Delegation and information revelation*

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Abstract

This paper addresses the question of delegation in an organization where there is an initial asymmetry of information between the principal and the agent. We assume that the principal cannot use revelation techniques à la Baron Myerson to elicit agent's superior information and in contrast, we posit that the decision and the state of the world parameter cannot be contracted for. With these simple contracts, we show that delegation is an alternative to contracting to elicit agent's information. We can show that delegated decisions completely reveal the state of the world to the principal. Therefore the principal can extract agent's information by giving up the control right over some decisions. As the organization takes a sequence of decisions, the information learned by the principal can be used for the other decisions. So delegation is only partial: the principal delegates some decisions and keeps control over other.

keywords: Delegation, Asymmetric information, Incomplete contract, Signalling game

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1 Introduction

This paper addresses the question of delegation in a principal-agent setting with asymmetric information. We develop the idea that the principal may find an advantage in delegating decisions to the better informed agent[1] in order to acquire information. By contrast to other papers, we show that the information is not transmitted through revelation contracts but through delegated decisions. And hence, delegation is an alternative to contracts to transfer information within organizations.

In the literature[2], the trade off between delegation and centralization is often a simple trade off between loss of control associated with delegation and informational benefits when the delegated is better informed than his supervisor.

Loss of control comes from diverging interests between the principal and the agent(s). When the principal gives some power to the agent, he implements his preferred decision rather than the principal's one.

Benefits of a delegated structure could be a better communication (Melumad, Mookherjee and Reichelstein [1992]), a better ability to prevent collusion (Laffont Martimort [1998] and Felli [1996]), an informed decider (Legros [1993], Dessein [1999]) or increased incentives provided to the agent (Aghion and Tirole [1997]).

In this paper, we show that delegation is useful to reduce the initial asymmetry of information between the principal and the agent and that delegation can play the same role as complete contracts.

To show that, we model an organization composed of one principal and one agent. The organization should take a sequence of (two) decisions affected by a common state of the world parameter. There is an initial asymmetry of information between the principal and the subordinate agent: the agent knows the state of the world parameter while the principal has only some prior about its distribution. Moreover, we assume that the agent and the principal have diverging interests[3]. They disagree on the choice of the optimal decisions.

We assume that the principal cannot use revelation techniques à la Baron Myerson to elicit agent's superior information. In contrast, we adopt an incomplete contract framework (Grossman and Hart [1986], Hart and Moore [1990], Hart [1995] and Tirole [1999]) and posit that the decisions and the state of the world parameter cannot be contracted for, neither ex-ante nor ex-post. Therefore, the remaining contracting variable is the allocation of decision rights. The only feasible contract is to decide who is in charge of each decision.

[1] We will refer as 'she' for the principal and 'he' for the agent.

[2] In the standard principal agent theory, following the revelation principle (Myerson, [1982]), delegation is always weakly dominated by a grand contract between the principal and all the agents. To speak about delegation in a principal agent setting, one needs to relax some assumption of the revelation principle. Melumad, Mookherjee and Reichelstein [1992] relax the assumption of perfect communication between the principal and the agent, Felli [1996] relaxes the assumption of infinitely costly communication between agents, in order to allow collusion. Laffont and Martimort [1998] assume that communication between the principal and the agents is imperfect and that side contracting between agents is feasible. Aghion and Tirole [1997] and this paper assume that the contracts are incomplete.

[3] In the financial literature for example, it is often assumed that managers have a preference for empire (Jensen [1986], Harris and Raviv [1998]).

Focusing on that simple contract is a convenient way to study how the agent's decision can *signal* his information to the principal. After observing the agent's decision (if he has power to decide), the principal revises her prior about the state of the world and use this new information to take subsequent decisions. Using an appropriate equilibrium refinement, Cho and Kreps [1987] intuitive criterion, we can show that delegated decisions completely reveal the state of the world to the principal. Therefore the principal can extract agent's information by giving up the control right over some decisions. As the organization takes a sequence of decisions, the information learned by the principal can be used for the other decisions. So delegation is only partial: the principal delegates some decisions and keeps control over other.

Using the properties of signaling games, we show that delegation plays the same role as complete contract: it transfers perfectly information from the agent to the principal. If the result is the same, the two mechanisms work differently: when the principal *contracts* with the agent, information is transmitted through a report by the agent and the agent is rewarded according to the contract and his report. When the principal *delegates* decision, the information is transmitted through decision. By observing agent's choice, the principal becomes informed about the agent's private information. We establish this property of delegation by using the results of the signaling game literature.

This result should be contrasted with the results of the literature on dynamic incentive contracts[4] where there can be pooling (information revelation is delayed). In our delegated mechanism, the separating equilibrium emerges as the sole surviving equilibrium and so there is no delay in information revelation[5].

Delegation is costly for the principal: as the agent doesn't share her preferences, delegation entails loss of control. And these can be high relative to the benefits of delegation. So delegation does not always emerge as the optimal organizational form.

Last, we try to see how the principal can limit the use (or abuse) of the decision right by the agent by imposing some rules that constraint the choice of the subordinate agent. We analyses rules that take the form of a limitation of the agents' subset of actions. In most case, a rule is useful tool to mitigate the losses of control but it has some limits. These limits are the requirement that the delegated decision remains informative (the principal should learn something by observing it) and that the rule doesn't constraint the agent to quit the organization (he must receive at least his reservation utility). Within these limits, we describe what is in our framework an optimal rule. Even if the principal can restrict the agent's discretion, she cannot suppress all the costs associated with delegation.

There are several papers related to ours. Aghion and Tirole [1997], study the rational for delegation in a structure where the asymmetry of information between the principal and the agent is endogenous. They show that giving authority to the subordinate increases his incentive to be informed, which in turn increases his effective control over decisions (sometimes at the expense of the principal). The trade off studied by these authors is between loss of control and the agent's increased initiative under delegation. Another paper that studies the rationale for delegation in an incomplete contract set up is Dessein [1999]. He shows that the trade off between delegation and no delegation, where the

[4]Freixas Guesnerie and Tirole [1985], Laffont and Tirole [1988]

[5]This difference comes from the fact that the principal can perfectly commit to the second period contract by giving up the right to decide to the agent for the first decision only.

agent only communicates some information to the principal, is a trade off between loss of control and loss of information. Under delegation, the decision is based on perfect information but take by an agent who doesn't share organization's preferences, while under no delegation, there is no bias in the decision but the information transmitted by the agent is noisy (à la Crawford Sobel): the principal doesn't learn the state of the world from the message transmitted by the agent but only improves her prior. In Legros [1993], at each period the principal delegates the choice of a policy to an agent with unknown preference. While taking a decision, the delegate trades off the immediate gain of taking his preferred decision (or a decision close to his preferred one) and the information about his preferences transmitted through the decision to the principal. This information is important because it affects the probability of being chosen as a delegate for the next period. By contrast to this paper, Legros shows that, when there is an asymmetry of information about preferences, the decisions cannot be completely informative and there is some bunching between types.

The paper is organized as follow: in the next section, we present the model. In section 3, we describe the equilibrium decisions under the different organizational forms. We look, in section 4, at the costs and benefits of delegation. In section 5, we describe how the principal may restrain the agent's discretionary power, and how this affects the outcome of the game. Section 6 discusses some extensions and section 7 concludes.

2 Model

We model an organization composed of one principal and one agent. This organization takes a sequence of two decisions (labeled d_1 and d_2) These decisions affect the welfare of both organization's members[6]. The utility of the principal and the agent are also affected by a common environmental parameter θ. This parameter is constant over periods[7][8].

Contractual restrictions In this model, the only contracting variable is the allocation of decision rights over d_1 and d_2. These decision rights are allocated by the principal at the beginning of the first period either to herself or to the agent[9]. These contractual restrictions are consistent with the incomplete contract view of organizations. Giving authority to a subordinate agent is giving the right to select a decision from an allowed set (see Simon [1958], Grossman and Hart [1986], Hart and Moore [1990], Aghion and Tirole [1997]).

[6] Even if there is no dynamic in the model, we will sometimes refer to d_1 as the first period decision and d_2 as the second period decision.

[7] This is a simplification. We can alternatively assume that the state of the world changes over periods and that there is some correlation between the state of the world in the two periods. In this case, the results of the paper remains 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 (Laffont and Tirole [1988])

[9] The fact that the principal initially possess decision rights over both decisions can be justified by ownership of physical assets that confers the right to decide about their use (Grossman and Hart [1986]) or by institutional agreement, as it is the case in political decisions (Aghion and Tirole [1997]).

Environmental parameter We assume that the agent knows the "state of the world". This environmental parameter affects the utility of both the principal and the agent. The state of the world is drawn out of a set Θ from a common knowledge distribution $F(\theta)$. For simplicity, we assume[10] that $\Theta = \{\theta_1, \theta_2\}$, with $\theta_1 < \theta_2$ and we call $\Delta\theta = \theta_2 - \theta_1$. The probability that θ equals θ_1 is denoted v_1, the probability of $\theta = \theta_2$ equals $v_2 = 1 - v_1$.

Decisions The choice of a decision represents the choice of a project implemented by the organization. The project is one dimensional. We suppose that there is a continuum of possible decisions given by $]0, +\infty[$.

Utility functions We assume that the agent and the principal have Euclidian preferences: they have a preferred project d_1 and d_2 and their utility is a quadratic function of the distance between their preferred project and the selected project. More precisely, we assume that the utility of the agent is:

$$U^A = \alpha_1 d_1 - \frac{(\theta - d_1)^2}{2} + \alpha_2 d_2 - \frac{(\theta - d_2)^2}{2}$$

The utility of the principal is:

$$U^P = \beta_1 d_1 - \frac{(\theta - d_1)^2}{2} + \beta_2 d_2 - \frac{(\theta - d_2)^2}{2}$$

These utility functions exhibit three characteristics: first, the divergence of interest between the principal and the agent is measured by the different private benefit associated with each decision: $\alpha_i d_i$ and $\beta_i d_i$, $i = 1, 2$. These private benefits are measured in monetary units. Second, the cost is state dependent and identical for the principal and the agent. The cost of implementing a decision d_i in state θ is: $\frac{(\theta - d_i)^2}{2}$. Third, these functions are single peaked in each decision. The single peak assumption implies that the utility of the agent and the principal achieves a unique maximum in each decision for d_i equals to respectively $\alpha_i + \theta$ and $\beta_i + \theta$. A high θ pushes up the ideal point of both the principal and the agent. So the interest of the two members are not completely antinomic. The ratios $\frac{\alpha_1}{\alpha_2}$ and $\frac{\beta_1}{\beta_2}$ measure the relative importance of d_1 over d_2 for the agent and the principal[11].

Note that these utility functions satisfy (trivially) the single crossing property.

Agent's participation: individual rationality After learning θ and the allocation of decision rights (the organizational form), the agent has the possibility of quitting the organization. We assume that the agent has an outside opportunity that gives him a utility level normalized to zero. If the agent refuses to participate in the organization, it shuts down and both the principal and the agent get a zero payoff. A simple way to force the participation of the agent when d_1 and d_2 are such that $U^A(\theta, d_1, d_2) < 0$ is to pay to the agent an unconditional wage W such that: $U^A(\theta, d_1, d_2) + W = 0$. In this case, only ex ante efficient organizations, organizations such that the total welfare (ex ante) is positive

[10]The two states of the world framework simplifies the signalling game between, the principal and the agent without making it trivial. The model is extended to N types in section 7.

[11]Assuming that these ratios are different from one, helps us to identify more clearly in the analysis the influence of the first and the second decision.

($EU^P + U^A \geq 0$), are carried out. For the remaining of the paper we assume that the private benefits associated with decisions are large enough and we ignore participation constraints.

Timing of events The timing of decisions is as follow:

- The principal allocates decision rights.
- The agent observes the state of the world.
- The agent decides to stay within the organization or quit it.
- The first decision d_1 is taken (and observed)
- The second decision d_2 is taken
- Payoffs are realized and collected

3 Equilibrium decisions

We assume that the only contracting variable is the allocation of decision rights over d_1 and d_2. There are four possible allocations of decisions right: centralization, delegation, complete delegation and second period delegation. We call *centralization* the case in which the principal keeps the decision rights over both decisions, *delegation* (or *first period delegation*) the case in which the better informed agent receives the decision right over d_1; *complete delegation* is the allocation of both decision rights to the agent and *second period delegation* is the allocation of d_1 to the principal and d_2 to the agent. This section describes the outcome of the game under these four organizational forms.

3.1 Centralization

Under centralization, the principal does not know the state of the world θ till the end of the game and the realization of costs. She therefore takes decisions that are not contingent on the value of θ. These decisions are chosen in order to maximize the principal's expected utility and are given by the following equations:

$$d_1 = v_1\theta_1 + v_2\theta_2 + \beta_1 = E\theta + \beta_1 \tag{1}$$

$$d_2 = v_1\theta_1 + v_2\theta_2 + \beta_2 = E\theta + \beta_2 \tag{2}$$

3.2 Delegation

When the principal delegates d_1 to the agent, she observes agent's decision before choosing d_2. This observation imposes a revision of her prior believes about the distribution of the state of the world parameter θ. The game played by the principal and the agent is a standard signalling game. The equilibrium concept used in this kind of game is the Bayesian Nash equilibrium (BNE).

Definition 1 *A BNE of this signalling game is :*$\{d_1^*(\theta_1), d_1^*(\theta_2), d_2^*(\theta_1),$
$d_2^*(\theta_2), \mu(d_1)\}$ *where*

$$d_1^*(\theta_i) \in \underset{d_1}{\operatorname{argmax}}\, U^A(\theta_i | d_2^*, d_1^*(\theta_j), \mu(d_1))$$

$$d_2^*(\theta_i) \in \underset{d_2}{\operatorname{argmax}}\, U^P(.|d_1^*, \mu(d_1))$$

and $\mu(d_1)$ *are the posterior distribution of* θ *after the principal has observed* d_1*. These posterior beliefs are computed with Bayes rule.*

This kind of game usually has multiple equilibria. We use the intuitive criterion (Cho-Kreps, [1987]) to select among all the possible equilibria.

Definition 2 *A BNE does not satisfy the intuitive criterion if* $\exists\, d_1$ *such that:*

$$U^A(\theta_i, d_1) \leq U^A(\theta_i, d_1^*(\theta_i))$$

and

$$U^A(\theta_j, d_1) \geq U^A(\theta_j, d_1^*(\theta_j))$$

with at least one strict inequality.

In the remaining of this section, we describe the outcome of the signalling game played by the principal and the agent when the principal delegates d_1. The difficulty of this task comes from the fact the game is a non standard one and incentive constraints can go in both direction . We start by describing the separating equilibria, after we analyze the pooling equilibria. For convenience, part of the analysis has been relegated to an appendix. Our results are summarized in proposition 1.

Separating equilibria: The set of separating equilibria is the set of $\{d_1^*(\theta_1), d_1^*(\theta_2), d_2^*(\theta_1), d_2^*(\theta_2)\}$ that satisfy the following incentive compatible constraints:

$$U^A(\theta_1, d_1^*(\theta_1), d_2^*(\theta_1)) \geq U^A(\theta_1, d_1^*(\theta_2), d_2^*(\theta_2)) \qquad (IC_1)$$

$$U^A(\theta_2, d_1^*(\theta_2), d_2^*(\theta_2)) \geq U^A(\theta_2, d_1^*(\theta_1), d_2^*(\theta_1)) \qquad (IC_2)$$

In a separating equilibrium, the equilibrium beliefs are: $\mu\left(\theta_1 | d_1^*(\theta_1)\right) = 1, \mu\left(\theta_1 | d_1^*(\theta_2)\right) = 0$. With these beliefs we can compute $d_2^*(\theta)$:

$$d_2^*(\theta) = \beta_2 + \theta \qquad (3)$$

Using (3) and the definition of U^A, the constraint IC_1 and IC_2 become:

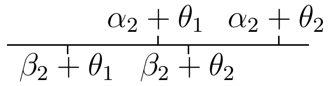
$$(\alpha_1 + \theta_1)(d_1^*(\theta_1) - d_1^*(\theta_2)) + \frac{1}{2}(d_1^*(\theta_2)^2 - d_1^*(\theta_1)^2) \geq \Delta\theta(\alpha_2 - \beta_2 - \frac{\Delta\theta}{2}) \qquad (IC_1')$$

$$(\alpha_1 + \theta_2)(d_1^*(\theta_2) - d_1^*(\theta_1)) + \frac{1}{2}(d_1^*(\theta_1)^2 - d_1^*(\theta_2)^2) \geq \Delta\theta(\beta_2 - \alpha_2 - \frac{\Delta\theta}{2}) \qquad (IC_2')$$

To characterize the separating equilibrium, we have to identify the relevant incentive constraint. The right hand side (RHS) of IC_i' represents the benefits[12] for type θ_i of mimicking the type θ_j; $i, j = 1, 2$. There are 3 possible cases:

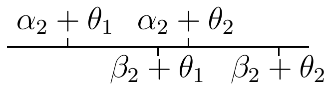
<u>Case S.1</u>: the RHS of IC_1' is positive ($\alpha_2 - \beta_2 - \frac{\Delta\theta}{2} \geq 0$), in this case, the utility of θ_1 increases if he acts as θ_2. This expression simply means that $\beta_2 + \theta_2$ is closest to $\alpha_2 + \theta_1$ than $\beta_2 + \theta_1$ and ceteris paribus, agent θ_1 prefers $d_1^*(\theta_2)$.

Case S1: $\alpha_2 - \beta_2 \geq \frac{\Delta\theta}{2}$



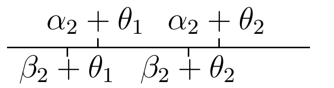
<u>Case S.2:</u> The RHS of IC_2' is positive ($\beta_2 - \alpha_2 - \frac{\Delta\theta}{2} \geq 0$), in this case, the utility of θ_2 increases if he acts as θ_1.

Case S2: $\beta_2 - \alpha_2 \geq \frac{\Delta\theta}{2}$



<u>Case S.3</u>: Both RHS are negative which means that no type has an incentive to misrepresent his type[13].

Case S3: $|\beta_2 - \alpha_2| \leq \frac{\Delta\theta}{2}$



<u>Case S.1:</u> Suppose that $\alpha_2 - \beta_2 - \frac{\Delta\theta}{2} \geq 0$. The set of separating equilibrium is:

$$d_1^*(\theta_1) = \alpha_1 + \theta_1 \tag{4}$$

$$d_1^*(\theta_2) \in D \equiv \{d_1(\theta_2)|IC_1', IR_2\} \tag{5}$$

This equilibrium is supported by pessimistic beliefs: $\mu(\theta_1|d_1) = 1, \forall\ d_1 \neq d_1^*(\theta_2)$ and $\mu(\theta_1|d_1^*(\theta_2)) = 0$.

The set D is the set of decisions that satisfy the participation constraint for type θ_2 and the constraint IC_1'. Ignoring IR_2, the set $D \equiv]0, \alpha_1+\theta_1-\sqrt{K_1}] \cup [\alpha_1+\theta_1+\sqrt{K_1}, +\infty[$; $K_1 = (2\alpha_2 - 2\beta_2 - \Delta\theta)\Delta\theta$.

Now we us the intuitive criterion to select one equilibrium in D. Consider a deviation by θ_2 from $d_1^*(\theta_2)$ to $d_1 \in D$. By definition of the set D, such a deviation can benefit the agent only in state θ_2. Therefore, the intuitive criterion imposes that the beliefs associated with $d_1 \in D$ should be updated to $\mu(\theta_1|d_1 \in D) = 0$.

[12]By benefits, we mean the difference in $U^A(\theta_i)$ when the principal chooses $d_2 = \beta_2 + \theta_j$ rather than $d_2 = \beta_2 + \theta_i$.

[13]It is impossible to have the two incentive constraints relevant at the same time. This comes from the single crossing property of the utility function.

And hence, a rational agent θ_2 will select his preferred decision within D. The only equilibrium surviving the intuitive criterion is: $d_1^*(\theta_2) = \alpha_1 + \theta_2$ if $\alpha_2 - \beta_2 \leq \Delta\theta$ and $d_1^*(\theta_2) = \alpha_1 + \theta_1 + \sqrt{K_1} = \alpha_1 + \theta_2 + (\sqrt{K_1} - \Delta\theta)$ otherwise. In the first case, $\alpha_1 + \theta_2 \in D$[14], in the second case, $d_1^*(\theta_2)$ is the decision closest to $\alpha_1 + \theta_2$ within D[15].

The cases S.2 and S.3 which are similar to S.1 are relegated to appendix A.1.

To sum up our finding, in the case of separating equilibria, there is only one equilibrium that survives the intuitive criterion. This equilibrium is what is called the least costly separating equilibrium (LCS). Now let's turn to the case of pooling equilibria.

Pooling equilibria In a pooling equilibrium: $d_1^*(\theta_1) = d_1^* = d_1^*(\theta_2)$, $\mu(\theta_1|d_1^*) = v_1$ and then $d_2^* = E\theta + \beta_2$. To define the set of pooling equilibria, we have to define out-of-equilibrium beliefs that support the equilibrium. To do this, we distinguish three cases:

In case P.1, regarding the second decision, the agent θ_1 prefers the pooling decision $d_2 = \beta_2 + E\theta$ to the signalling decision $d_2 = \beta_2 + \theta_1$. We are in case P.1 when the distance between $\alpha_2 + \theta_1$ and $\beta_2 + E\theta$ is smaller than the distance between $\alpha_2 + \theta_1$ and $\beta_2 + \theta_1$. This condition is met when (i) $\alpha_2 + \theta_1 \geq \beta_2 + E\theta$ or when (ii) $\alpha_2 + \theta_1 \leq \beta_2 + E\theta$ and $\alpha_2 - \beta_2 \geq \frac{v_2\Delta\theta}{2}$. When θ_1 prefers the pooling decision, θ_2 prefers the separating decision $\beta_2 + \theta_2$ to the pooling solution because, the conditions (i) and (ii) could be satisfied only if $\alpha_2 > \beta_2$ but then $\alpha_2 + \theta_2 > \beta_2 + \theta_2 > \beta_2 + E\theta$. Then, in case P.1, the pooling equilibrium is supported by out-of-equilibrium beliefs: $\mu(\theta_1|d_1 \neq d_1^*) = 1$.

Case P.1

$\alpha_2 + \theta_1$

$\beta_2 + \theta_1$ $\beta_2 + E\theta$

In case P.2, the agent θ_2 prefers pooling decision d_2^* to the separating decision $\beta_2 + \theta_2$. The case P.2 corresponds to the conditions: (i) $\alpha_2 + \theta_2 \leq \beta_2 + E\theta$ or (ii) $\alpha_2 + \theta_2 \geq \beta_2 + E\theta$ and $\beta_2 - \alpha_2 \geq \frac{v_1\Delta\theta}{2}$. If θ_2 prefers the pooling decision, θ_1 prefers the separating. The argument is the same as in P.1: to have (i) or (ii) satisfied, one needs $\beta_2 > \alpha_2$ but then $\alpha_2 + \theta_1 > \beta_2 + \theta_1 > \beta_2 + E\theta$. Then in case P.2, the pooling equilibrium is supported by out-of-equilibrium beliefs: $\mu(\theta_1|d_1 \neq d_1^*) = 0$.

Case P.2

$\alpha_2 + \theta_2$

$\beta_2 + E\theta$ $\beta_2 + \theta_2$

In case P.3, both agents prefer the signalling decision to the pooling decision. In case P.3, the pooling equilibrium is supported by passive beliefs: $\mu(\theta_1|d_1) = v_1$.

Case P.3

$\alpha_2 + \theta_1$ $\alpha_2 + \theta_2$

$\beta_2 + \theta_1$ $\beta_2 + \theta_2$

$\beta_2 + E\theta$

[14]Notice that $\alpha_1 + \theta_2 \in D$ if the costs of mimicking θ_2 for θ_1 (which are the lost utility when θ_1 chooses $d_1(\theta_1) = \alpha_1 + \theta_2$ instead of $d_1(\theta_1) = \alpha_1 + \theta_1$) are greater than the benefits given by the RHS of IC_1'. These costs of mimicking are $\frac{\Delta\theta^2}{2}$, and they are greater than benefits if $\alpha_2 - \beta_2 \leq \Delta\theta$.

[15]At that solution, the other incentive constraint (IC_2') is satisfied with slack.

Now we describe the equilibrium in the three cases and we apply the intuitive criterion.

Case P.1: the set of pooling equilibria is the set of d_1^* such that: $\forall\, d_1 \neq d_1^*$,

$$U^A(\theta_1, d_1^*, d_2^*) \geq U^A(\theta_1, d_1, d_2 = \beta_2 + \theta_1) \tag{6}$$

$$U^A(\theta_2, d_1^*, d_2^*) \geq U^A(\theta_2, d_1, d_2 = \beta_2 + \theta_1) \tag{7}$$

Using these two conditions, we can define the set D of pooling equilibria. The condition (6) is satisfied for all d_1 if it is satisfied for $d_1 = \alpha_1 + \theta_1$. Condition (6) is equivalent to: $d_1^* \in D_1 \equiv [\alpha_1 + \theta_1 - \sqrt{A}, \alpha_1 + \theta_1 + \sqrt{A}]$, where $A = v_2\Delta\theta(2\alpha_2 - 2\beta_2 - v_2\Delta\theta)$. Condition (7) is satisfied for all d_1 if it is satisfied for $d_1 = \alpha_1 + \theta_2$. (7) becomes: $d_1^* \in D_2 \equiv [\alpha_1 + \theta_2 - \sqrt{B}, \alpha_1 + \theta_2 + \sqrt{B}]$, where $B = v_2\Delta\theta(2\alpha_2 - 2\beta_2 + (1 + v_1)\Delta\theta)$. The set of pooling equilibria is defined as[16]: $d_1^* \in D \equiv D_1 \cap D_2$.

Now we use the intuitive criterion to suppress all the pooling equilibria.

Lemma 1 *$\forall\, d_1^*$, $\exists\, \tilde{d}_1$ such that:*
(i) θ_1 prefers the pooling equilibrium d_1^* to $\tilde{d}_1$, whatever the beliefs associated with $\tilde{d}_1$
(ii) θ_2 prefers $\tilde{d}_1$ to the pooling equilibrium if the principal is convicted that $\mu(\theta_1|\tilde{d}_1) = 0$.

The proof of this lemma is relegated to an appendix.

Then, if θ_1 will never deviate to $\tilde{d}_1$, the beliefs associated with $\tilde{d}_1$ should be (according to the intuitive criterion): $\mu(\theta_1|\tilde{d}_1) = 0$. But with these updated beliefs, the agent θ_2 prefers to quit the pooling equilibrium (part (ii) of the lemma). And hence, the initial equilibrium d_1^* does not survive the intuitive criterion.

Cases P.2 and P.3 which are similar to P.1 are relegated to appendix A.2.

From our previous discussion, we can establish that:

Proposition 1 *The only equilibrium that survives the intuitive criterion is the least costly separating (LCS) equilibrium[17].*
The LCS equilibrium is:

$$d_2(\theta) = \beta_2 + \theta \tag{8}$$

If $\Delta\theta \geq |\alpha_2 - \beta_2|$

$$d_1(\theta) = \alpha_1 + \theta \tag{9}$$

If $\alpha_2 - \beta_2 \geq \Delta\theta$

$$d_1(\theta_1) = \alpha_1 + \theta_1 \tag{10}$$

$$d_1(\theta_2) = \alpha_1 + \theta_2 + (\sqrt{K_1} - \Delta\theta) \tag{11}$$

Where $K_1 = (2\alpha_2 - 2\beta_2 - \Delta\theta)\Delta\theta$

[16] As B is greater than A, if the set D is non empty, its upper bound is given by $\alpha_1 + \theta_1 + \sqrt{A}$.
[17] This equilibrium is often referred to the Riley [1979] outcome.

If $\beta_2 - \alpha_2 \geq \Delta\theta$

$$d_1(\theta_1) = \alpha_1 + \theta_1 - (\sqrt{K_2} - \Delta\theta) \tag{12}$$

$$d_1(\theta_2) = \alpha_1 + \theta_2 \tag{13}$$

Where $K_2 = (2\beta_2 - 2\alpha_2 - \Delta\theta)\Delta\theta$

In the remaining of the paper we will call the first case 'free lunch' signal and the other 'costly signaling' cases.

This first proposition is the central result of the paper. It establishes that using the properties of signalling games, delegation is going together with a transfer of information from the agent to the principal. When the contracts are incomplete, the principal can still extract information from the agent by delegating the choice of some decision. Observing delegated decision is enough for the principal to learn agent's hidden information. When the principal allocates decision rights to the agent, he is forced to reveal his information through decisions. Proposition 1 establishes that delegating d_1 suppress the asymmetric information between the principal and the agent. In the next section, we show that such a delegation has benefits as well as costs and that even if it reduces the information asymmetry it is not always optimal to delegate.

3.3 Complete delegation and second period delegation

Finally, we mention the two other possible allocations of decision rights: the complete delegation and the second period delegation. These cases have in common that there is no problem of information transmission from the agent to the principal. Under complete delegation, the agent takes his preferred decisions d_1 and d_2:

$$d_1 = \alpha_1 + \theta \tag{14}$$

$$d_2 = \alpha_2 + \theta \tag{15}$$

The complete delegation of decision rights to the agent raises a problem of time consistency: after observing d_1, the principal has an incentive to retake from the agent the control right over d_2. Indeed, after observing d_1, the principal learns the state of the world θ. Delegating the second period decision has no benefit but just a cost[18]. Therefore, if the principal cannot commit to the allocation of decision right over d_2 to the agent[19], he will anticipate that the allocation of decision will be changed. If there is no commitment to the allocation of the second decision, the case of complete delegation is identical to the case of delegation[20].

[18] Except if the interests over d_2 are perfectly congruent.

[19] Aghion and Tirole [1997] study this particular problem of commitment in a given organizational structure.

[20] For the remaining of the paper, when we speak about complete delegation, we assume that the principal can commit to a given allocation of decision rights.

If the principal delegates only d_2, she takes d_1 according to (1) (as under centralization) and the agent takes d_2 according to (15) (as in complete delegation). In this case, only the second decision is taken by an informed party. Second period delegation is equivalent to a one period model where information transmission plays no role.

4 Optimal organizational structure

When the principal delegates some decision to the agent, she suffers a loss of control because the agent doesn't have the same preferences over decisions. But, on the other hand, the agent is better informed about the state of the world and delegated decisions are taken on the basis of better information. Moreover, when the principal delegates d_1, information is transferred from the agent to the principal (proposition 1). Delegation has a benefit as well as a cost. The benefits are linked to the information, the cost to the divergence of interests. The relative value of information compared to the loss of control determines the optimal orgnizational structure.

To clarify the choice between the four possible allocations of decision rights, we first define the loss of control associated with delegation as the difference between the expected utility of an informed principal and the expected utility of the principal under delegation.

Definition 3 *The costs associated with delegation of d_1 are measured by:*
$CD_1 = EU^P(\textit{Principal informed}) - EU^P(\textit{Delegation of } d_1)$

As in both cases, the decisions are taken by an informed party, we abstract from informational gains that can be produced by delegation

In the case of free lunch signals when $\Delta\theta \geq |\alpha_2 - \beta_2|$, the costs of delegation are a simple quadratic function of the divergence of interests: $CD_1 = \frac{(\alpha_1-\beta_1)^2}{2}$

When signals are costly, the agent takes a decision that is not his preferred one in order to transmit his information to the principal. This differentiation can benefit or cost the principal depending on i) the direction of preferences and ii) the magnitude of the change.

In the case where $\alpha_2 - \beta_2 \geq \Delta\theta$, $d_1(\theta_2) = \alpha_1 + \theta_2 + \sqrt{K_1} - \Delta\theta > \alpha_1 + \theta_2$. This increases in $d_1(\theta_2)$ benefits to the principal if (i) $\beta_1 > \alpha_1$ which means that the principal's ideal point is greater than those of the agent and (ii) the increase in $d_1(\theta_2)$[21] is not too big compared to $\beta_1 - \alpha_1$. Using our definition, the costs of delegation associated with $\alpha_2 - \beta_2 \geq \Delta\theta$ are:

$$CD_1 = \frac{(\alpha_1 - \beta_1)^2}{2} + v_2(\sqrt{K_1} - \Delta\theta)(\alpha_1 - \beta_1 + \frac{\sqrt{K_1} - \Delta\theta}{2})$$

Similarly in the case $\beta_2 - \alpha_2 \geq \Delta\theta$, the costs of delegation are:

$$CD_1 = \frac{(\alpha_1 - \beta_1)^2}{2} + v_1(\sqrt{K_2} - \Delta\theta)(\beta_1 - \alpha_1 + \frac{\sqrt{K_2} - \Delta\theta}{2})$$

[21] The function $f(\Delta\theta) = \sqrt{K_1} - \Delta\theta$ first increases and then decreases on the interval $[0, \alpha_2 - \beta_2]$ with $f(0) = 0 = f(\alpha_2 - \beta_2)$.

For small values of $\Delta\theta$, the costs of delegation (and hence the choice of the organizational form) depend not only on the distance between the principal's and agents ideal points but also on the direction of preferences[22]. The fact that signals are costly for the agent can indeed benefit to the principal if it forces the agent to take a decision closest to her preferred one. This is another interesting property of delegated decisions.

Now we can turn to the optimal organizational structure. The preferred repartition of decision right is the one who gives the highest expected utility to the principal. It is given in the following (technical) proposition and represented in figure 1 for the case $\alpha_2 \geq \beta_2$. Comparative static results are summarized in corollaries 1, 2 and 3.

Proposition 2 *The optimal organization is:*
to delegate d_1 if:

$$CD_1 \leq v_1 v_2 \Delta\theta^2 \tag{16}$$

and if $(\alpha_2 - \beta_2)^2 \leq v_1 v_2 \Delta\theta^2$, the following additional condition is required:

$$(\alpha_1 - \beta_1)^2 - (\alpha_2 - \beta_2)^2 \leq v_1 v_2 \Delta\theta^2 \tag{17}$$

to delegate d_2 if:

$$(\alpha_2 - \beta_2)^2 \leq v_1 v_2 \Delta\theta^2 \tag{18}$$

and

$$(\alpha_1 - \beta_1)^2 - (\alpha_2 - \beta_2)^2 \geq v_1 v_2 \Delta\theta^2 \tag{19}$$

and centralization otherwise.

Proof: See Appendix

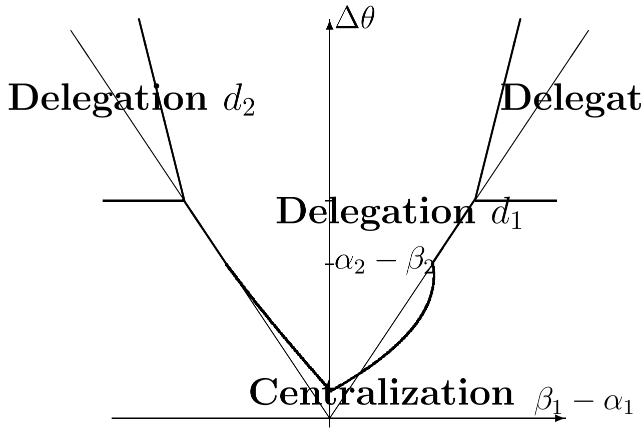


Figure 1: The optimal organizational structure

[22]When the costs of delegation are greater than $\frac{(\alpha_1-\beta_1)^2}{2}$, the principal can decrease them by offering a random delegation mechanism to the agent. In such a mechanism, the agent receives control right over d_2 with a probability $p < 1$. In that case, the right hand side of the binding incentive constraint IC_i' is multiplied by $(1-p)$. And hence, K_i decreases and the costs of delegation decreases. The drawback of the random delegation mechanism is that the principal gives control right over d_2 with probability p and hence suffers an additional loss of control equals to $p\frac{(\alpha_2-\beta_2)^2}{2}$.

Corollary 1 *For large $\Delta\theta$, some form of delegation is optimal. If $|\alpha_1 - \beta_1|$ is large compared to $|\alpha_2 - \beta_2|$, the principal delegates d_2 only, otherwise she delegates d_1.*

When $\Delta\theta$ is large, the agent's information has a great value. It is important for the principal to have informed decisions which imply that delegation is optimal. She delegates d_2 in the case where the costs of delegating d_1 is large relative to the costs of delegating d_2. Notice also that when $\Delta\theta$ is large, the agent's can transfer their information at no cost.

Corollary 2 *For small $\Delta\theta$, the optimal organizational structure is either to delegate d_1 or centralization. The choice depends on (i) the distance between α_1 and β_1 and (ii) the sign of the difference $(\alpha_1 - \beta_1)$.*

When $\Delta\theta$ is small, it is more difficult for the agent to transfer his information to the principal. This difficulty leads to more extreme decisions than in the case of a high $\Delta\theta$. More extreme decisions benefits to the principal only if, an informed principal would have been more extreme than the agent. This explains why when for a given $|\alpha_1 - \beta_1|$, when the interests go in the same direction, the principal delegates more often and when they go in opposite direction, she delegates less.

Corollary 3 *When $\alpha_1 = \alpha_2$ and $\beta_1 = \beta_2$, the optimal organizational structure is delegation if $CD_1 \leq v_1 v_2 \Delta\theta^2$ and centralization otherwise.*

If both decisions have the same importance, if the principal delegates, she delegates d_1. In this particular case, the costs of delegation are identical when the principal delegates d_1 or d_2 and hence, if it is optimal to delegate, the principal prefer delegate the first decision.

In proposition 1, we have shown that delegation is going together with a transfer of information from the better informed agent to the principal. This communication of information through decision is important for the principal because she can implement her preferred second decision d_2. The drawbacks is that she has to allow the agent to take his preferred decision d_1. The main difference between this simple contract who just specify who decide and the standard contract is that the principal cannot reward and punish some type of agent. In the standard contracting framework, the principal extract the hidden information by paying some rent to the agent who has an incentive to lie. Here by contrast, if the principal wants to extract information, she has to delegate d_1 to the agent and the agent enjoys rents in both state of the world. In our model, the rents are the private benefits of taking his preferred decision. But these rents are not conditional on θ, and this make this kind of contract more costly than the standard contracts. In the next section, we study how the principal can diminish these rents by constraining agent's choice.

5 Restricting agent's discretion: the case of rules

When the principal leaves some power to the agent, she would like to reduce the discretion of the agent by imposing some constraints on the choice of the subordinate. Constraining the choice of the agent appears to be a useful way to reduce the cost of delegation while preserving what we called the benefits of information. To reduce the discretion of the agent, the principal may constraint the agent to choose d_1 within a given subset L. By doing so, we will say that the principal imposes a *rule* that limits the discretion of the agent in the choice of d_1. We define a rule as a compulsory requirement that must be followed when the principal delegates the decision rights over d_1. Our interest in this subsection is to see how the principal can effectively reduces the cost of delegation by imposing such a rule and to compute the optimal way of doing so, what we call the *optimal rule.*

The emergence of rule that lowers the power of incentives is a fundamental characteristic of any organization (see for example Martimort [1997]). Here by contrast, we describes rules that keep the delegated decision informative. In that sense, our work is to find how to reduce the agent's discretion and preserve the incentives to signal the information through his decision. Our work is related to Armstrong [1994][23] who studies how reducing agent's discretion may increase overall organization's performance.

Constraining the choice of the agent may be done in a variety of ways. We will restrict our attention to rules that are formed of a connected subset of possible decisions d_1.

Assumption 1 *A rule is a connected subset L of the possible decisions d_1.*

Choosing a rule for the principal is to choose the boundaries $\underline{l}$ and $\overline{l}$ of the subset $L = \left[\underline{l}, \overline{l}\right]$. To do the analysis, we have to assume that the principal can enforce the rule. i.e. She can effectively constraint the choice of the agent[24]. Another important assumption, that follows directly from our contractual restrictions, is that the rule cannot be state contingent. In other words, the subset L is independent of θ.

The optimal rule depends on how the agent acts when he receives control right over d_1. To compute it, we distinguish two cases: the case of costless signals where, without rules, the agent implements his preferred decision in both states of the world[25] and the case where one incentive constraint binds (case of costly signals).

5.1 Rule in the case of free lunch signals

The following lemma reduces the set of possible rules:

Lemma 2 *Without loss of generality, we can restrict our attention to rules of the form $[0, \overline{l}]$, with $\alpha_1 + \theta_1 \leq \overline{l} \leq \alpha_1 + \theta_2$, when β_1 is smaller than α_1. While when $\beta_1 > \alpha_1$, we can consider, wlog, only rules of the form $[\underline{l}, +\infty[$ with $\alpha_1 + \theta_2 \geq \underline{l} \geq \alpha_1 + \theta_1$.*

Proof: Appendix

As it appears from lemma 2, the rules takes a different form if α_1 is greater or smaller than β_1. This corresponds to the case where the agent takes a greater/ smaller decision

[23] Armstrong's main results is to show that the discretion of the agent is reduced when there is a greater risk of (the agent and the principal) having diverging interest over policies.

[24] But the agent has still the possibility of quitting the organization.

[25] This correspond to the case where $\Delta\theta \geq |\alpha_2 - \beta_2|$.

than an informed principal would have taken. The reaction of the principal differs in the two situations: in one case, it is important to decrease the agent's decision, in the other case, it is important to increase it. In the paper, we treat the case in which the principal wants to decreases the decision of the agent (case where $\alpha_1 > \beta_1$)[26]. The other case is symmetric and can be easily be computed with our analysis.

Reaction of the agent to the rule. The following proposition describes the decisions of the agent when the principal imposes a rule of the type described in lemma 2:

Proposition 3 *When the principal imposes a rule to the agent, his equilibrium decisions are:*

$$d_1(\theta_2) = \bar{l} \tag{20}$$

- *When* $\beta_2 - \alpha_2 \leq \frac{\Delta\theta}{2}$*:*

$$d_1(\theta_1) = \alpha_1 + \theta_1 \tag{21}$$

- *When* $\frac{\Delta\theta}{2} \leq \beta_2 - \alpha_2 \leq \Delta\theta$

$$d_1(\theta_1) = \alpha_1 + \theta_1 \qquad\qquad if\, \bar{l} \geq \tilde{l} \tag{22}$$

and

$$d_1(\theta_1) = \alpha_1 + \theta_2 - \sqrt{H(l)} \qquad if\, \bar{l} \leq \tilde{l} \tag{23}$$

Where $\tilde{l} = \alpha_1 + \theta_2 - \sqrt{2}\sqrt{\Delta\theta}\sqrt{\alpha_2 - \beta_2 + \Delta\theta}$ *and* $H(l) = (\alpha_1 - l)^2 - 2l\theta_2 + 2(\alpha_2\Delta\theta + \beta_2\Delta\theta + \alpha_1\theta_2 + \beta_2\theta_2 + \theta_2\theta_1) - \theta_1^2$ *And* $H(l)$ *is a monotone and decreasing function with* $H(\tilde{l}) = \Delta\theta$*.*

proof: appendix

In state θ_2, the agent selects the decision that is closest to his ideal point within the allowed subset. This decision is the upper bound of the subset L. In state θ_1, the agent selects the decision gives him the highest utility and such that $IC\prime_2$ is satisfied. This decision is either $\alpha_1 + \theta_1$ or given by the constraint[27].

The value $\tilde{l}$ is the smallest value of $\bar{l}$ that keeps the decisions $d_1(\theta_1) = \alpha_1 + \theta_1, d_1(\theta_2) = \bar{l}$ incentive compatible and is derived from (IC_2'). When $\bar{l} < \tilde{l}$, if the agent wants to reveal his information in state θ_1, his decision is not is preferred one. So, imposing a rule may change the agent's decision in both state of the world.

Limits to the imposition of rules (I): incentive constraint The first limit to the imposition of rules is the preservation of information transmission by the agent. The agent θ_1 has an incentive to misrepresent his type when $\alpha_2 - \beta_2 \geq \frac{\Delta\theta}{2}$. In that case, θ_2 cannot differentiate himself from θ_1 by taking a higher decision. Therefore, the rule preserves information transmission if its upper bound $\bar{l}$ is such that the incentive compatible condition IC_1' is satisfied.

[26] We will also assume for expositional simplicity that $\beta_1 + \theta_2 > \alpha_1 + \theta_1$.

[27] IC_2' is always slack if $\beta_2 - \alpha_2 \leq \frac{\Delta\theta}{2}$. When this condition is not satisfied, IC_2' is slack if it is too costly for θ_2 to copy θ_1, i.e. $\bar{l}$ is sufficiently large (see corollary 4).

Corollary 4 *When $\frac{\Delta\theta}{2} \leq \alpha_2 - \beta_2 \leq \Delta\theta$, the rule preserves information transmission if $\overline{l}$ is such that:*

$$\overline{l} \geq \overline{l}^{IC_1'} = \alpha_1 + \theta_1 + \sqrt{\Delta\theta}\sqrt{2\alpha_2 - 2\beta_2 - \Delta\theta} \tag{24}$$

This equation is derived by solving for $\overline{l}$, the following incentive compatible condition:

$$U^A(\theta_1, d_1(\theta_1) = \alpha_1 + \theta_1, d_2(\theta_1) = \beta_2 + \theta_1) \geq U^A(\theta_1, d_1(\theta_2) = \overline{l}, d_2(\theta_2) = \beta_2 + \theta_2)$$

.

Limits to the imposition of rules (II): participation constraints As the rule pushes down the decision of the agent in at least one state of the world, we have to check that the constrained decision leaves a positive utility to the agent in both states of the world θ_1 and θ_2. The agent's participation constraint limits the possibilities of restricting the agent's discretion.

The optimal rule We can now compute the optimal rule that preserves agent's participation and information transmission. We identify the optimal rule with its upper bound $\overline{l^*}$. The optimal rule is the rule that minimize the resulting costs of delegation and is computed by solving the following program:

$$\max_{\overline{l}} U^P$$

s.t. $\overline{l} \geq \overline{l}^{IC_1'}$ and the behavior of the agent as a function of $\overline{l}$ is described in proposition 3.

Lemma 3 *The optimal rule can have three possible forms:*

RULE A: $\overline{l^*} = \beta_1 + \theta_2$

RULE B: *Choose $\overline{l^*} = \max_{\overline{l}} U^P$, such that $\overline{l^*} \in [\alpha_1 + \theta_1, \tilde{l}]$. If an interior maximum exists it is given by:*

$$v_1 \left[\beta_1 - \alpha_1 - \Delta\theta + \sqrt{H(\overline{l^*})}\right] \frac{H'(\overline{l^*})}{2\sqrt{H(\overline{l^*})}} = -v_2(\beta_1 + \theta_2 - \overline{l^*}) \tag{25}$$

RULE C: $\overline{l^*} = \overline{l}^{IC_1'}$.

With rule A, the interests of the principal and the agent completely coincide in state θ_2. If there is no modification in $d_1(\theta_1)$, which is the case if $\beta_1 + \theta_2$ is greater than $\tilde{l}$, the costs of delegation are reduced to: $v_1 \frac{(\alpha_1 - \beta_1)^2}{2}$. With rule A, delegation is costly only in state θ_1.

With rule B, the principal reduces agent's decisions in both state of the world. As we know, $d_1(\theta_1) = \alpha_1 + \theta_2 - \sqrt{H(l)}$ and $d_1(\theta_2) = l$ when $l < \tilde{l}$, the rule B selects the combination of $d_1(\theta_1)$ and $d_1(\theta_2)$ that maximizes the principal's utility.

With rule C, the principal selects the highest incentive compatible rule.

Proposition 4 *The optimal rule $\overline{l^*}$ is such that:*

- *If* $|\alpha_2 - \beta_2| \leq \frac{\Delta\theta}{2}$*, the optimal rule is rule A*
- *If* $\frac{\Delta\theta}{2} \leq \alpha_2 - \beta_2 \leq \Delta\theta$ *and , the optimal rule is rule A if* $\beta_1 + \theta_2 \geq \bar{l}^{IC'_1}$ *and rule C otherwise.*
- *If* $\frac{\Delta\theta}{2} \leq \beta_2 - \alpha_2 \leq \Delta\theta$*, the optimal rule is rule B if* $\tilde{l} \geq \beta_1 + \theta_2$ *and rule A or rule B if* $\tilde{l} \leq \beta_1 + \theta_2$*.*

The first case corresponds to the case where the agent never mimics the other type. Hence, the principal cannot only constraint the agent in state θ_2 and forces him to take her preferred decision[28].

In the second case, the agent θ_1 mimics θ_2 if $d_1(\theta_2) = \bar{l}$ is close enough to $\alpha_1 + \theta_1$. Therefore the principal can force θ_2 to take her preferred decision only if $\beta_1 + \theta_2$ is greater than $\bar{l}^{IC'_1}$. Otherwise, the rule must be set at the highest level that preserves information transmission ($=\bar{l}^{IC'_1}$).

In the third case, the agent θ_2 will mimic θ_1 if $\bar{l}$ is close enough to $\alpha_1 + \theta_1$. If $\beta_1 + \theta_2$ is smaller than $\tilde{l}$, the optimal rule is to set $\bar{l}^* \in [\alpha_1 + \theta_1, \tilde{l}]$ in order to maximize the principal's utility. In that case, the principal decreases agent's decision in both state of the world. If $\tilde{l}$ is smaller than $\beta_1 + \theta_2$, the principal can either use rule A and constraint the agent to take is preferred decision in state θ_2 or constraint the agent to take a decision $d_1(\theta_2)$ smaller than $\beta_1 + \theta_2$ in order to decrease the decision $d_1(\theta_1)$. In between these two strategies, the principal selects the rule that maximize her expected utility.

Costs of delegation with constrained decisions We have seen that constraining decisions is done (optimally) by setting an upper limit on the choice of the agent. With constrained delegation there is still a transfer of information. Imposing a rule is useful only if it diminishes the associated costs of delegation.

Observation 1 *Restricting agent's discretion decreases the associated loss of control without suppressing them.*

For example if the optimal rule is rule A, the agent chooses the principal's preferred decision in state θ_2 but select his preferred decision in state θ_1. So there is a loss of control in state θ_1. With rule A, the costs of delegation are equal to $v_1 \frac{(\alpha_1 - \beta_1)^2}{2}$

As we mentioned at the end of the previous section, the drawbacks associated with delegation, the loss of control, are greater when contracts are limited to simple right to decide contracts than under standard complete contract à la Baron-Myerson because the rents received by the agent are not conditional on their type. If the principal is able to constraint the choice of the agent, she can reduce the rent paid by the agent at least in one state of the world. But this ability to constraint the agent is restricted by the necessity of keeping the decisions informative. If the principal restricts 'too much' the discretion of the agent, the incentive constraints may not be satisfied and delegation looses its property of revealing information. As the loss of control decrease when delegation is accompanied with rules, the space parameter for which delegation is optimal is greater.

[28] If $\beta_2 > \alpha_1 + \theta_1$, the optimal rule is $\bar{l}^* = \alpha_1 + \theta_1 + \epsilon$.

5.2 Rules in the case of costly signals

When the signals are costly for the agent, we perform the same analysis to derive the optimal rule. Again we suppose that $\alpha_1 > \beta_1$, so the goal of the principal is the rule is to reduce agent's decisions.

When $\alpha_1 > \beta_1$ and $\alpha_2 - \beta_2 \geq \Delta\theta$, no rule is the optimal rule. When $\alpha_2 - \beta_2 \geq \Delta\theta$, the decision $d_1(\theta_2)$ is greater than agent θ_2 ideal point. In this case, if the principal set a rule at any level smaller than $d_1(\theta_2)$, the only effect is to bunch the decision of both agents at $\bar{l}$. Therefore any rule will destroy the informative content of delegated decision.

When $\beta_2 - \alpha_2 \geq \Delta\theta$, imposing a rule reduces both decision. If such a reduction decreases the costs of delegation imposing a rule is optimal otherwise, it is better to leave the choice of the agent unconstrained.

6 Robustness and extensions

6.1 More than two types

An important result of this paper is to show that delegated decisions have an informational content: the principal learns the state of the world when she delegates d_1 to the agent. This result is constructed using the properties of signaling games and especially the intuitive criterion. Now we would like to discuss the robustness of this result when there are more than two states of the world. With $N \geq 2$, the results of proposition 1 are extended in the following proposition:

Proposition 5 *With N types, the only surviving equilibrium is the least costly separating equilibrium.*

Proof: see Appendix

Our results are robust when the problem is extended to more than two states of the world[29]: delegated decisions signals θ to the principal.

These results should be contrasted with the results of Crawford and Sobel where the equilibrium of their signalling game is a partition equilibrium in which the agent introduce noise in the message send to the principal. In Crawford Sobel, the agent has an interest to hide at least partially the information he possess. If the agent discloses his information, the decision taken by the principal does not correspond to the agent's ideal decision, so there is an incentive not to disclose perfectly the information. In our model, in some state, the agent doesn't have this incentive to misrepresent his information. Even if the agent's and principal's ideal points do not coincide, when the state of the world is low (high), they both prefer smaller (greater) decisions. And this effect is enough to make the decision perfectly informative. But even if information is transmitted when the principal

[29]The key point is not the number of state but the gap between two adjacent values of θ: $\theta_i - \theta_{i-1}$. When this difference is too small, for example if there is a continuum of θ, all the incentive constraints are binding and the decisions of all types (but the highest one) are distorted downward. And this in turn may create a participation problem for the lowest types. As long as all the type participate, proposition 5 is valid.

delegates, the costs (loss of control) associated with delegation may be extremely high for the principal, so delegation is not necessary the optimal organizational form.

6.2 Cheap talks and message games

If the principal keeps control rights over decisions, the agent may want to transfer (part of) his information to the decider. This informal communication by the agent changes the principal's beliefs about the state of the world and then changes the decisions. Informal communication from the informed party to the decider may be an alternative to delegation[30]. The problem with communication is that it is only strategic: the aim of the communication is to manipulate principal's beliefs. The agent wants to communicate not the true information but the information that, used by the principal,fosters his interest. Cheap talks equilibria are described in Crawford Sobel [1982]: for a continuum of types, the equilibria are partition equilibria where a (continuous) subset of types sends the same message. In the discrete case, the equilibria are probability distributions over a fixed number of messages.

If the agent can signal his information when he receives control right over d_1, it is not anymore the case when he wants to signal it through pre play communication. For example, if one type of agent prefers a non informed principal (centralization) to an informed principal, this type of agent can communicate exactly the same information as the other type would have done and hence, the principal learns nothing with this pre play communication. By contrast, giving control right to agent is enough to extract his information. Decisions are better signals than communication. As communication is only partial, the principal cannot enjoy the full benefits of information.

The main difference between cheap talks and delegation as a a mean to extract agent's hidden information is that delegation is costly for the agent: he should take a decision that has direct consequences on his utility. Therefore separation of type is feasible. By contrast, transferring information in cheap talk games has no direct cost. It only changes the beliefs of the principal and hence, communication is used by the agent only to manipulate the principal's beliefs.

7 Conclusion

The main message of this paper is to show that when contracts à la Baron Myerson are prohibited, the principal can still extract information from the agent by delegating the choice of projects to the agent. Using the properties of signalling games, we have shown that delegation is an alternative to contracting. If delegation has the advantage of extracting agent's information, it has also some costs (loss of control). So we have shown that the principal will not always use this delegation-revelation mechanism, especially if the agent's information has little value ($\Delta\theta$ is small) or if the divergence of interest ($|\alpha_1 - \beta_1|$) is large.

The main difference between the standard complete contract framework and the model

[30]The problem of cheap talks versus delegation is treated in Dessein [1999]. The main difference with this paper is that he doesn't consider delegation as a mean to extract information.

developed in this paper is that the principal cannot control the rents she pays to the agent. In the complete contract framework, rents are function of the agent's report of his private information and the principal can elicit information by paying higher rents to efficient agents. In our incomplete contract framework, the rents paid by the principal are unconditional on the type. The rents received by the agent is the utility he has when he is in charge of the first decision. The unconditionallity of the rents increases the costs of information for the principal. We have shown that the principal can reduce the costs of delegation (and therefore agent's rents) by reducing his discretion but she cannot completely suppress these loss of control.

These results should be contrasted with another result from complete contract theory : the existence of pooling contract in multi-period adverse selection models (ratchet effect). In these models, a separating equilibrium where the agent reveals his information at the beginning of the first period does not always exist[31]. By contrast we have shown that delegation is going together with (perfect) information revelation. By giving full discretion to the agent, a type can use this freedom to differentiate from the other when he fears to be copied. Suppose that both types prefers to be taken for (say) θ_2. In the complete (dynamic) contract framework, the principal will pay a bonus for the agent that reveal a type θ_1. But the bonus may be too large and the other incentive constraint may not be longer satisfy resulting in a pooling equilibrium. In our delegation-revelation mechanism, if both prefers to be taken for θ_2, the type θ_2 will take a decision that is not is preferred one but such that mimicking is too costly for θ_1. So one hand, in a complete contract framework, information revelation is achieved by paying bonus to efficient agents, on the other hand, in delegated mechanism, differentiation is achieved by self-imposed penalties (lost utility). Delegation can be used to extract private information in multi-period game[32].

Another message from the paper is that when delegation occurs in organization, the principal doesn't leave full control to the subordinate. In our model it is optimal to delegate only one decision, and let the principal decide on the remaining decisions. This paper advocates for a split in decision rights between the informed subordinate and the principal. Some decisions are delegated in order to extract information the other are not in order to mitigate loss of control.

[31] See Freixas et al [1985]

[32] Another major difference is that our model is a private benefit model where we can ignore participation constraints while they are important in complete contract framework.

A Complement to section 3.2

A.1 Separating equilibria: cases S.2 and S.3

Case S.2: the set of separating equilibrium is:

$$d_1^*(\theta_1) \in D \equiv \{d_1(\theta_1)|IC_1', IR_1\} \tag{26}$$

$$d_1^*(\theta_2) = \alpha_1 + \theta_2 \tag{27}$$

This equilibrium is supported by pessimistic beliefs: $\mu(\theta_1|d_1) = 0, \forall\ d_1 \neq d_1^*(\theta_1)$ and $\mu(\theta_1|d_1^*(\theta_1)) = 1$.

The set D is the set of decisions that satisfy the participation constraint for type θ_1 and the constraint IC_2': $D \equiv]0, \alpha_1+\theta_2-\sqrt{K_2}] \cup [\alpha_1+\theta_2+\sqrt{K_2}, +\infty[$; $K_2 = (2\beta_2 - 2\alpha_2 - \Delta\theta)\Delta\theta$.

Again, we use the intuitive criterion. It refines all the beliefs associated with D to $\mu(\theta_1|d_1 \in D) = 1$ and the surviving equilibrium is $d_1^*(\theta_1) = \alpha_1 + \theta_1$ if $\Delta\theta \leq \beta_2 - \alpha_2$ and $d_1^*(\theta_1) = \alpha_1 + \theta_1 + \sqrt{K_2} - \Delta\theta$ otherwise.

Case S.3: When $|\alpha_2 - \beta_2| \leq \frac{\Delta\theta}{2}$, a possible separating equilibrium is[33]:

$$d_1^*(\theta_1) = \alpha_1 + \theta_1 \tag{28}$$

$$d_1^*(\theta_2) \in D \equiv \{d_1(\theta_2)|IC_1'\} \tag{29}$$

With beliefs $\mu(\theta_1|d_1) = 1, \forall\ d_1 \neq d_1^*(\theta_2)$ and $\mu(\theta_1|d_1^*(\theta_2)) = 0$ We use the intuitive criterion to refine beliefs and the only surviving equilibrium is: $d_1^*(\theta_1) = \alpha_1 + \theta_1$, $d_1^*(\theta_2) = \alpha_1 + \theta_2$.

A.2 Pooling equilibria: cases P.2 and P.3

The case P.2 is symmetric to P.1. The set of pooling equilibria is the set of d_1^* such that: $\forall\ d_1 \neq d_1^*$,

$$U^A(\theta_1, d_1^*, d_2^*) \geq U^A(\theta_1, d_1, d_2 = \beta_2 + \theta_2) \tag{30}$$

$$U^A(\theta_2, d_1^*, d_2^*) \geq U^A(\theta_2, d_1, d_2 = \beta_2 + \theta_2) \tag{31}$$

(30) is equivalent to $d_1^* \in D_3 \equiv [\alpha_1 + \theta_1 - \sqrt{C}, \alpha_1 + \theta_1 + \sqrt{C}]$; $C = v_1\Delta\theta(2\beta_2 - 2\alpha_2 + (1 + v_2)\Delta\theta)$ and (31) is equivalent to $d_1^* \in D_4 \equiv [\alpha_1 + \theta_2 - \sqrt{D}, \alpha_1 + \theta_2 + \sqrt{D}]$; $D = v_1\Delta\theta(2\beta_2 - 2\alpha_2 - v_1\Delta\theta)$. The set D of pooling equilibria is the intersection of D_3 and D_4.

We use the following lemma, similar to lemma 1:

Lemma 4 $\forall\ d_1^*$, $\exists\ \tilde{d}_1$ *such that:*
(i) θ_2 *prefers the pooling equilibrium* d_1^* *to* $\tilde{d}_1$*, whatever the beliefs associated with* $\tilde{d}_1$
(ii) θ_1 *prefers* $\tilde{d}_1$ *to the pooling equilibrium if the principal is convicted that* $\mu(\theta_1|\tilde{d}_1) = 1$*.*

The proof is similar to lemma 1, and with this lemma, we can show that in case P.2, no equilibrium survives the intuitive criterion.

[33] There is another separating equilibrium where $d_1^*(\theta_2) = \alpha_1 + \theta_2$. The reasoning in this case is similar.

In case P.3, The set of pooling equilibria is the set of d_1^* such that: $\forall\, d_1 \neq d_1^*$,

$$U^A(\theta_1, d_1^*, d_2^*) \;\geq\; U^A(\theta_1, d_1, d_2 = \beta_2 + v_1\theta_1 + v_2\theta_2) \qquad (32)$$

$$U^A(\theta_2, d_1^*, d_2^*) \;\geq\; U^A(\theta_2, d_1, d_2 = \beta_2 + v_1\theta_1 + v_2\theta_2) \qquad (33)$$

and we use the intuitive criterion in the same way as before to eliminate all the pooling equilibria.

B Proof of lemma 1

To each d_1^*, we can associate a $\tilde{d}_1$ defined as:

$$U^A(\theta_2, \tilde{d}_1, d_2 = \beta_2 + \theta_2) = U^A(\theta_2, d_1^*, d_2^* = \beta_2 + E\theta) \qquad (34)$$

$$\tilde{d}_1 > \alpha_1 + \theta_2$$

$\tilde{d}_1$ is the decision d_1 that left the agent θ_2 indifferent between the pooling equilibrium (d_1^*, d_2^*) and $(\tilde{d}_1, \beta_2 + \theta_2)$. So part (ii) of the lemma is satisfied[34]. As θ_2 prefers to signal his type, the function on the right hand side of (34) is a vertical translation of the function on the left hand side. Therefore, $\tilde{d}_1$ always exist (actually two values $\tilde{d}_1$ satisfies (34) by the single peakness assumption but we select those on the right of $\alpha_1 + \theta_2$).

Now we concentrate on part (i) of the lemma. It is satisfied if, whatever the beliefs associated with the observation of $\tilde{d}_1$:

$$U^A(\theta_1, d_1^*, d_2^*) > U^A(\theta_1, \tilde{d}_1, d_2) \qquad (35)$$

If the beliefs associated with $\tilde{d}_1$ are $\mu(\theta_1|\tilde{d}_1) = 1$, the condition (35) is satisfied. In that case, the agent θ_1 looses on both sides: the first decision is greater than d_1^*[35] and and θ_1 prefers d_2^* to $d_2 = \beta_2 + \theta_1$, by definition of case P.1.

If the beliefs associated with $\tilde{d}_1$ are $\mu(\theta_1|\tilde{d}_1) = v_1$, the condition (35) is also satisfied. $\tilde{d}_1$ is greater than d_1^* and the second decision is identical. Therefore, θ_1 prefers the initial equilibrium.

If the beliefs associated with $\tilde{d}_1$ are $\mu(\theta_1|\tilde{d}_1) = 0$, there is as in the previous case a cost of taking a decision greater than d_1^*, but there may be benefits if the agent prefers the second decision $d_2 = \beta_2 + \theta_2$ to d_2^*. This is the case if $2\alpha_2 - 2\beta_2 - (1 + v_2)\Delta\theta \geq 0$. And we will now concentrate on these cases. For the reasoning, it is important to note that these benefits (the increase in U^A when the principal takes $d_2 = \beta_2 + \theta_2$ rather than $d_2 = \beta_2 + E\theta$) are constant, i.e. independent of the initial equilibrium d_1^* and equals to $\frac{v_1\Delta\theta}{2}(2\alpha_2 - 2\beta_2 - (1 + v_2)\Delta\theta)$. Therefore, we have to look at the cost of switching from d_1^* to $\tilde{d}_1$ for θ_1 and check if they exceed the benefits. For simplicity, we first concentrate on pooling equilibria on the right of $\alpha_1 + \theta_2$, those in the subset of D' of D; $D' \equiv [\alpha_1 + \theta_2, \alpha_1 + \theta_1 + \sqrt{A}]$. We use the following lemma:

Lemma 5 *The cost of switching from $d_1^* \in D'$ to the associated $\tilde{d}_1$ increases with d_1^*.*

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

[35] whatever the initial d_1^* even those smaller than $\alpha_1 + \theta_1$

Proof: Solving (34) for $\tilde{d}_1$ and taking the value greater than $\alpha_1 + \theta$, we have $\tilde{d}_1$ as a function of the equilibrium d_1^*:

$$\tilde{d}_1 = \alpha_1 + \theta_+ \sqrt{d_1^{*2} - 2d_1^*(\alpha_2 + \theta_2) + C} \tag{36}$$

where $C = (\alpha_1 + \theta_2)^2 + 2v_1\Delta\theta(\alpha_2 - \beta_2) + v_1^2(\theta_1 + \theta_2)^2$.
With some algebra, we can show that $\frac{\partial \tilde{d}_1}{\partial d_1^*} \geq 0$ and $\frac{\partial\partial \tilde{d}_1}{\partial\partial d_1^*} > 0$ for all $d_1^* \in D'$.
On the other hand, the derivative of $U^A(\theta_1)$ with respect to d_1 is equal to $\alpha_1 + \theta_1 - d_1$. For all $d_1 > \alpha_1 + \theta_1$, the impact (on utility) of a given change in d_1, is greater the greater d_1 is. Combining these two elements: the impact of a change in d_1^* on $\tilde{d}_1$ and the impact of a change in $\tilde{d}_1$ on U^A, it is straightforward to show that the cost of switching from $d_1^* \in D'$ to $\tilde{d}_1$ is greater, the greater the initial equilibrium is. And this proves the lemma.

Therefore, the condition (35) is satisfied for all $d_1^* \in D'$ if it is satisfied for $d_1^* = \alpha_1 + \theta_2$ (remember that the benefits of switching are constant). Replacing d_1^* by $\alpha_2 + \theta_2$ and $\tilde{d}_1$ by (36), (35) becomes (after simplifications):

$$\Delta\theta(v_1\Delta\theta + \sqrt{\Delta\theta v_1(2\alpha_2 - 2\beta_2 + v_1\Delta\theta)}) > 0$$

which is always positive since we considered cases in which $\alpha_2 > \beta_2$ and hence, for all d_1^* in D', $\exists\, \tilde{d}_1$ satisfying the conditions of lemma 1.

Now consider the remaining equilibria in D, if θ_2 switch from d_1^* to $\tilde{d}_1 = \alpha_1 + \theta_2 + \sqrt{2v_1\Delta\theta(\alpha_2 - \beta_2) + v_1^2(\theta_1 + \theta_2)^2}$, such a deviation increases (strictly) his utility if the beliefs associated with $\tilde{d}_1$ are $\mu(\theta_1|\tilde{d}_1) = 0$. For θ_1, the cost of switching from d_1^* to $\tilde{d}_1$ is the sum of the cost of switching from d_1^* to $\alpha_1 + \theta_2$ plus the cost of switching from $\alpha_1 + \theta_2$ to $\tilde{d}_1$. Then the costs of switching from any $d_1^* \in D$, $d_1^* < \alpha_1 + \theta_2$ are greater than the costs associated with $d_1^* = \alpha_1 + \theta_2$ and therefore greater than the benefits. And this prove lemma 1.

C Proof of proposition 2

To prove the proposition, we first compute the difference between the expected utility of the principal under all forms of delegation and the expected utility under centralization.

$$\begin{aligned}
EU^P(\text{Delegation } d_1) - EU^P(\text{Centralization}) &= v_1v_2\Delta\theta^2 - CD_1 \\
EU^P(\text{Delegation } d_2) - EU^P(\text{Centralization}) &= \frac{1}{2}(v_1v_2\Delta\theta^2 - (\alpha_2 - \beta_2)^2) \\
EU^P(\text{Complete Delegation}) - EU^P(\text{Centralization}) &= v_1v_2\Delta\theta - \frac{1}{2}((\alpha_1 - \beta_1)^2 + (\alpha_2 - \beta_2)^2)
\end{aligned}$$

The optimal organizational structure is the one with the highest difference (if positive) and centralization if all these differences are negative.

We first show that complete delegation is always dominated: if $CD_1 = \frac{(\alpha_1 - \beta_1)^2}{2}$, which is the case when $\Delta\theta \geq |\alpha_2 - \beta_2|$, complete delegation is dominated by delegation d_1. When $\Delta\theta \leq |\alpha_2 - \beta_2|$, it implies $\Delta\theta^2 \leq (\alpha_2 - \beta_2)^2$. Then $\frac{(\alpha_1 - \beta_1)^2}{2} + \frac{(\alpha_2 - \beta_2)^2}{2}$ cannot be smaller than $v_1v_2\Delta\theta^2$, which means that centralization dominates complete delegation.

Delegation d_2 dominates centralization if $v_1 v_2 \Delta\theta^2 \geq (\alpha_2 - \beta_2)^2$.

Delegation d_1 dominates centralization if $v_1 v_2 \Delta\theta^2 \geq CD_1$

When delegation d_1 and delegation d_2 both dominate centralization, delegation d_1 dominates if[36]:

$$(\alpha_1 - \beta_1)^2 - (\alpha_2 - \beta_2)^2 \geq v_1 v_2 \Delta\theta$$

D Proof of lemma 2

If α_1 is greater than β_1, the agent takes a decision greater than the principal's ideal point in both state of the world. Therefore, the objective of the rule is to decrease the agent's decisions. We show that the only possibility of decreasing agent's decision is to set the upper bound of L smaller (or equal to) than $\alpha_1 + \theta_2$.

If $\alpha_1 + \theta_1, \alpha_1 + \theta_2 \in L$, the decisions are unchanged compared to the no rule case and the rule is ineffective.

If the lower bound $\underline{l}$ is greater than $\alpha_1 + \theta_1$, the decision $d_1(\theta_1)$ will be greater than in the no rule case. This kind of rule benefits to the principal only if there is a decrease in $d_1(\theta_2)$ that compensate the utility lost due to the increase in $d_1(\theta_1)$. We have to look at the equilibrium decisions when the agent must choose $d_1 \geq \underline{l}$. Whatever $d_1(\theta_1)$, the agent θ_2 has two possibilities: either he takes $d_1(\theta_2) = d_1(\theta_1)$, or he takes a decision $d_1(\theta_2)$ that satisfies the incentive constraint IC_1'. This incentive compatible decision $d_1(\theta_2)$ will be greater or equal to $\alpha_1 + \theta_2$. Therefore setting $\underline{l} > \alpha_1 + \theta_1$ results in either a pooling equilibrium or in an increase in $d_1(\theta_1)$ and no decrease in $d_1(\theta_2)$. Hence, such a rule doesn't benefit the principal.

Then the only rule that potentially benefits the principal is to set the upper bound of L smaller or equal than $\alpha_1 + \theta_2$. In this case, $d_1(\theta_2)$ decreases. The resulting equilibrium decisions will be either a pooling equilibrium (a situation which is bad for the principal) or in a separating equilibrium where $d_1(\theta_1)$ doesn't increase compared to the no rule case (a situation that benefits to the principal).

Last, we have to show that the principal has no advantages in specifying a lower bound of L smaller than $\alpha_1 + \theta_1$. By doing so, the principal can limit the decrease in $d_1(\theta_1)$ (if any). But as we will show in proposition 3, the only potential effect is to suppress the existence of a separating equilibrium.

When α_1 is greater than β_1, the same reasoning applies and the only rule to consider are: $[\underline{l}, +\infty[$, with $\underline{l} \geq \alpha_1 + \theta_1$.

E Proof of proposition 3

From proposition 1, we know that the only equilibrium that survives the intuitive criterion is the least costly separating equilibrium. In proposition 3, we describe the LCS equilibrium of the game when $\alpha_1 > \beta_1$ and the rule is $[0, \overline{l}]$.

[36] When both dominates centralization $CD_1 = \frac{(\alpha_1 - \beta_1)^2}{2}$.

Given $d_1(\theta_1)$, the type θ_2 chooses either $d_1(\theta_2) = d_1(\theta_1)$ or his preferred decision within L. This latter case corresponds to the decision in L closest to $\alpha_1 + \theta_2$ and is given by the upper bound of L: $\bar{l}$.

Given that $d_1(\theta_2) = \bar{l}$, the type θ_1 chooses his preferred decision that satisfies the constraint IC_2'. So $d_1(\theta_1)$ equals $\alpha_1 + \theta_1$ if for $(d_1(\theta_1), d_1(\theta_2)) = (\alpha_1 + \theta_1, \bar{l})$, IC_2' is satisfied. This is the case if: $|\alpha_2 - \beta_2| \leq \frac{\Delta\theta}{2}$ or if $\frac{\Delta\theta}{2} \leq \beta_2 - \alpha_2 \leq \Delta\theta$[37] and $\bar{l} \geq \tilde{l} = \alpha_1 + \theta_2 - \sqrt{2}\sqrt{\Delta\theta}\sqrt{\alpha_2 - \beta_2 + \Delta\theta}$.
When $\frac{\Delta\theta}{2} \leq \beta_2 - \alpha_2 \leq \Delta\theta$ and $\bar{l} \leq \tilde{l}$, IC_2' is binding and the decision $d_1(\theta_1)$ is given by this constraint. Solving IC_2' for $d_1(\theta_1)$ we found that:

$$d_1(\theta_1) = \alpha_1 + \theta_2 - \sqrt{H(\bar{l})} \tag{37}$$

With $H(\bar{l}) = (\alpha_1 - \bar{l})^2 - 2\bar{l}\theta_2 + 2(\alpha_2\theta_1 + \beta_2\Delta\theta + \alpha_1\theta_2 + \beta_2\theta_2 + \theta_2\theta_1) - \theta_1^2$. This function decreases when the upper bound of L decreases: $H'(\bar{l}) = 2\bar{l} - 2(\alpha_1 + \theta_2)$ which is negative for all $\bar{l} < \alpha_1 + \theta_2$. Therefore, if $\bar{l}$ is smaller than $\tilde{l}$, $d_1(\theta_1)$ decreases when $\bar{l}$ decreases.

Using a similar argument as in the proof of proposition 1, we can show that this equilibrium is the only one who satisfies the intuitive criterion. For the moment, we didn't check if the solution described in 3 satisfies the constraint IC_1' i.e. check that it is indeed optimal for θ_1 to differentiate from θ_2 rather than mimicking him and selecting $d_1(\theta_1) = \bar{l}$. This is done in corollary 4.

F Proof proposition 5

F.1 Elimination of pooling equilibria

Suppose that the state of the world parameter belongs to a set $\Theta \equiv \{\theta_1, \theta_2, ..., \theta_N\}$ with $\theta_1 < \theta_2 < ... < \theta_N$. Consider an equilibrium in which in some state of the world, the agent takes an identical decision d_1^*. To prove proposition 5, we show that any of these pooling (or partial pooling) equilibrium survive the intuitive criterion.

Our proof runs as follow: we first show that when $\alpha_2 < \beta_2$, the lowest type θ_1 cannot be in the pooling. Then we show that the second lowest type θ_2 cannot be in the pooling and by recurrence we show that no pooling equilibrium survives the intuitive criterion[38].

If $\alpha_2 < \beta_2$, the lowest type θ_1 has an incentive to deviate from any pooling equilibrium because θ_1 always prefer $d_2 = \beta_2 + \theta_1$ to the decision d_2^* associated with the pooling equilibrium. After observing a first decision d_1^*, the principal chooses $d_2^* = \sum_{i \in I} \mu_i(\theta_i | d_1^*)\theta_i$, where I is the subset of Θ in which the agent takes d_1^* and $\mu_i(\theta_i | d_1^*)$ are the posterior beliefs after observing d_1^*. It is straightforward to show that d_2^* is greater than $\beta_2 + \theta_1$, and as $\alpha_2 < \beta_2$: $\alpha_2 + \theta_1 < \beta_2 + \theta_1 < d_2^*$, then the agent θ_1 prefers the separating decision to the pooling one.

Let's define $\tilde{d}_1$ as:

$$U^A(\theta_1, \tilde{d}_1, d_2 = \beta_2 + \theta_1) = U^A(\theta_1, d_1^*, d_2^*) \tag{38}$$

[37] Remember that for the moment we consider only the case of free lunch signals when $|\alpha_2 - \beta_2| \leq \Delta\theta$

[38] In the case $\beta_2 < \alpha_2$, the reasoning is similar but we have to start by showing that the highest type θ_N cannot be in the pooling and next that the second highest type cannot be in the pooling and e.t.c.

$$\tilde{d}_1 < \alpha_1 + \theta_1$$

To show that θ_1 cannot be in the pooling, we have to show that if θ_1 switches from d_1^* to $\tilde{d}_1$, the other types prefer the initial pooling equilibrium whatever the beliefs associated with $\tilde{d}_1$. The type for which it is the least costly to switch from d_1^* to $\tilde{d}_1$ is the type closest to θ_1, namely θ_2. If θ_2 has no incentives to switch, all other types $\theta > \theta_2$ will neither.

The proof is identical to what is done to derive proposition 1. If the costs of switching exceed the benefits for $d_1^* = \alpha_1 + \theta_1$, then they exceed benefits for all d_1^*. The value of $\tilde{d}_1$ associated with $d_1^* = \alpha_1 + \theta_1$ is (we define $d_2^* = \beta_2 + \theta_1 + X$, $X > 0$):

$$\tilde{d}_1 = \alpha_1 + \theta_1 - \sqrt{2(\beta_2 - \alpha_2)X + X^2} \tag{39}$$

With some algebra we can show that θ_2 does not benefit from a change of decision whatever the beliefs associated with $\tilde{d}_1$[39].

This proves that the lowest type cannot belong to the pooling equilibrium. Now let's suppose that second lowest type (θ_2) pools with other types. In that case (when θ_1 is out of the pool but θ_2 belongs to it), θ_2 prefers the decision $\beta_2 + \theta_2$ to the pooling decision d_2^* because $\alpha_2 + \theta_2 < \beta_2 + \theta_2 < d_2^*$. But then , θ_2 can deviate to a decision $\tilde{d}_1$, and hence, no pooling equilibrium including θ_2 survives the intuitive criterion.

We proceed like this in all the cases to show that the lower type in a pooling equilibrium has an incentive to quit the pool and if he switches to the associated $\tilde{d}_1$, he can signal his type. Hence no pooling (or partial pooling) equilibrium survives the intuitive criterion.

F.2 Separating equilibria

When α_2 is smaller than β_2, the relevant incentive constraints are the downward constraints: those who prevent agent θ_i of mimicking agent θ_{i-1}. In a separating equilibrium, $d_2^*(\theta) = \beta_2 + \theta$. The set of separating equilibrium decision d_1^* is the set $\{d_1^*(\theta_1), d_1^*(\theta_2), ..., d_1^*(\theta_N)\}$ such that:

$$\begin{aligned}
d_1^*(\theta_N) &= \alpha_1 + \theta_N & (40)\\
U^A(\theta_N, d_1^*(\theta_N), d_2^*(\theta_N)) &\geq U^A(\theta_N, d_1^*(\theta_{N-1}), d_2^*(\theta_{N-1})) & (41)\\
U^A(\theta_{N_1}, d_1^*(\theta_{N_1}), d_2^*(\theta_{N_1})) &\geq U^A(\theta_{N_1}, d_1^*(\theta_{N-2}), d_2^*(\theta_{N-2})) & (42)\\
&\cdot \quad \cdot \quad \cdot & \\
U^A(\theta_2, d_1^*(\theta_2), d_2(\theta_2)) &\geq U^A(\theta_1, d_1^*(\theta_1), d_2(\theta_1)) & (43)
\end{aligned}$$

For example, equation (41) defines a set D of decisions $d_1^*(\theta_{N-1})$ that are incentive compatible given $d_1^*(\theta_N)$. The intuitive criterion implies that all the beliefs associated with a decision $d_1 \in D$ should be $\mu(\theta_{N-1}|d_1 \in D) = 1$. And hence, the agent θ_{N-1} selects his preferred decision within D. And $d_1^*(\theta_{N-1})$ is either $\alpha_1 + \theta_{N-1}$ or given by the constraint.

[39] The only beliefs to consider are: $\mu(\theta_1|\tilde{d}_1) = 1$ or $\mu(\theta_2|\tilde{d}_1) = 1$.

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