d_2, \theta_i),$$

where posterior beliefs $\mu^*(\theta_i | d_1^*)$ are consistent with Bayes' rule.

Signalling games usually have multiple equilibria. We use the intuitive criterion (CHO AND KREPS [1987]) to restrict the equilibrium set. The intuitive criterion is a refinement of the out-of-equilibrium beliefs. A BNE fails the intuitive criterion if the equilibrium strategies are not consistent with the refined beliefs.

Definition 2 Let A's equilibrium payoff in state θ be $U^{A^*}(\theta) = U^A(d_1^*, d_2^*, \theta)$.
A BNE fails the intuitive criterion if, in state θ_i, $\forall\, d_1 \neq d_1^*$,

$$U^{A^*}(\theta_i) > \max_{d_2 \in BR(d_1, \Theta)} U^A(d_1, d_2, \theta_i), \tag{4}$$

and, in state θ_j, there is some d_1 such that

$$U^{A^*}(\theta_j) < \min_{d_2 \in BR(d_1, \Theta \backslash \theta_i)} U^A(d_1, d_2, \theta_j). \tag{5}$$

A BNE fails the intuitive criterion if A's equilibrium payoff in one state of the world (θ_i) is greater with the equilibrium strategy d_1^* than with any other strategy (condition (4)). Moreover, d_1 must be such that A's equilibrium payoffs in the other state of the world (θ_j) are smaller than those with a d_1 strategy, once P is convinced that d_1 could not have been chosen by A in state θ_i (condition (5)).

In the rest of this section we describe the outcome of the signalling game played by the two individuals when P delegates d_1. Results are summarized in Proposition 1.

Proposition 1 *Under partial delegation, the only equilibrium that survives the intuitive criterion is the least costly separating (LCS) equilibrium (i.e., the Riley outcome*[11] *).*

We prove this by considering the possible separating, pooling and partially separating equilibria, and showing that only the Riley outcome survives, once we require equilibria to satisfy the intuitive criterion. First we look at the possible separating equilibria.[12]

Separating equilibria If the equilibrium is separating, by observing $d_1^*(.)$, P learns θ_i. Then she selects her preferred project:

$$d_2^*(\theta) = \hat{d}_2^P(\theta). \tag{6}$$

[11] Riley [1979].

[12] In the analysis, we neglect the agent's outside option (the individual rationality constraints) and assume that the agent's equilibrium payoff is always higher than his outside option. Thus a separating equilibrium always exists. Alternatively, if the total payoff ($U^A + U^P$) is positive and if P has liquidity, she can make an unconditional transfer to A, which is equivalent to a decrease of his outside option.

A strategy profile $(d_1^*(.), d_2^*(.))$ is a separating equilibrium if the following incentive compatibility constraints are satisfied:

$$U_1^A(d_1^*(\theta_L), \theta_L) + U_2^A(d_2^*(\theta_L), \theta_L) \geq U_1^A(d_1^*(\theta_H), \theta_L) + U_2^A(d_2^*(\theta_H), \theta_L), \quad (7)$$

$$U_1^A(d_1^*(\theta_H), \theta_H) + U_2^A(d_2^*(\theta_H), \theta_H) \geq U_1^A(d_1^*(\theta_L), \theta_H) + U_2^A(d_2^*(\theta_L), \theta_H). \quad (8)$$

To determine the relevant constraint, we must first identify the state where A could have an incentive to misrepresent his information. This may happen in state θ_i only if the resulting period 2 decision satisfies:

$$U_2^A(d_2^*(\theta_j), \theta_i) \geq U_2^A(d_2^*(\theta_i), \theta_i). \quad (9)$$

A has, indeed, to make a suboptimal decision to misrepresent his information. This behaviour is optimal for A only if P's period 2 decision counterbalances his losses in the first period.

Three mutually exclusive cases must be distinguished: (S1) condition (9) is satisfied in state θ_L; i.e. if θ_L, A has a second period benefit if he misrepresents his type; (S2) condition (9) is satisfied in state θ_H; and (S3) condition (9) is neither satisfied in θ_L nor in θ_H. The increasing difference assumption rules out the case where (9) would have been satisfied in both states.

Consider case S1. A's benefits from misrepresenting his type in state θ_L are given by

$$U_2^A(d_2^*(\theta_H), \theta_L) - U_2^A(d_2^*(\theta_L), \theta_L) > 0. \quad (10)$$

By ID and lemma 1, if equation (9) is satisfied for $\theta_i = \theta_L$, then it is not satisfied for $\theta_i = \theta_H$. So, in case S1, the relevant incentive constraint is given by (7). This constraint could be equally well written as:

$$U_1^A(d_1^*(\theta_L), \theta_L) - U_1^A(d_1^*(\theta_H), \theta_L) \geq U_2^A(d_2^*(\theta_H), \theta_L) - U_2^A(d_2^*(\theta_L), \theta_L). \quad (11)$$

This means that, in state θ_L, A's costs (in the first period) of mimicking the behavior of A in state θ_H (given by the left-hand-side of equation (11)) are greater than the benefits he would have in the second period (given by equation (10)).

P uses Bayes's rule to update her beliefs. Thus at a separating equilibrium, $\mu(\theta_L | d_1^*(\theta_L)) = 1$ and $\mu(\theta_L | d_1^*(\theta_H)) = 0$. In (S1), the equilibrium is supported by beliefs $\mu(\theta_L|d_1) = 1, \forall\, d_1 \neq d_1^*(\theta_H)$. Given P's beliefs, A selects his preferred project in state θ_L, and the set of separating equilibria is given by:

$$(12) \qquad d_1^*(\theta_i) \begin{cases} = \hat{d}_1^A(\theta_L) & \text{if } \theta_i = \theta_L \\ \in D \equiv \{d_1(\theta_H)|(11) \text{ is satisfied}\} & \text{if } \theta_i = \theta_H \end{cases},$$

$$(13) \qquad d_2^*(\theta_i) = \hat{d}_2^P(\theta_i),$$

$$(14) \qquad \mu^*(\theta_i|d_1^*(\theta_i)) = 1.$$

Given (10), it is easy to check that these are the only possible separating equilibria in (S1).

We now use the intuitive criterion to select a unique equilibrium in D. In state θ_H, consider a deviation by A from $d_1^*(\theta_H)$ to $d_1 \in D$. By definition of D, such a deviation can benefit A only in state θ_H. So the intuitive criterion demands that the beliefs associated with $d_1 \in D$ should be updated to $\mu(\theta_L|d_1 \in D) = 0$.

Thus at θ_H, a rational agent will select his preferred decision within D. The only equilibrium surviving the intuitive criterion is the efficient separating equilibrium (the Riley outcome). If $\hat{d}_1^A(\theta_H) \in D$, the Riley outcome is $d_1^*(\theta) = \hat{d}_1^A(\theta)$. Otherwise, it is $d_1^*(\theta_L) = \hat{d}_1^A(\theta_L)$ and $d_1^*(\theta_H) = \text{argmax}_{d_1 \in D}\, U_1^A(., \theta_H)$.

In case S2, the relevant incentive constraint is (8). The set of separating equilibria is:

$$(15) \qquad d_1^*(\theta_i) \begin{cases} \in D' \equiv \{d_1(\theta_L)|(8) \text{ is satisfied}\} & \text{if } \theta_i = \theta_L \\ = \hat{d}_1^A(\theta_H) & \text{if } \theta_i = \theta_H \end{cases},$$

$$(16) \qquad d_2^*(\theta_i) = \hat{d}_2^P(\theta_i),$$

$$(17) \qquad \mu^*(\theta_i|d_1^*(\theta_i)) = 1.$$

And similarly, the intutive criterion selects the most efficient separating equilibrium within this set.

In case S3, regarding period 2, the agent has no incentive to misrepresent his type. In this case, the following belongs to the set of separating equilibria: $d_1^*(\theta) = \hat{d}_1^A(\theta)$, $d_2^*(\theta) = \hat{d}_2^P(\theta)$ and $\mu^*(\theta_i|d_1^*(\theta_i) = 1$. Applying the intuitive criterion, all the separating equilibria except this one are eliminated.

Pooling equilibria One must bear in mind that if there is no revelation the rationale for delegation disappears and the principal is better off making both decisions herself. We analyze pooling equilibria because it is important to stress that none of them survives the intuitive criterion. Thus partial delegation will always mean full revelation.

If A plays a pooling equilibrium, P does not obtain any information by observing d_1^*, and her period 2 choice is:

$$d_2^* = \underset{d_2}{\operatorname{argmax}}\, v_L U_2^P(d_2, \theta_L) + v_H U_2^P(d_2, \theta_H). \tag{18}$$

Given our assumptions, d_2^* is unique and $d_2^* \in [\hat{d}_2^P(\theta_L), \hat{d}_2^P(\theta_H)]$.

As in the case of separating equilibria, we have to identify the state where A hides his information. He prefers an uninformed P in state θ_i only if:

$$U_2^A(d_2^*, \theta_i) \geq U_2^A(\hat{d}_2^P(\theta_i), \theta_i). \tag{19}$$

This is because if A decides to hide his information he has to make a sub-optimal decision in state θ_i. This behaviour is optimal only if the period 2 decision of P counterbalances A's first period loss.

To define the out-of-equilibrium beliefs supporting the pooling equilibrium, it is important to identify the state of nature in which A has no interest in revealing his private information. Thus once again we need to consider three different cases: N1 (A prefers an uninformed P in state θ_L), N2 (A prefers an uninformed P in state θ_H) and N3 (A always prefers an informed P). Our assumptions on the preferences rule out the case in which the agent prefers an uninformed principal in both states.

Consider the case N1. A may prefer an uninformed P in state θ_L only if

$$U_2^A(d_2^*, \theta_L) \geq U_2^A(\hat{d}_2^P(\theta_L), \theta_L). \tag{20}$$

By **A4** and **A5**, if this condition holds, in state θ_H, the agent prefers an informed principal, that is:

$$U_2^A(d_2^*, \theta_H) \leq U_2^A(\hat{d}_2^P(\theta_H), \theta_H). \tag{21}$$

To support the pooling equilibrium, the out-of-equilibrium beliefs must be $\mu(\theta_L | d_1 \neq d_1^*) = 1$.

We can now define the set of pooling equilibria as the set of d_1^* such that A's equilibrium payoffs in both states are greater than his payoffs if he deviate from the equilibrium. Obviously we only have to consider deviations to A's preferred project $\hat{d}_1^A(\theta)$.

In N1, the set of pooling equilibria is the set d_1^* such that:

$$
\begin{aligned}
(22)\quad U_1^A(d_1^*,\theta_L)+U_2^A(d_2^*,\theta_L) &\geq U_1^A(\hat{d}_1^A(\theta_L),\theta_L)+U_2^A(\hat{d}_2^P(\theta_L),\theta_L),\\
(23)\quad U_1^A(d_1^*,\theta_H)+U_2^A(d_2^*,\theta_H) &\geq U_1^A(\hat{d}_1^A(\theta_H),\theta_H)+U_2^A(\hat{d}_2^P(\theta_L),\theta_H).
\end{aligned}
$$

We now apply the intuitive criterion to get rid of all the pooling equilibria.

Lemma 2 *For each d_1^*, there exists $\tilde{d}_1$ such that:*
(i) if θ_L, A prefers the pooling equilibrium d_1^* to $\tilde{d}_1$, whatever the beliefs associated with $\tilde{d}_1$.
(ii) if θ_H, A prefers $\tilde{d}_1$ to the pooling equilibrium d_1^* if P believes that $\mu(\theta_L|\tilde{d}_1)=0$.

The proof is in Appendix A.1.

Given Lemma 2, if θ_L, A will never deviate to $\tilde{d}_1$. As a result, according to the intuitive criterion, the beliefs associated with $\tilde{d}_1$ should be $\mu(\theta_L|\tilde{d}_1)=0$. However with these updated beliefs, if θ_H is realized, A prefers to quit the pooling equilibrium (part (ii) of the Lemma). Thus the initial equilibrium d_1^* does not survive the intuitive criterion.

Case N2 is identical to N1 and therefore omitted. In case N3, A prefers an informed principal in both states. Hence, whatever the out-of equilibrium beliefs, it is always profitable for the agent to deviate in at least one state and no pooling equilibria can be sustained.

Partially separating equilibria In a partially separating equilibrium, in one state, θ_i, the agent randomizes between two projects. In the other state, θ_j, A chooses a project with probability one.[13] We will consider partially separating equilibria in which, in state θ_j, A chooses his preferred project for sure, that is $d_1(\theta_j)=\hat{d}_1^A(\theta_j)$. And, in state θ_i, A chooses his preferred project $\hat{d}_1^A(\theta_i)$ with probability q and the other type's preferred project ($\hat{d}_1^A(\theta_j)$) with the complement probability $1-q$.[14]

The principal, when she observes $\hat{d}_1^A(\theta_i)$, correctly infers that the true state of the world is θ_i and therefore chooses $\hat{d}_2^P(\theta_i)$ in period 2. When she

[13] Our assumptions on preferences rule out the case where the agent randomizes in both states.

[14] Other equilibria where agent does not choose his preferred project in state θ_j can be eliminated in the same way.

observes $\hat{d}_1^A(\theta_j)$, she revises her prior beliefs on θ to $\mu_i(q) = \mu(\theta_i|\hat{d}_1^A(\theta_j)) = \frac{v_i(1-q)}{v_j+v_i(1-q)}$. Given her knowledge at time 2, she selects the project that gives her the highest utility:

$$(24) \qquad d_2^*(\mu_i(q)) = \operatorname*{argmax}_{d_2} \mu_i(q)U_2^P(d_2,\theta_i) + (1-\mu_i(q))U_2^P(d_2,\theta_j).$$

In state θ_i, the payoff of the agent is $U_1^A(\hat{d}_1^A(\theta_i),\theta_i) + U_2^A(\hat{d}_2^P(\theta_i),\theta_i)$ if he chooses $\hat{d}_1^A(\theta_i)$. His payoff is equal to $U_1^A(\hat{d}_1^A(\theta_j),\theta_i) + U_2^A(d_2^*(\mu_i(q)),\theta_i)$ if he chooses $\hat{d}_1^A(\theta_j)$. In a partially separating equilibrium, q must be such that, in state θ_i, A achieves the same payoff with the two actions. Hence, the equilibrium probability q^* is given by the following equality:

$$(25) \quad U_1^A(\hat{d}_1^A(\theta_i),\theta_i) + U_2^A(\hat{d}_2^P(\theta_i),\theta_i) = U_1^A(\hat{d}_1^A(\theta_j),\theta_i) + U_2^A(d_2^*(\mu_i(q^*)),\theta_i).$$

The equilibrium payoff of A in state θ_i is then given by (25). A partially separating equilibrium exists, if (1) q^* defined in (25) is in $(0,1)$ and (2) the equilibrium payoff of the agent is greater than what he could obtain by deviating which depends on out-of-equilibrium beliefs. Partially separating equilibria, when they exist, do not survive the intuitive criterion. To show that, we proceed as for pooling equilibria. For convenience, the analysis is relegated to appendix A.2.

This concludes the proof of Proposition 1, our key result. Given an appropriate equilibrium concept, partial delegation entails full revelation.

In the case of partial delegation, given that the only surviving equilibrium is separating, the principal does not need to rely on messages to become informed. Thus with this organizational structure we can ignore cheap-talk games, with no loss of generality.

4 Centralization

In a centralized mechanism, the principal can still acquire information by simply asking the agent to provide it. Given that the projects and the state of the world cannot be contracted upon, the principal cannot reward or punish the agent if he does not transmit the true information. Thus in a centralised mechanism communication is a cheap-talk game.

If the preferences are not time invariant, the agent could have different incentives to transmit information at different times. Thus P could require A to communicate his private information twice, before each of her decisions.

Obviously, if A communicates the true information at $t = 1$, the second message game is useless.

In these message games, A sends a message to P, who revises her beliefs about θ before making her choice. Beliefs are updated according to Bayes's rule. We represent P's knowledge of the state of the world after the message game at period t by posterior beliefs $M_t = (\mu_L, \mu_H)$ where μ_i, $i = L, H$ is the belief that $\theta = \theta_i$. We call $M_0 = (v_L, v_H)$, the prior beliefs.

In the centralized mechanism, P maximizes her utility according to the knowledge she has available. At time t, P's utility is maximized for

$$d_t^*(M_t) = \underset{d_t}{\operatorname{argmax}}\, \mu_L U_t^P(d_t, \theta_L) + \mu_H U_t^P(d_t, \theta_H). \tag{26}$$

A chooses his message before each decision taken by P (according to (26)), A chooses his message. Centralization is, thus, a four-stage game. For each period there are two stages: Communication and decision.

In a cheap talk game, there is always a babbling equilibrium, where P learns nothing.[15] In addition to this uninformative equilibrium, there may be a separating equilibrium where the agent sends the message m_L if $\theta = \theta_L$ and m_H if $\theta = \theta_H$. In such an equilibrium, the principal's beliefs after receiving the messages m_L and m_H are updated to respectively $\mu_L = \mu(\theta_L | m_L) = 1$ and $\mu_H = \mu(\theta_H | m_H) = 1$. Then, after observing this information, P chooses her preferred project $\hat{d}_t^P(\theta)$.

We now concentrate on the conditions that guarantee that there is an informative equilibrium. There is such an equilibrium if the agent's payoff with the equilibrium message m_i, $i = L, H$ is larger than the payoff he could obtain by deviating and sending the other message m_j, $j \neq i$. By deviating, the agent changes the principal's decision from $\hat{d}_t^P(\theta_i)$ to $\hat{d}_t^P(\theta_j)$.

Consider first the message game played before P chooses d_1. There is a separating equilibrium if in both states A has a higher payoff when P implements $\hat{d}_t^P(\theta_i)$, for $t = 1, 2$, in state θ_i than when P implements $\hat{d}_t^P(\theta_j)$, for $t = 1, 2$, in state θ_i. Thus there is a separating equilibrium if the following

[15] Crawford and Sobel [1982].

two conditions hold simultaneously:

$$\sum_{t=1}^{2} U_t^A(\hat{d}_t^P(\theta_L), \theta_L) \geq \sum_{t=1}^{2} U_t^A(\hat{d}_t^P(\theta_H), \theta_L), \tag{27}$$

$$\sum_{t=1}^{2} U_t^A(\hat{d}_t^P(\theta_H), \theta_H) \geq \sum_{t=1}^{2} U_t^A(\hat{d}_t^P(\theta_L), \theta_H). \tag{28}$$

If these conditions hold, the agent in state θ_i is better off if he sends message m_i than if he deviates to message m_j . Hence, (27) and (28) guarantee that there is an informative equilibrium before P chooses d_1.

Next, suppose that these conditions do not hold. The agent will thus not transmit his private information before the choice of the first project. However after the principal has chosen $d_1 = d_1^*(M_0)$, the agent may wish to disclose the true value of θ before P chooses d_2. A separating equilibrium exists in the second period, if, for $t = 2$, the following two conditions hold simultaneously:

$$U_t^A(\hat{d}_t^P(\theta_L), \theta_L) \geq U_t^A(\hat{d}_t^P(\theta_H), \theta_L), \tag{29}$$

$$U_t^A(\hat{d}_t^P(\theta_H), \theta_H) \geq U_t^A(\hat{d}_t^P(\theta_L), \theta_H). \tag{30}$$

Anticipating that information will be disclosed at $t = 2$, when these two conditions hold, the agent may wish to reveal the information before, if both (29) and (30) are also satisfied at $t = 1$. But this necessarily implies that (27) and (28) are satisfied. We end up with two sets of conditions that guarantee that there is a separating equilibrium at $t = 1$ and at $t = 2$.

We may then have two equilibria, information and no information. The equilibrium played has an important impact on the principal's decision on whether to delegate or not. P will certainly not delegate the project choice to A if she expects that information will be revealed if she retains control. Hence the equilibrium selected by the agent is crucial to understand the decision of the principal on whether to delegate or not.

Likewise, the type of equilibrium played by the agent has an influence on his associated payoff. If there are two equilibria, we can assume that the agent plays the separating equilibrium if this Pareto dominates the babbling equilibrium. This means that, if *in both states*, A has a higher payoff if he sends a state dependent message than if he leaves P uninformed, then he chooses to play the informative equilibrium.

Consider the informative equilibrium at $t = 1$. It Pareto dominates the pooling equilibrium if:

$$\sum_{t=1}^{2} U_t^A(\hat{d}_t^P(\theta_L), \theta_L) \geq \sum_{t=1}^{2} U_t^A(d_t^*(M_0), \theta_L), \tag{31}$$

$$\sum_{t=1}^{2} U_t^A(\hat{d}_t^P(\theta_H), \theta_H) \geq \sum_{t=1}^{2} U_t^A(d_t^*(M_0), \theta_H). \tag{32}$$

Similarly, the informative equilibrium at $t = 2$ Pareto dominates the pooling equilibrium if:

$$U_2^A(\hat{d}_2^P(\theta_L), \theta_L) \geq U_2^A(d_2^*(M_0), \theta_L), \tag{33}$$

$$U_2^A(\hat{d}_2^P(\theta_H), \theta_H) \geq U_2^A(d_2^*(M_0), \theta_H). \tag{34}$$

Proposition 2 *With centralization there is an informative equilibrium at $t = 1$ and it Pareto dominates the uninformative equilibrium if conditions (27), (28), (31) and (32) hold. There is an informative equilibrium at $t = 2$ and it Pareto dominates the uninformative equilibrium if conditions (29), (30), (33) and (34) hold.*

If only (27) and (28) hold, the informative equilibrium exists but it does not dominate the uninformative one; this is also true if only (29) and (30) hold. In these cases, it is not possible to rank the equilibria with the Pareto criterion. We will not make assumptions on which equilibrium is being play in these circumstances. But, in the example developed in the next section, we will show that there is room for partial delegation even if the agent plays the separating equilibrium whenever it exists. Hence, delegation within organizations does not depend on the equilibrium selection in the message game.

To summarize: in the centralized mechanism, either (a) the principal acquires the true information at $t = 1$, or (b) at $t = 2$, or (c) the principal acquires information neither at $t = 1$ nor at $t = 2$. Depending on the information she has available, P implements either her preferred project $\hat{d}_t^P(\theta)$ or $d_t^*(M_0)$. Unlike in the case of partial delegation, under centralization P will not always become informed. Free communication from A to P does not guarantee that P always learns the state of the world.

5 Comparisons of organizational structures

We have just established that the information transmission process could have different results with the two organizational structures. The aim of this section is to determine if (and when) partial delegation is the optimal organizational structure for the principal. - We use an example to show that (1) communication may fail and (2) P may optimally transfer control over the first decision to A. This means that when the agent does not communicate, the loss of control associated with delegation is small when compared to the benefits of the information obtained.

5.1 An example

Consider the following preferences for A and P: $U_t^A = \left(\alpha d_t - \frac{(\theta - d_t)^2}{2}\right)$ and $U_t^P = \left(\beta d_t - \frac{(\theta - d_t)^2}{2}\right)$. These preferences are time invariant and satisfy Assumptions **A1** to **A5**. A's preferred project at time t is $\hat{d}_t^A(\theta) = (\alpha + \theta)$, while P's preferred project is $\hat{d}_t^P(\theta) = (\beta + \theta)$. We suppose that A has a bias toward larger projects, that is $\alpha > \beta$.

Partial delegation Following Proposition 1, under partial delegation the only equilibrium surviving the intuitive criterion is the Riley outcome. In our example, to compute it, we need to identify the relevant incentive constraint. In a separating equilibrium, P's decision at $t = 2$ is $d_2^*(\theta) = \hat{d}_2^P(\theta) = (\beta + \theta)$. Since $\alpha > \beta$, if θ_H, A prefers to signal his type. The relevant incentive constraint is then given by (7) and this defines the set of separating equilibria. Applying the intuitive criterion, the Riley outcome is:

$$(35)\quad d_1^*(\theta_L) = \hat{d}_1^A(\theta_L) = \alpha + \theta_L,$$

$$(36)\quad d_1^*(\theta_H) = \begin{cases} \hat{d}_1^A(\theta_H) = \alpha + \theta_H, & \text{if } \Delta\theta \geq \alpha - \beta, \\ \alpha + \theta_L + \sqrt{(2\alpha - 2\beta - \Delta\theta)\Delta\theta} > \hat{d}_1^A(\theta_H) & \text{otherwise,} \end{cases}$$

$$(37)\quad d_2^*(\theta) = \hat{d}_2^P(\theta) = \beta + \theta.$$

Centralization In the centralized mechanism, P maximizes her utility given her knowledge. At time t, given beliefs $M_t = (\mu_L, \mu_H)$, P's utility is maximized for $d_t^* = (\beta + \mu_L\theta_L + \mu_H\theta_H)$. With preferences time invariant, either all information is transmitted at $t = 1$ or the messages are completely noisy. The following lemma derives the condition for the existence of informative equilibrium and for Pareto dominance.

Lemma 3 *There is informative equilibrium in the message game if and only if* $(\alpha - \beta) \leq \frac{\Delta\theta}{2}$. *This equilibrium Pareto dominates the pooling equilibrium if and only if* $(\alpha - \beta) \leq \frac{v_H \Delta\theta}{2}$.

Proof These conditions correspond to condition (27), (28), (31) and (32) *Q.E.D.*

Comparisons If A reveals his private information in the message game, centralization dominates since it allows the principal to select her preferred project $\hat{d}_t^P(\theta)$ in both periods. If A does not reveal his information in the message game, P faces the following trade-off: either she remains uninformed and take decisions on her own or she delegates d_1 and both decisions are taken by an informed party (A at $t = 1$, P at $t = 2$) but, in the first period, the decision-maker is biased. Thus the question of choosing centralization or partial delegation depends on weighing the value of the information acquired against the losses due to lack of control.

Lemma 4 *Partial delegation is preferred to uninformed centralization if*

$$(\alpha - \beta)^2 \leq 2 v_L v_H \Delta\theta^2. \tag{38}$$

Equation (38) is easily interpreted: Its left hand side represents the loss of control, its right hand side the value of the information. Loss of control can be expressed as the difference between P's expected utility when she takes a decision knowing the true state θ and her utility when A decides $E_\Theta U_1^P(\hat{d}_1^P(\theta), \theta) - E_\Theta U_1^P(\hat{d}_1^A(\theta), \theta) = (\alpha - \beta)^2$. The value of information is the difference in P's expected utility when her decision is based on the true state θ rather than on her prior knowledge. Without knowing θ, P selects the decision $d_t^*(M_0) = (\beta + v_L\theta_L + v_H\theta_H)$. At each period t, information increases P's utility by $E_\Theta U_t^P(\hat{d}_t^P(\theta), \theta) - E_\Theta U_t^P(d_t^*(M_0), \theta) = v_L v_H \Delta\theta^2$. Hence, $(\alpha - \beta)^2$ is the lost utility due to a biased agent and $2 v_L v_H \Delta\theta^2$ is the benefit of having an informed decision-maker in both periods. Note that when partial delegation is preferred to uninformed centralization, the agent selects his preferred project $\hat{d}_1^A(\theta)$ at $t = 1$.[16] To sum up, we have:

PROPOSITION 3 *The principal prefers partial delegation if* $\frac{(\alpha-\beta)}{\sqrt{2v_L v_H}} \leq \Delta\theta \leq \frac{2(\alpha-\beta)}{v_H}$. *This space is non-empty if* $v_L > \frac{1}{9}$.

Partial delegation dominates when $\Delta\theta$ is not large enough to reveal information in the message game, but large enough to have the benefits of information larger than the loss of control. Figure 1 illustrates the result.

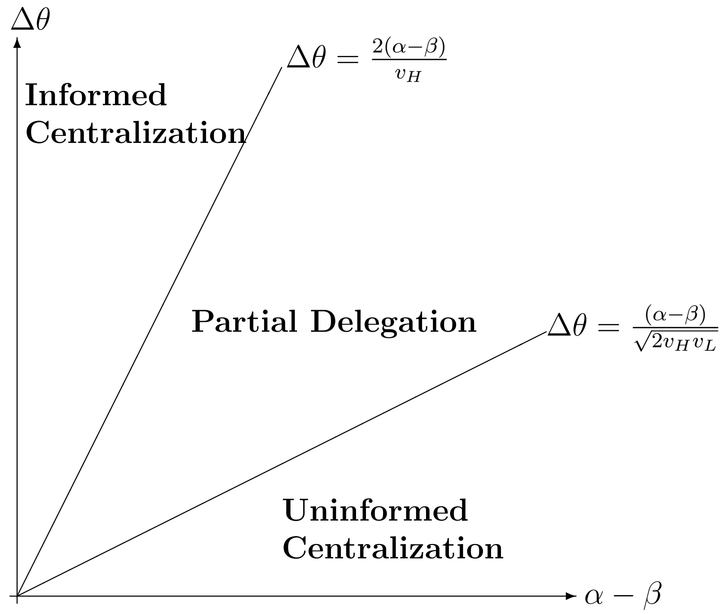

Figure 1: The efficient organizational structure.

Note that if we assume that the agent plays the separating equilibrium in the message game whenever it exists, that is when $(\alpha - \beta) \leq \frac{\Delta\theta}{2}$, we find again a non-empty parameter space where partial delegation is efficient. More precisely, partial delegation is efficient for $\frac{(\alpha-\beta)}{\sqrt{2v_L v_H}} \leq \Delta\theta \leq 2(\alpha - \beta)$. This space is non-empty if $v_L.v_H > \frac{1}{8}$.

The main reason for a transfer of control is not that the agent is better informed, but that information will be transmitted if he has control. Figure

[16]There are additional loss of control if, to signal his type, A does not select his preferred project.

1 shows how differences in the structure of A's private information result in different organizations, with different levels of success. Some manage to acquire information at no cost, some should delegate and suffer the loss of control to acquire information and some should prefer to remain uninformed.

5.2 Complete delegation and partial delegation of d_2

So far we have concentrated only on two organizational structures: Partial delegation and centralization. There are, however, two other possible allocations of the decision rights: Complete delegation and partial delegation of d_2. In both these structures, there is no information transfer. As we can see from the above example, it is clear that these two structures are never optimal.

Consider first complete delegation. If the agent controls the two decisions, he chooses his preferred project $\hat{d}_t^A(\theta)$ in each period t. Compared to partial delegation, this leads to a duplication of the loss of control as the agent also implements $\hat{d}_1^A(\theta)$ when he controls the first decision.

So complete delegation can only dominate partial delegation when in the latter situation (1) the agent chooses a decision $d_1^*(\theta)$ which is not his preferred project and (2) the principal prefers $\hat{d}_1^A(\theta)$ to $d_1^*(\theta)$. In this case, there is an extra loss of control at $t = 1$ under partial delegation and the effects of this must be compared to the extra loss of control at $t = 2$ under complete delegation. If these two conditions are satisfied, complete delegation may emerge as the optimal organizational structure. However as we can see from the above example, the second condition is never satisfied, and complete delegation is always dominated by partial delegation.

Consider next partial delegation of d_2. This organization could emerge if there is large disagreement at $t = 1$ so that partial delegation is not considered an efficient outcome and, in period $t = 2$, the preferences of the agent and the principal are more congruent. In the example, with preferences which do not change over time, delegation of d_2 is always dominated.

5.3 The role of limited liability constraint

Finally, suppose that the agent is not liquidity constrained and that he can buy control over both decisions at the beginning of the relationship, i.e. before he learns θ. We call $E_\Theta U^{K*}$ the expected payoff of player $K = A, P$ under the preferred organizational structure. Both parties are better off if the agent buys the right to take both decisions for an amount ω that satisfies:

$$\sum_t E_\Theta U_t^P(\hat{d}_t^A(\theta),\theta)+\omega \;\geq\; E_\Theta U^{P*}, \tag{39}$$

$$\sum_t E_\Theta U_t^A(\hat{d}_t^A(\theta),\theta)-\omega \;\geq\; E_\Theta U^{A*}. \tag{40}$$

We use now the functional forms of our example to discover the conditions in which the absence of liquidity constraint can make both parties better off, i.e., the conditions to have an ω that satisfies (39) and (40).

PROPOSITION 4 *It is only when the preferred organizational structure is uninformed centralization that an agent who is not liquidity constrained can increase the welfare of both parties.*

PROOF (1) When the preferred organization is informed centralization, $E_\Theta U^{A*} = 2[\alpha(\beta + v_L\theta_L + v_H\theta_H) - \beta^2/2]$ and $E_\Theta U^{P*} = 2[\beta(v_L\theta_L + v_H\theta_H) + \beta^2/2]$. Replacing in (39) and (40), we have:

$$\omega \;\geq\; \frac{(\alpha-\beta)^2}{2}, \tag{41}$$

$$\omega \;\leq\; \frac{(\alpha-\beta)^2}{2}. \tag{42}$$

Clearly, with a cut-off pay of $\omega = \frac{(\alpha-\beta)^2}{2}$, for both parties there is no difference between informed centralization and an organization where the agent buys the control over the two decisions. This is because total welfare does not increase when the agent buys control.

(2) Similarly, when the preferred organization is partial delegation, if A buys control, he cannot increase total welfare. Hence both parties cannot be absolutely better-off

(3) When the preferred organization is uninformed centralization, conditions (39) and (40) are equivalent to:

$$\omega \;\geq\; \frac{1}{2}(v_L v_H \Delta\theta^2 - (\alpha-\beta)^2), \tag{43}$$

$$\omega \;\leq\; \frac{1}{2}(v_L v_H \Delta\theta^2 + (\alpha-\beta)^2). \tag{44}$$

These two equations define the set of ω such that the agent can improve the utility of both parties if he buys the organization from the principal at the beginning of the relationship. *Q.E.D.*

6 Conclusions

Our paper provides a new justification for delegation: In repeated interactions, the delegation of control to the agent results in full revelation of his private information. Thus partial delegation is an instrument that can be used inside an organization in order to discover information. We establish this result in three steps. First, we show that information is fully revealed when the agent gets control. Next, we show that message games may not be informative. Finally we show that, when direct communication fails, partial delegation may be the optimal organizational structure for the principal.

This result means that in different decision processes -centralized or partially delegated- an agent has different incentives to transmit his private information to his superior. To be more precise, we have shown that the agent is more likely to transmit information if he has effective control over the decision than if he is simply required to communicate his piece of information in a centralized decision making process. The reason for this difference is that misrepresenting his type of information is free in a message game while it is costly when the agent controls the decision. In other words, information transfer is more effective when the agent can suffers utility loss if he does not signal his type.

We make three important assumptions in our analysis: We restrict the preferences to a certain class of functions, we consider only two values for the state of the world parameter and we assume that P can commit on a given organizational structure at the beginning of the game. We analyse the implications of each of these assumptions in turn.

With regard to preferences, we consider single peaked utility functions with the principal and the agent diverging on their preferred project. The systematic bias assumption (**A4**) also implies that at time t, in both states, the agent prefers either a larger scale or a lower-scale project than the principal. These assumptions on preferences guarantee possible congruence of interests between the principal and the agent. To be more precise, we assume that in at least one state the agent is better-off if he manages to transmit the true situation to the principal. This does not guarantee that the information will be transmitted in equilibrium and we have shown that it is, indeed, not always the case. But, since our focus is on the possibility of transferring information, either through communication or through a transfer of control, we require that, in at least one state, the agent prefers an informed principal to an uninformed one. We are then able to show that information transmission is the only outcome of partial delegation, even if, in the other state, the agent would have been better off if information were not disclosed. In this respect, assumptions **A4** and **A5** are important for our results to hold. By contrast, if the agent is always better off if he manages to hide his private information, information will never be transmitted and our rationale for delegation disappears.

Our model considers two values for the state of the world parameter. In a more general setting, with N states of the world, the main result still holds: Only the Riley outcome survives the intuitive criterion when signals are free, i.e., if the agent's preferred project belongs to the set of separating equilibria. When signals are costly, the intuitive criterion is not strong enough to eliminate all the pooling equilibria and the equilibrium under delegation may involve some degree of pooling. However, with N states of the world, the argument is similar, even though there is some pooling. We show that one rationale for delegation is information revelation and that, as long as there is some revelation[17], delegation still brings benefits. In these cases the information received by the principal is incomplete, but she can still use what she has to make her choice in the second period. Moreover, with N states of the world communication is noisy, and the principal should not expect the agent to communicate his private information in the cheap-talk game (Crawford and Sobel [1982] and Dessein [2002]). Thus, when communication fails or is imperfect, delegation may still allow her to discover the agent's hidden information. More complex mechanisms mixing communication and delegation may also emerge in this context.[18]

Our analysis assumes that the principal can decide on a given organizational structure at the beginning of the game. If we relax this hypothesis, then in a case of partial delegation, the agent may play a pooling equilibrium in order to receive control in period 2. Hiding information in the first period may be optimal for the agent, if he can make the principal give him control and thus implement his preferred project at date 2. Without com-

[17]This situation occurs when not all the N types pool on the same decision.

[18]For instance, the first project is delegated, while before undertaking the second project, the agent can send some message to the principal. This mechanism doesn't change anything in the two types case because under partial delegation the information is fully transmitted at $t = 1$. In a more general information structure, this mechanism can potentially be preferred to partial delegation and centralization.

mitment, a pooling equilibrium can survive the intuitive criterion because, unlike in the case of commitment, in both states the agent has an incentive to misrepresent his type of information. Hence, two equilibria may coexist under partial delegation: A pooling equilibrium where the agent hides his information and receives control at date 2 and the separating equilibrium described in Proposition 1. If the principal anticipates that the agent will play a pooling equilibrium at date 1, she will not give up control in the first period. Thus, if there is no commitment to the organizational structure, partial delegation of d_2 may be the optimal organizational structure. Lack of commitment could drastically change the organizational structure.

Appendix

A.1 Proof of Lemma 2

Restating Lemma 2, to each d_1^*, we can associate a $\tilde{d}_1$ such that:

$$\text{(A1)} \qquad U_1^A(d_1^*, \theta_L) + U_2^A(d_2^*, \theta_L) \geq U_1^A(\tilde{d}_1, \theta_L) + U_2^A(X, \theta_L),$$

$$\text{(A2)} \qquad U_1^A(\tilde{d}_1, \theta_H) + U_2^A(\hat{d}_2^P(\theta_H), \theta_H) \geq U_1^A(d_1^*, \theta_H) + U_2^A(d_2^*, \theta_H),$$

where X is either $\hat{d}_2^P(\theta_L)$, d_2^* or $\hat{d}_2^P(\theta_H)$

Assume that there exists $\tilde{d}_1$ such that:

$$\text{(A3)} \qquad U_1^A(\tilde{d}_1, \theta_H) + U_2^A(\hat{d}_2^P(\theta_H), \theta_H) = U_1^A(d_1^*, \theta_H) + U_2^A(d_2^*, \theta_H),$$

$$\text{(A4)} \qquad \tilde{d}_1 > \hat{d}_1^A(\theta_H).$$

Given such a value of $\tilde{d}_1$, in θ_H, A is indifferent between the pooling equilibrium (d_1^*, d_2^*) and $(\tilde{d}_1, \hat{d}_2^P(\theta_H))$. Therefore, part (ii) of the Lemma is satisfied.[19] Given that, in θ_H, A prefers to signal his type, the function on the right hand side of (A3) is a vertical translation of the one on the left hand side. Therefore, $\tilde{d}_1$ always exists (actually two values $\tilde{d}_1$ satisfy (A3) by the single peak assumption. We select those on the right of $\hat{d}_1^A(\theta_H)$). Figure 2 illustrates the selection of $\tilde{d}_1$ (and shows its existence).

Now, we focus on part (i). This condition is satisfied if (A1) holds whatever the beliefs associated with the observation of $\tilde{d}_1$. First of all, notice that, by construction, $U_1^A(\tilde{d}_1, \theta_L) < U_1^A(d_1^*, \theta_L)$.

[19] To have strict preference take $\tilde{d}_1 - \epsilon$.

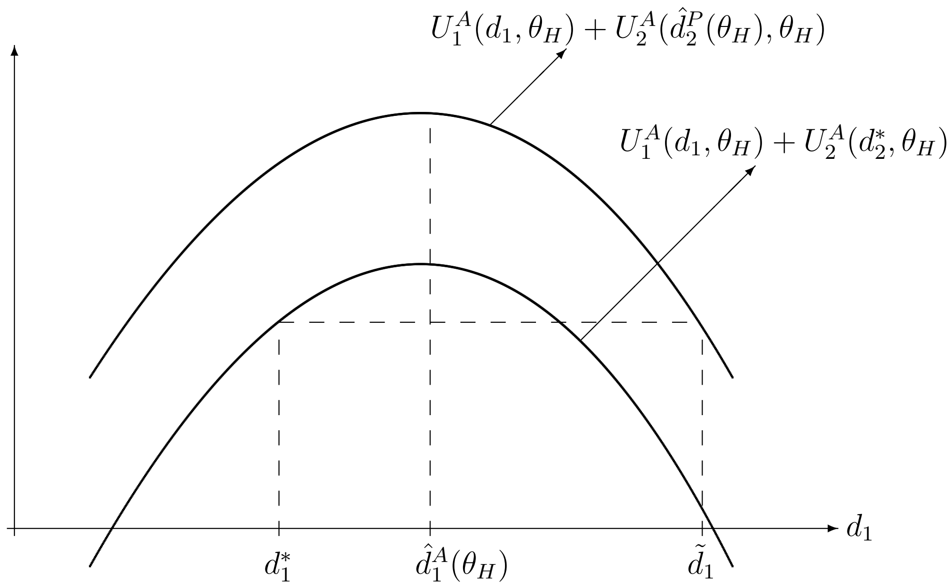

Figure 2: $\tilde{d}_1$ defined by equations (A3) and (A4).

If the beliefs associated with $\tilde{d}_1$ are $\mu(\theta_L|\tilde{d}_1) = 1$ ($X = \hat{d}_2^P(\theta_L)$), in θ_L, A loses in both periods: $U_1^A(\tilde{d}_1,\theta_L) < U_1^A(d_1^*,\theta_L)$ and $U_2^A(\hat{d}_2^P(\theta_L),\theta_L) < U_2^A(d_2^*,\theta_L)$ by definition of case N1. Hence, (25) is satisfied.

If the beliefs associated with $\tilde{d}_1$ are $\mu(\theta_L|\tilde{d}_1) = v_L$ ($X = d_2^*$), (A1) is also satisfied, because $U_1^A(\tilde{d}_1,\theta_L) < U_1^A(d_1^*,\theta_L)$ and $U_2^A(d_2^*,\theta_L) = U_2^A(d_2^*,\theta_L)$.

If the beliefs associated with $\tilde{d}_1$ are $\mu(\theta_L|\tilde{d}_1) = 0$ ($X = \hat{d}_2^P(\theta_H)$), (A1) is satisfied for sure if A loses in both periods, that is if $U_2^A(\hat{d}_2^P(\theta_H),\theta_L) < U_2^A(d_2^*,\theta_L)$.

If this last condition is not satisfied, there is as before a first period cost associated with leaving the pooling but there is also a second period benefit given by:

(A5) $$U_2^A(\hat{d}_2^P(\theta_H),\theta_L) - U_2^A(d_2^*,\theta_L) > 0.$$

We now use the increasing difference assumption to show that the pooling equilibrium does not survive the intuitive criterion. Since $\tilde{d}_1 > d_1^*$ and $\hat{d}_2^P(\theta_H) > d_2^*$, ID implies that:

(A6) $$U_1^A(\tilde{d}_1,\theta_H) - U_1^A(d_1^*,\theta_H) > U_1^A(\tilde{d}_1,\theta_L) - U_1^A(d_1^*,\theta_L)$$

and

(A7) $$U_2^A(\hat{d}_2^P(\theta_H),\theta_H) - U_2^A(d_2^*,\theta_H) > U_2^A(\hat{d}_2^P(\theta_H),\theta_L) - U_2^A(d_2^*,\theta_L).$$

(A3) and (A7) imply:

(A8) $$U_2^A(d_2^*,\theta_L) - U_2^A(\hat{d}_2^P(\theta_H),\theta_L) > U_1^A(\tilde{d}_1,\theta_H) - U_1^A(d_1^*,\theta_H).$$

(A6) and (A8) together imply:

(A9) $$U_2^A(d_2^*,\theta_L) - U_2^A(\hat{d}_2^P(\theta_H),\theta_L) > U_1^A(\tilde{d}_1,\theta_L) - U_1^A(d_1^*,\theta_L).$$

Rearranging the terms in this last equation, we obtain (A1). Hence, our candidate $\tilde{d}_1$ satisfies both conditions of Lemma 2.

A.2 Elimination of partially separating equilibria

Consider the partially separating equilibrium in which A randomizes in state θ_L. A selects in state θ_L his preferred project $\hat{d}_1^A(\theta_L)$ with probability q^*, defined in (25) for $i = L$ and $j = H$, and $\hat{d}_1^A(\theta_H)$ with probability $1 - q^*$. In state θ_H, A selects $\hat{d}_1^A(\theta_H)$ with probability one.

This constitutes an equilibrium if the equilibrium payoff of A in state θ_L is higher than what he could obtain by deviating. Consider a deviation to $\hat{d}_1^A(\theta_L) + \epsilon$. The associated payoff depends on P's beliefs about $\hat{d}_1^A(\theta_L) + \epsilon$. Beliefs could be either $\mu(\theta_L|\hat{d}_1^A(\theta_L) + \epsilon) = v_L$ or $\mu(\theta_L|\hat{d}_1^A(\theta_L) + \epsilon) = 1$. In the former case, the deviation payoff for A in state θ_L is $U_1^A(\hat{d}_1^A(\theta_L) + \epsilon, \theta_L) + U_2^A(d_2^*, \theta_L)$ where d_2^* is given by (18). In the latter case, the deviation payoff is $U_1^A(\hat{d}_1^A(\theta_L) + \epsilon, \theta_L) + U_2^A(\hat{d}_2^P(\theta_L), \theta_L)$. In the sequel, we suppose that the out-of-equilibrium beliefs are those associated with the highest deviation payoff, though the argument developed below generalizes to the other case.

Suppose that the above partially separating equilibrium exists. We use the following lemma, which establishes that the partially separating equilibrium does not survive the intuitive criterion.

LEMMA 5 *There exists $\tilde{d}_1$ such that:*
(i) if θ_L, A prefers the partially separating equilibrium to $\tilde{d}_1$, whatever the beliefs associated with $\tilde{d}_1$.
(ii) if θ_H, A prefers $\tilde{d}_1$ to the partially separating equilibrium if P believes that $\mu(\theta_L|\tilde{d}_1) = 0$.

PROOF Define $\tilde{d}_1$ as:

(A10) $$U_1^A(\tilde{d}_1, \theta_H) + U_2^A(\hat{d}_2^P(\theta_H), \theta_H) = U_1^A(\hat{d}_1^A(\theta_H), \theta_H) + U_2^A(d_2^*(\mu(q^*)), \theta_H),$$

(A11) $$\tilde{d}_1 > \hat{d}_1^A(\theta_H),$$

where $\mu(q^*) = (\mu_L(q^*), \mu_H(q^*))$. We know from the proof of lemma 2 that such a $\tilde{d}_1$ exists. By definition $\tilde{d}_1$ satisfies part (ii) of the lemma.

We must then show that the equilibrium payoff of A in state θ_L is higher than the payoff associated with a deviation to $\tilde{d}_1$ whatever the beliefs associated with. If the beliefs are $\mu(\theta_L|\tilde{d}_1) = 1$, the equilibrium payoff is clearly higher. Otherwise, it would have been profitable for A to deviate to $\hat{d}_1^A(\theta_L)+\epsilon$ which would have broken the equilibrium.

We must then only consider the case in which $\mu(\theta_L|\tilde{d}_1) = 0$. In this case, a deviation from the equilibrium could be profitable only if $U_2^A(\hat{d}_2^P(\theta_H), \theta_L) - U_2^A(\hat{d}_2^P(\theta_L), \theta_L) > 0$. We assume now that this condition is satisified.

By definition of q^*, the equilibrium payoff of A is

(A12) $$\begin{aligned} &U_1^A(\hat{d}_1^A(\theta_L), \theta_L) + U_2^A(\hat{d}_2^P(\theta_L), \theta_L) = \\ &U_1^A(\hat{d}_1^A(\theta_H), \theta_L) + U_2^A(d_2^*(\mu(q^*)), \theta_L). \end{aligned}$$

To prove the lemma, we must show that

(A13) $$U_1^A(\hat{d}_1^A(\theta_H), \theta_L) + U_2^A(d_2^*(\mu(q^*)), \theta_L) > U_1^A(\tilde{d}_1, \theta_L) + U_2^A(\hat{d}_2^P(\theta_H), \theta_L).$$

Since $\tilde{d}_1 > \hat{d}_1^A(\theta_H)$ and $\hat{d}_2^P(\theta_H) > d_2^*(\mu(q^*))$, ID implies the following:

(A14) $$U_1^A(\tilde{d}_1, \theta_H) - U_1^A(\tilde{d}_1, \theta_L) > U_1^A(\hat{d}_1^A(\theta_H), \theta_H) - U_1^A(\hat{d}_1^A(\theta_H), \theta_L),$$

(A15) $$\begin{aligned} &U_2^A(\hat{d}_2^P(\theta_H), \theta_H) - U_2^A(\hat{d}_2^P(\theta_H), \theta_L) > \\ &U_2^A(d_2^*(\mu(q^*)), \theta_H) - U_2^A(d_2^*(\mu(q^*)), \theta_L). \end{aligned}$$

(A10) and (A14) imply:

$$U_2^A(d_2^*(\mu(q^*)) - U_2^A(\hat{d}_2^P(\theta_H), \theta_H) > U_1^A(\tilde{d}_1, \theta_L) - U_1^A(\hat{d}_1^A(\theta_H), \theta_L).$$

(A15) is equivalent to:

$$U_2^A(d_2^*(\mu(q^*)) - U_2^A(\hat{d}_2^P(\theta_H), \theta_H) < U_2^A(d_2^*(\mu(q^*)), \theta_L) - U_2^A(\hat{d}_2^P(\theta_H), \theta_L).$$

Combining these two equations, we obtain (A13). Hence, our candidate $\tilde{d}_1$ satisfies both conditions of Lemma 5. Then, the partially separating equilibrium does not survive the intuitive criterion. *Q.E.D.*

With a similar argument, the partially separating equilibrium in which A randomizes in state θ_H can also be eliminated.

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