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Fondazione Eni Enrico Mattei

**Delegation and Information
Revelation**

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NOTA DI LAVORO 47.2000

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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.

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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 agent¹ in order to acquire information. By contrast to other papers, we show that the information is not transmitted through contracts but through delegated decisions.

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] (hereafter MMR) relax the assumption of perfect communication between the principal and the agent, Felli [1996] relaxes the assumption of infinitely costly communication between agent, 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. In all these models, delegation is costly. This cost of delegation, often referred in the literature as the loss of control, comes from the fact that the principal and the agent don't share the same preferences over decisions. On the other hand, delegation may also have its benefits: for MMR, the benefits of delegation (they call them flexibility gains) are linked to the inability for the agents to communicate with the principal. For Laffont Martimort and Felli, a three layer hierarchy is better able to prevent collusion than a centralized structure. For Aghion and Tirole, delegating authority stimulates the effort of the agent in information acquisition. In this paper, we show that delegation is useful to reduce the initial asymmetry of information between the principal and the agent.

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. We assume that 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. They disagree on the choice of the optimal decision.

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 decision 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.

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, 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

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

[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.

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. In the paper, we provide a convenient way to isolate costs and benefits associated with delegation.

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.

We believe that the trade off between information transmission and loss of control can be a rational for delegation in many complex organizations. The following examples illustrates some of the relations, we would like to explain:

Example 1 (political decision): In the political area, decision makers (ministers, governments, ...) especially those who are new in office do not have the necessary knowledge of the problems and environment to take the best political decision. On the other hand, bureaucracies, advisors and experts generally have this knowledge but lack the power of decision. One solution for the minister is to delegate the decision to the administration. This has harmful effects if the administration has objectives that are not those of the minister (which seems to be plausible, as decision maker changes while administration remains in place). Such a delegation has two advantages: first the administration is informed about (its) best decision and secondly, if the minister knows the administration's preference, he can learn through the observation of the decision what are the environmental conditions and use this information for subsequent decisions. The relations between ministers and administrations can be explained by a trade off between loss of control over decisions and information transfers.

Example 2 (capital budgeting procedures): Within firm, the CEO has to elicit manager's information about project profitability in order to allocate funds between projects. If profitability cannot be verified, the CEO cannot use screening contracts to elicit the information. In that case, delegating the funding decision for some project to the informed manager is a tool for the CEO to learn the profitability of that project but also the profitability of other projects with correlated profitability (in the same line of business for example). Giving discretion to the manager for the funding of some projects is a tool to transfer information from managers to the CEO. We will develop further this example in section 6.

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 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 taken 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. In our model, even if the organization is organized as follows: 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. In section 6, we apply the model to capital budgeting procedures. Section 7 discusses some extensions and section 8 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 members². The utility of the principal and the agent are also affected by a common environmental parameter θ . This parameter is constant over periods³.

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 agent⁴. These contractual

²Even 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.

³This 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.

⁴The 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 or by institutional agreement,

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]).

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 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 principal⁵

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

as it is the case in political decisions.

⁵Assuming 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.

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 ($EU^P + U^A \geq 0$), are carried out.

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
- 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 beliefs 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

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

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

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 . We start by describing the separating equilibria, after we analyze the pooling equilibria. 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:

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

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

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

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

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

$$(\alpha_1 + \theta_1)(d_1^*(\theta_1) - d_1^*(\theta_2)) + \frac{1}{2}(d_1^*(\theta_2)^2 - d_1^*(\theta_1)^2) \geq \Delta\theta(\alpha_2 - \beta_2 - \frac{\Delta\theta}{2}) \quad (IC'_1)$$

$$(\alpha_1 + \theta_2)(d_1^*(\theta_2) - d_1^*(\theta_1)) + \frac{1}{2}(d_1^*(\theta_1)^2 - d_1^*(\theta_2)^2) \geq \Delta\theta(\beta_2 - \alpha_2 - \frac{\Delta\theta}{2}) \quad (IC'_2)$$

To characterize the separating equilibrium, we have to identify the relevant incentive constraint. The right hand side (RHS) of IC'_i represents the benefits⁶ for type θ_i of mimicking the type θ_j ; $i, j = 1, 2$. There are 3 possible cases:

Case S.1: 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 $d_1^*(\theta_2)$.

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

$$\frac{\alpha_2 + \theta_1 \quad \alpha_2 + \theta_2}{\beta_2 + \theta_1 \quad \beta_2 + \theta_2}$$

Case S.2: 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 .

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

$$\frac{\alpha_2 + \theta_1 \quad \alpha_2 + \theta_2}{\beta_2 + \theta_1 \quad \beta_2 + \theta_2}$$

Case S.3: Both RHS are negative which means that no type has an incentive to misrepresent his type⁷.

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

$$\frac{\alpha_2 + \theta_1 \quad \alpha_2 + \theta_2}{\beta_2 + \theta_1 \quad \beta_2 + \theta_2}$$

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

$$d_1^*(\theta_1) = \alpha_1 + \theta_1 \quad (4)$$

$$d_1^*(\theta_2) \in D \equiv \{d_1(\theta_2) | IC'_1, IR_1\} \quad (5)$$

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 . $D \equiv D_1 \cap D_2$ where D_1 is the set of incentive compatible decisions: $D_1 \equiv]0, \alpha_1 + \theta_1 - \sqrt{K_1}] \cup [\alpha_1 + \theta_1 + \sqrt{K_1}, +\infty[$; $K_1 = (2\alpha_2 - 2\beta_2 - \Delta\theta)\Delta\theta$ and D_2 is the set of decisions that left a positive utility to agent θ_2 : $D_2 \equiv [\alpha_1 + \theta_2 - \sqrt{H}, \alpha_1 + \theta_2 + \sqrt{H}]$; $H = (\alpha_1 + \theta_2)^2 - \beta_2^2 + \frac{\alpha_2\beta_2}{2} - \theta_2^2$.

⁶By benefits, we mean the difference in $U^A(\theta_i)$ when the principal chooses $d_2 = \beta_2 + \theta_j$ rather than $d_2 = \beta_2 + \theta_i$.

⁷It is impossible to have the two incentive constraints relevant at the same time. This comes from the single crossing property of the utility function.

Now we use 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 $\mu(\theta_1|d_1 \in D) = 0$.

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 $\alpha_2 - \beta_2 \geq \Delta\theta$ 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, $\alpha_1 + \theta_2 \in D^8$, in the second case, $d_1^*(\theta_2)$ is the decision closest to $\alpha_1 + \theta_2$ within D .

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

$$d_1^*(\theta_1) \in D \equiv \{d_1(\theta_1)|IC'_1, IR_1\} \quad (6)$$

$$d_1^*(\theta_2) = \alpha_1 + \theta_2 \quad (7)$$

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 : $D \equiv D_3 \cap D_4$. D_3 is the set of incentive compatible decisions: $D_3 \equiv]0, \alpha_1 + \theta_2 - \sqrt{K_2}] \cup [\alpha_1 + \theta_2 + \sqrt{K_2}, +\infty[$; $K_2 = (2\beta_2 - 2\alpha_2 - \Delta\theta)\Delta\theta$ and D_4 is the set of decisions that left a positive utility to agent θ_1 .

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 is⁹:

$$d_1^*(\theta_1) = \alpha_1 + \theta_1 \quad (8)$$

$$d_1^*(\theta_2) \in D \equiv \{d_1(\theta_2)|IC'_1\} \quad (9)$$

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: $d_1^*(\theta_1) = \alpha_1 + \theta_1, d_1^*(\theta_2) = \alpha_1 + \theta_2$.

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

⁸Notice 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 $\alpha_2 - \beta_2 \leq \Delta\theta$.

⁹There is another separating equilibrium where $d_1^*(\theta_2) = \alpha_1 + \theta_2$. The reasoning in this case is similar.

$\alpha_2 - \beta_2 \geq \frac{v_2 \Delta \theta}{2}$. 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: $\mu(\theta_1|d_1 \neq d_1^*) = 1$.

$$\begin{array}{c} \text{Case P.1} \\ \frac{\alpha_2 + \theta_1}{\beta_2 + \theta_1 \quad \beta_2 + E\theta} \end{array}$$

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: $\mu(\theta_1|d_1 \neq d_1^*) = 0$.

$$\begin{array}{c} \text{Case P.2} \\ \frac{\alpha_2 + \theta_2}{\beta_2 + E\theta \quad \beta_2 + \theta_2} \end{array}$$

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: $\mu(\theta_1|d_1) = v_1$.

$$\begin{array}{c} \text{Case P.3} \\ \frac{\alpha_2 + \theta_1 \quad \alpha_2 + \theta_2}{\beta_2 + \theta_1 \quad \beta_2 + \theta_2} \\ \beta_2 + E\theta \end{array}$$

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: $\forall d_1 \neq d_1^*$,

$$U^A(\theta_1, d_1^*, d_2^*) \geq U^A(\theta_1, d_1, d_2 = \beta_2 + \theta_1) \quad (10)$$

$$U^A(\theta_2, d_1^*, d_2^*) \geq U^A(\theta_2, d_1, d_2 = \beta_2 + \theta_1) \quad (11)$$

Using these two conditions, we can define the set D of pooling equilibria. The condition (10) is satisfied for all d_1 if it is satisfied for $d_1 = \alpha_1 + \theta_1$. Condition (10) 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 (11) is satisfied for all d_1 if it is satisfied for $d_1 = \alpha_1 + \theta_2$. (11) 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 as¹⁰: $d_1^* \in D \equiv D_1 \cap D_2$.

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 $\mu(\theta_1|\tilde{d}_1) = 0$.

¹⁰As B is greater than A , if the set D is non empty, its upper bound is given by $\alpha_1 + \theta_1 + \sqrt{A}$.

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.

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

$$U^A(\theta_1, d_1^*, d_2^*) \geq U^A(\theta_1, d_1, d_2 = \beta_2 + \theta_2) \quad (12)$$

$$U^A(\theta_2, d_1^*, d_2^*) \geq U^A(\theta_2, d_1, d_2 = \beta_2 + \theta_2) \quad (13)$$

(12) 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 (13) 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 2 $\forall d_1^*, \exists \tilde{d}_1$ 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.

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

$$U^A(\theta_1, d_1^*, d_2^*) \geq U^A(\theta_1, d_1, d_2 = \beta_2 + v_1\theta_1 + v_2\theta_2) \quad (14)$$

$$U^A(\theta_2, d_1^*, d_2^*) \geq U^A(\theta_2, d_1, d_2 = \beta_2 + v_1\theta_1 + v_2\theta_2) \quad (15)$$

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

From our previous discussion, we can establish that:

Proposition 1 *The only equilibrium that survives the intuitive criterion is the least costly separating (LCS) equilibrium¹¹.*

The LCS equilibrium is:

$$d_2(\theta) = \beta_2 + \theta \quad (16)$$

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

$$d_1(\theta) = \alpha_1 + \theta \quad (17)$$

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

$$d_1(\theta_1) = \alpha_1 + \theta_1 \quad (18)$$

$$d_1(\theta_2) = \alpha_1 + \theta_2 + (\sqrt{K_1} - \Delta\theta) \quad (19)$$

¹¹This equilibrium is often referred to the Riley [1979] outcome.

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

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

$$d_1(\theta_1) = \alpha_1 + \theta_1 - (\sqrt{K_2} - \Delta\theta) \quad (20)$$

$$d_1(\theta_2) = \alpha_1 + \theta_2 \quad (21)$$

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 :

$$d_1 = \alpha_1 + \theta \quad (22)$$

$$d_2 = \alpha_2 + \theta \quad (23)$$

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 cost¹². Therefore, if the principal cannot commit to the allocation of decision right over d_2 to the agent¹³, 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 delegation¹⁴.

¹²Except if the interests over d_2 are perfectly congruent.

¹³Aghion and Tirole [1997] study this particular problem of commitment in a given organizational structure.

¹⁴For 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 (23) (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 Costs and benefits of delegation

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. We call the latter *costs of delegation* and the former *benefits of information*. In this section, we isolate costs and benefits associated with delegation and identify the optimal organization.

4.1 Costs and benefits of delegating d_1

4.1.1 Benefits of delegation (benefits of information)

The benefits of delegation are the benefits of having informed deciders. The benefits of information can be easily computed by taking the difference between the expected utility of an *informed* principal and the expected utility of an *uninformed* principal. In both cases, we suppose that the principal takes both decisions. When she is informed, $d_i = \beta_i + \theta$; $i = 1, 2$, when she's not, $d_i = \beta_i + v_1\theta_1 + v_2\theta_2$; $i = 1, 2$. The benefits of delegation are the difference $EU^P(\text{Principal informed}) - EU^P(\text{Centralization}) = v_1v_2\Delta\theta^2$. Being informed increases EU^P by $v_1v_2\Delta\theta^2$. The following lemma follows immediately:

Lemma 3 *The benefits of information are equal to:*

$$v_1v_2\Delta\theta^2$$

when the principal delegates d_1 .

When the principal delegates d_1 , both decisions are taken on the basis of the true value of θ because the first decision signals θ to the principal and she becomes informed before choosing d_2 as established in proposition 1 ¹⁵.

The positive benefits of information reflects the quadratic nature of the cost function used in the model. A large $\Delta\theta$ means that agent's information has a great value.

¹⁵If the state of the world changes over periods, under delegation the second decision is not taken on the basis of the correct information but on the basis of posterior beliefs $\mu(\theta_i|d_1)$. In that case, the benefits of information associated with the second decision are smaller than in the full correlation case.

4.2 Costs of delegation (loss of control)

To compute the benefits of delegation, we have abstracted from the loss of control associated with diverging interests between the principal and the agent. Now, similarly, to compute the costs of delegation we abstract from the asymmetry of information between the principal and the agent and concentrate only on the problem of diverging interests. To measure the loss of control, we compare the principal's expected utility in two situations: in the first, the principal is informed and take all the decisions, in the second, she delegates the first decisions to the agent. $CD_1 = EU^P(\text{Principal informed}) - EU^P(\text{Delegation of } d_1)$. As in both cases, the decisions are taken by an informed party, we abstract from informational gains that can be produced by delegation

Lemma 4 *The costs of first period delegation (CD_1) are:*

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

$$CD_1 = \frac{(\alpha_1 - \beta_1)^2}{2} \quad (24)$$

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

$$CD_1 = \frac{(\alpha_1 - \beta_1)^2}{2} + v_2(\sqrt{K_1} - \Delta\theta)(\alpha_1 - \beta_1 + \frac{\sqrt{K_1} - \Delta\theta}{2}) \quad (25)$$

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

$$CD_1 = \frac{(\alpha_1 - \beta_1)^2}{2} + v_1(\sqrt{K_2} - \Delta\theta)(\beta_1 - \alpha_1 + \frac{\sqrt{K_2} - \Delta\theta}{2}) \quad (26)$$

The costs of delegation have three possible values depending on the signalling equilibrium played by the agent. In the case of free lunch signals, the costs are simply a function of the distance between α_1 and β_1 . When the signals are costly, there is an additional term reflecting the fact that in one state, d_1 is not the agent's preferred decision. This term is positive or negative depending on (i) the direction and (ii) the size of the change in the decision relative to the case of free lunch signals.

For example, in the case $\alpha_2 - \beta_2 \geq \Delta\theta$, we have $d_1(\theta_2) = \alpha_1 + \theta_2 + \sqrt{K_1} - \Delta\theta > \alpha_1 + \theta_2$. 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 $d_1(\theta_2)$ ¹⁶ is not too big compared to $\beta_1 - \alpha_1$. If $\sqrt{K_1} - \Delta\theta \geq 2(\beta_1 - \alpha_1)$, the actual decision $d_1(\theta_2)$ is greater than the principal's preferred decision and the distance between $d_1(\theta_2)$ and $\beta_1 + \theta_2$ is greater than the distance between $\alpha_1 + \theta_2$ and $\beta_1 + \theta_2$. Hence the costs of delegation are greater than $\frac{(\alpha_1 - \beta_1)^2}{2}$. Then we can say that: When $\Delta\theta$ is small ($\leq |\alpha_2 - \beta_2|$), the costs of first period delegation are smaller than $\frac{(\alpha_1 - \beta_1)^2}{2}$ if:

When $\alpha_2 - \beta_2 \geq \Delta\theta$, (i) $\beta_1 > \alpha_1$ and (ii) $2(\beta_1 - \alpha_1) > (\sqrt{K_1} - \Delta\theta)$

When $\beta_2 - \alpha_2 \geq \Delta\theta$, (i) $\alpha_1 > \beta_1$ and (ii) $2(\alpha_1 - \beta_1) > (\sqrt{K_2} - \Delta\theta)$

When $\alpha_1 = \alpha_2$ and $\beta_1 = \beta_2$, the costs of delegation are always greater than $\frac{(\alpha_1 - \beta_1)^2}{2}$.

¹⁶The 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 preferences¹⁷.

4.3 costs and benefits of delegating d_2 or d_1 and d_2

Under complete delegation, the decider is informed (by definition) but there are losses of control associated with the two decisions. Using the same definition as before, the costs of complete delegation are:

$$CD_{12} = \frac{(\alpha_1 - \beta_1)^2}{2} + \frac{(\alpha_2 - \beta_2)^2}{2} \quad (27)$$

Similarly, when the principal delegates d_2 , only the second decision is taken under full information. The costs of delegation associated with the delegation of d_2 are:

$$CD_2 = \frac{(\alpha_2 - \beta_2)^2}{2} \quad (28)$$

4.4 Optimal organizational structure

From the computation of costs and benefits of delegation, comparisons between the four organizational structure are easy.

The optimal organizational structure is given in the following technical lemma. Comparative static results are summarized in propositions 2, 3 and 4 as well as in figure 1.

Lemma 5 *The optimal organization is:*

to delegate d_1 if:

$$CD_1 \leq v_1 v_2 \Delta\theta^2 \quad (29)$$

and if $CD_2 \leq \frac{v_1 v_2 \Delta\theta^2}{2}$, the following additional condition is required:

$$\frac{(\alpha_1 - \beta_1)^2}{2} - \frac{(\alpha_2 - \beta_2)^2}{2} \leq \frac{v_1 v_2 \Delta\theta^2}{2} \quad (30)$$

to delegate d_2 if:

$$CD_2 \leq \frac{v_1 v_2 \Delta\theta^2}{2} \quad (31)$$

or

$$\frac{(\alpha_1 - \beta_1)^2}{2} - \frac{(\alpha_2 - \beta_2)^2}{2} \geq \frac{v_1 v_2 \Delta\theta^2}{2} \quad (32)$$

and centralization otherwise.

¹⁷When 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 $p \frac{(\alpha_2 - \beta_2)^2}{2}$.

Proof. We first show that complete delegation is always dominated: when $\Delta\theta \geq |\alpha_2 - \beta_2|$, $CD_1 = \frac{(\alpha_1 - \beta_1)^2}{2}$ is always smaller than CD_{12} . Therefore if complete delegation dominates centralization ($CD_{12} \leq v_1 v_2 \Delta\theta^2$), complete delegation is dominated by first period delegation. 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 $v_1 v_2 \Delta\theta^2$, which means that centralization dominates complete delegation.

First period delegation dominates when $CD_1 \geq v_1 v_2 \Delta\theta^2$, and if second period delegation dominates centralization, $CD_1 - v_1 v_2 \Delta\theta^2$ must be greater than $CD_2 - \frac{v_1 v_2 \Delta\theta^2}{2}$. If this last expression is positive, it implies $\Delta\theta \geq |\alpha_2 - \beta_2|$ and we have $CD_1 = \frac{(\alpha_1 - \beta_1)^2}{2}$. Equation (30) is simply a reformulation of these conditions.

Second period delegation dominates if $CD_2 \leq \frac{v_1 v_2 \Delta\theta^2}{2}$ (equation 31) and if $\frac{v_1 v_2 \Delta\theta^2}{2} - CD_2 \geq v_1 v_2 \Delta\theta^2 - CD_1$ (equation 32). ■

Proposition 2 *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.

Proposition 3 *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.

Proposition 4 *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.

The following figure represents optimal organizational structure for the case of $\alpha_2 > \beta_2$.

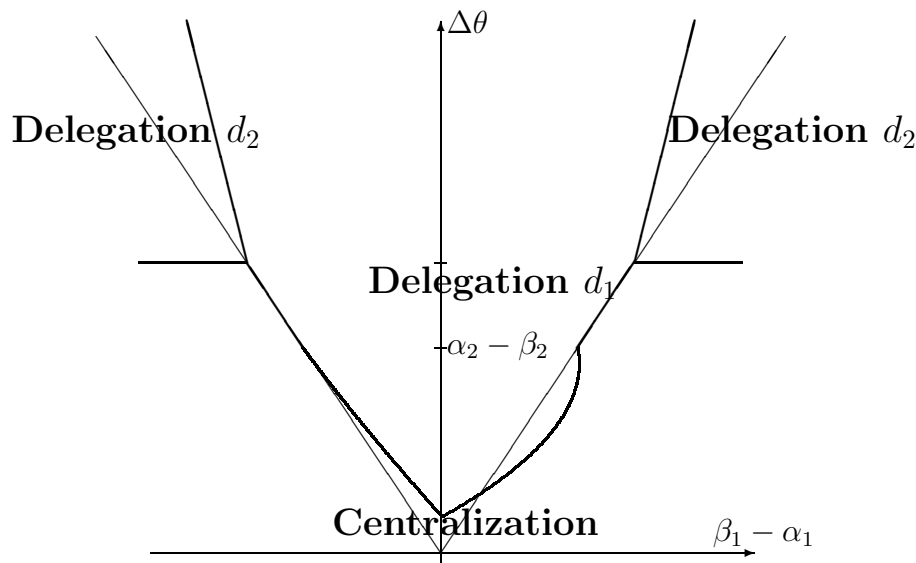


Figure 1: The optimal organizational structure

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 drawback 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 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]¹⁸. In this paper, we concentrate on rules that decrease the costs of delegation.

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 \bar{l} of the subset $L = [\underline{l}, \bar{l}]$.

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 agent¹⁹. 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 world²⁰ 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 6 *Without loss of generality, we can restrict our attention to rules of the form $[0, \bar{l}]$, with $\alpha_1 + \theta_1 \leq \bar{l} \leq \alpha_1 + \theta_2$, 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 6, 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 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 $\alpha_1 > \beta_1$)²¹. The other case is symmetric and can be easily be computed with our analysis.

¹⁸Armstrong’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.

¹⁹But the agent has still the possibility of quitting the organization.

²⁰This correspond to the case where $\Delta\theta \geq |\alpha_2 - \beta_2|$.

²¹We will also assume for expositional simplicity that $\beta_1 + \theta_2 > \alpha_1 + \theta_1$.

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 6:

Proposition 5 *When the principal imposes a rule to the agent, his equilibrium decisions are:*

$$d_1(\theta_2) = \bar{l} \quad (33)$$

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

$$d_1(\theta_1) = \alpha_1 + \theta_1 \quad (34)$$

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

$$d_1(\theta_1) = \alpha_1 + \theta_1 \quad \text{if } l \geq \tilde{l} \quad (35)$$

and

$$d_1(\theta_1) = \alpha_1 + \theta_2 - \sqrt{H(l)} \quad \text{if } l \leq \tilde{l} \quad (36)$$

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'_2 is satisfied. This decision is either $\alpha_1 + \theta_1$ or given by the constraint²².

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 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.

Corrolary 1 *When $\frac{\Delta\theta}{2} \leq \alpha_2 - \beta_2 \leq \Delta\theta$, the rule preserves information transmission if \bar{l} is such that:*

$$\bar{l} \geq \bar{l}^{IC'_1} = \alpha_1 + \theta_1 + \sqrt{\Delta\theta}\sqrt{2\alpha_2 - 2\beta_2 - \Delta\theta} \quad (37)$$

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

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

²² 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.

Limits to the imposition of rules (II): participation constraints As the rule push 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 \bar{l}^* . The optimal rule is the rule that minimize the resulting costs of delegation and is computed by solving the following program:

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

s.t. $\bar{l} \geq \bar{l}^{IC'_1}$ and the behavior of the agent as a function of \bar{l} is described in proposition 5.

Lemma 7 *The optimal rule can have three possible forms:*

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

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

$$v_1 \left[\beta_1 - \alpha_1 - \Delta\theta + \sqrt{H(\bar{l}^*)} \right] \frac{H'(\bar{l}^*)}{2\sqrt{H(\bar{l}^*)}} = -v_2(\beta_1 + \theta_2 - \bar{l}^*) \quad (38)$$

RULE C: $\bar{l}^* = \bar{l}^{IC'_1}$.

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 6 *The optimal rule \bar{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 decision²³.

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 $\bar{l}^{IC'}$. Otherwise, the rule must be set at the highest level that preserves information transmission ($=\bar{l}^{IC'}$).

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. Also, even with a rule, with delegation is associated a transfer of information. Imposing a rule is useful only if it diminishes the associated costs of delegation. This idea is summarized in proposition 7 and commented hereafter.

Proposition 7 *Restricting agent's discretion decreases the associated costs of delegation without suppressing them.*

The proof is trivial as the principal has always the possibility of setting $\bar{l} = \alpha_2 + \theta_2$. If the principal sets \bar{l} at a lower level, as it is the case with rules A, B and C, she does so only because it decreases the costs of delegation.

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 loses 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.

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.

²³If $\beta_2 > \alpha_1 + \theta_1$, the optimal rule is $\bar{l}^* = \alpha_1 + \theta_1 + \epsilon$.

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 An application: capital budgeting procedure

In this section, we apply the model to capital budgeting procedures within firms and confront our results to recent work in that topic an particularly Harris and Raviv [1996, 1998].

The main question concerning capital budgeting procedures is to understand how capital is effectively allocated by the CEO to the various operating divisions. If the CEO knows all the characteristics of projects, capital budgeting procedures are irrelevant. When the division manager has some private information, for example he knows the investment opportunities in his line of business, capital budgeting procedure should be designed to elicit manager's information and make correct investment decisions.

Usually in corporate finance²⁴, it is assume that managers have preferences for empire. Preference for empire means that, *ceteris paribus*, managers prefer to have larger fund at disposal than what is necessary to maximize firm's value. In the terms of our model, the managerial preferences for empire means that $\alpha_i > \beta_i$, $i = 1, 2$.

Suppose that the project needs two injections of money²⁵: an initial financing at time 1 and an additional amount (refinancing) at time 2.

Our model suggests that the optimal budgeting procedure is either to left both decisions - initial investment and refinancing - in the hand of the CEO. In that case, the CEO controls the managerial preference for empire but is uninformed. Or to delegate the financing decision to the manager and keeps the refinancing decision. This leads to a larger initial financing than those that maximize firm's value, but the refinancing decision is optimal. Section 5 suggests that to limit the over financing of the project by th manager, it is optimal to set an upper limit on the capital available²⁶.

Harris and Raviv [1996, 1998], in a similar setting where the manager is empire builder and the decisions are also non contractible, found that the optimal capital budgeting procedure is to allocate a fixed amount of fund to manager. The manager can either accept or refuse or ask for more funds. If the manager asks for more resources, the CEO

²⁴For example Jensen [1986]

²⁵Like in Holmström and Tirole [1998]

²⁶Alternatively, we can interpret d_1 and d_2 as two projects in the same line of business. The environmental parameter should be interpreted as a general business conditions, affecting the profitability of both projects. As we mentioned in footnote 3, the important assumption is not that the state of the world is the same for both projects but that there is some correlation between both. With this alternative interpretation, the optimal budgeting process is either to give discretion to the manager on the choice of one project (say project 1) with a maximal amount of capital to spend on it and discretion on the other to the CEO or to let the CEO decide on the investment level of both projects.

audits the division with a probability $q < 1$, and if the results of the audit are positive, the manager receives an additional amount of financing. With this procedure, if the cost of audit is not too high, the CEO can be informed about investment opportunities (the state of the world). In our model, the CEO can be informed, even audit is infeasible or infinitely costly.

7 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 delegation²⁷. 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 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.

8 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 the first project 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

²⁷The 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.

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 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 unconditionally 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.

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.

A Proof of lemma 1

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

$$U^A(\theta_2, \tilde{d}_1, d_2 = \beta_2 + \theta_2) = U^A(\theta_2, d_1^*, d_2^* = \beta_2 + E\theta) \quad (39)$$

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

\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 satisfied²⁸. As θ_2 prefers to signal his type, the function on the right hand side of (39) 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 (39) 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 :

$$U^A(\theta_1, d_1^*, d_2^*) > U^A(\theta_1, \tilde{d}_1, d_2) \quad (40)$$

If the beliefs associated with \tilde{d}_1 are $\mu(\theta_1|\tilde{d}_1) = 1$, the condition (40) is satisfied. In that case, the agent θ_1 loses on both sides: the first decision is greater than d_1^* ²⁹ 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 (40) 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 8 *The cost of switching from $d_1^* \in D'$ to the associated \tilde{d}_1 increases with d_1^* .*

Proof: Solving (39) 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^* :

$$\tilde{d}_1 = \alpha_1 + \theta + \sqrt{d_1^{*2} - 2d_1^*(\alpha_2 + \theta_2) + C} \quad (41)$$

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 $\alpha_1 + \theta_1 - d_1$.

²⁸To have strict preference take $\tilde{d}_1 + \epsilon$.

²⁹whatever the initial d^* even those smaller than $\alpha_1 + \theta_1$

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 (40) 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 (41), (40) 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, a 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.

B Proof of lemma 6

If β_1 is greater than α_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 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 5, 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 $\underline{l} \geq \alpha_1 + \theta_1$.

$$[\alpha_1 + \theta_1, \alpha_1 + \theta_2].$$

C Proof of proposition 5

From proposition 1, we know that the only equilibrium that survives the intuitive criterion is the least costly separating equilibrium. In proposition 5, we describe the LCS equilibrium of the game when $\beta_1 > \alpha_1$ and the rule is $[0, \bar{l}]$.

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 $\frac{\Delta\theta}{2} \leq \beta_2 - \alpha_2 \leq \Delta\theta$ ³⁰ 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:

$$d_1(\theta_1) = \alpha_1 + \theta_2 - \sqrt{H(\bar{l})} \quad (42)$$

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 5 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 1.

³⁰Remember that for the moment we consider only the case of free lunch signals when $|\alpha_2 - \beta_2| \leq \Delta\theta$

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