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Delegation, Externalities and Organizational Design

A. Gautier and D. Paolini

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Delegation, Externalities and Organizational Design*

Axel Gautier[†] Dimitri Paolini[‡]

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Abstract

In a repeated interaction between and a principal and two agents with inter-agents externalities and asymmetric information, we show that optimal decentralization within the organization is limited to the first period and across agents.

1 Introduction

In multi unit organizations, with externalities (the choices made by one unit affect the profit of the others), two key factors will drive the task allocation problem: externalities and asymmetric information. In the absence of externalities, there is no need to coordinate agents' choices and profit is maximized in a fully decentralized structure where the agents have all the power. In the absence of asymmetric information, there is no reason to delegate and profit is maximized in a centralized organization where the principal keeps all the power. In an organization where there are both externalities and asymmetric information, benefits and costs are associated with delegation.

In a single period interaction, delegation is beneficial because the decider has superior information (Dessein, 2002). With repeated interaction, delegation has an additional benefit: the principal can improve her knowledge of the agents' information by observing their past decisions (Gautier and Paolini, 2007). Delegation is a learning process: when the agent uses his private information to make better decision, the principal revises her beliefs by observing the agent's choice and she can improve her decisions.

We model a two-period interaction between one principal supervising two agents (units). At each period, a project must be implemented in each unit. At time zero, the principal chooses the process of decision-making for the following periods. Projects are transferable control actions (Aghion et al., 2002): projects cannot be contracted out but control is contractible. Each agent has a piece of private information and he exerts an externality on the other. The question, in this context, is which decisions should be decentralized and when?

In line with Gautier and Paolini (2007), we show that optimal decentralization within the organization is limited to the first period. Being a learning process, delegation is unnecessary when the non-informed party has acquired the information. Delegation is also limited across agents. With correlated information, the principal acquire information that is partially redundant when she delegates to both agents. Hence, symmetric agents can be treated asymmetrically

*Corresponding author. Tel.: +39 079 2017338; fax +39 079 2017338. *E-mail address*: dpaolini@uniss.it (D. Paolini).

†CREPP, HEC-ULg and CORE, Université Catholique de Louvain.

‡DEIR, Università degli Studi di Sassari, and CRENoS

within the organization. An agent receives control over the first project while the other does not. Necessary conditions for this asymmetric treatment of agents are repeated interaction and correlation between information.

2 The Model

There are three players, the principal and two agents, and two periods. Each period sees a project implemented in both units. Before the first period, the principal decides who will have the power to choose the project (d_t^l) in periods $t = 1, 2$ in unit $l = A, B$.

Each agent l has private information represented by a state parameter θ^l drawn out of a set $\Theta = \{\theta_1, \theta_2\}$ with $\theta_1 < \theta_2$ and $\Delta\theta = \theta_2 - \theta_1$. Each agent knows the true realization of θ while the principal only knows the prior distribution. The distribution of (θ^A, θ^B) over $\Theta \times \Theta$ is represented by a joint probability distribution $\{v_{11}, v_{12}, v_{21}, v_{22}\}$ where $v_{ij} = prob(\theta^A = \theta_i, \theta^B = \theta_j)$. Correlation can be measured by $\rho = |v_{11}v_{22} - v_{12}v_{21}|$. To simplify, we assume that: $v_{11} = v_{22} = v_{ii}$ and $v_{12} = v_{21} = v_{ij}$. Then, $\rho = |v_{ii} - \frac{1}{4}|$ and it takes a value between 0 (independence) and $\frac{1}{4}$ (perfect correlation).

The projects differ in just one dimension and there is a continuum of possible decisions: $d_t^l \in (0, +\infty)$.

Each unit is a profit center. Depending on θ^l, there is one project maximizing profit in unit l. There are externalities between the two units. The agents maximize their unit's profit, while the principal's aim is to maximize total profit. Profits in units l is:

$$\Pi^l = \alpha^l d_1^l - \frac{(\theta^l - d_1^l)^2}{2} + \alpha^l d_2^l - \frac{(\theta^l - d_2^l)^2}{2} - \gamma(d_1^k + d_2^k),$$

with $l \neq k$. Π^l is maximized for $d_t^l = \alpha^l + \theta^l$. Total profit $\Pi^A + \Pi^B$ is maximized for $d_t^l = \alpha^l + \theta^l - \gamma$.

3 Decisions of the principal and the agents

Each decision d_t^l is made by the person to whom the principal has allocated the right to decide. When the principal must decide on a project d_t^l, her decision depends on the information she has. Let us represent her information by a distribution of beliefs η_{ij} over $\Theta \times \Theta$. The decision d_t^l that maximizes total profit is:

$$d_t^l = \alpha^l + E(\theta^l \mid \eta_{ij}) - \gamma,$$

where $E(\theta^l \mid \eta_{ij})$ denotes the expected value of θ^l conditional on beliefs η_{ij}.

When agent l must decide on a project d_t^l, he must take into account that the principal will revise her beliefs after observing d_t^l. This changes the agents' profit if the principal can make a decision after the agent i.e. only if d_1^l is delegated and d_2^A or d_2^B is not. If the principal cannot use the agent's information, the agent chooses his preferred project $d_t^l = (\alpha^l + \theta^l)$. In all other cases, the agents and the principal play a signaling game and we must search for equilibria. Usually, signaling games have multiple equilibria. We use Cho and Kreps (1987) intuitive criterion (IC) to refine the set of equilibria. We can establish that:

Proposition 1 *Under delegation of d_1^l, the only equilibrium that survives IC is the least costly separating (LCS) equilibrium.*[1]

[1]The Riley (1979) outcome.

Proof. See appendix. ■

Proposition **??** implies that the agents disclose their private information by taking a state contingent decision when they receive control at period 1. Hence, if the principal delegates d_1^l, she learns θ^l and improve her knowledge of θ^k. Second period decisions are then based on a more accurate information.

Corollary 2 *If $\Delta\theta^2 \geq \gamma^2$, the LCS equilibrium is $d_1^l(\theta) = \alpha^l + \theta^l$.*

4 Optimal organization

Given that there is an externality between the two units, any form of delegation has a cost for the principal because there is no coordination in the project choices. Nevertheless, delegation benefits the principal because (i) the decisions of the agents are based on better information than those of the principal and (ii) the principal improves her knowledge of the state parameter after observing delegated decisions. In line with that, delegation of second period decisions should never occur.[2]

Starting from a fully centralized organization, let us define the marginal benefit of delegating first period projects to the agents. Delegating one project amounts to a change of total profit equals to $Mb(1) = -\gamma^2 + \frac{1}{2}(1+8\rho^2)\Delta\theta^2$. The marginal benefit of delegating a second decision is $Mb(2) = -\gamma^2 + \frac{1}{2}(1-8\rho^2)\Delta\theta^2$. Hence, if $Mb(1) > 0$, the total profit increases if d_1^l is delegated to agent l. Likewise, if $Mb(2) > 0$, both first period projects must be delegated to the agents. Clearly, $Mb(1) \geq Mb(2)$, that is the marginal benefit of delegating a first project is higher than the marginal benefit of delegating a second one because the information contained in a second signal is partially redundant (at least for $\rho > 0$). Hence, if $Mb(1) > 0 > Mb(2)$, the principal optimally delegates to only one agent.

Proposition 3 *The optimal organization is: centralization for $\Delta\theta^2 \leq \frac{2\gamma^2}{1+8\rho^2}$, delegation of d_1^l to agent l for $\Delta\theta^2 \in [\frac{2\gamma^2}{1+8\rho^2}, \frac{2\gamma^2}{1-8\rho^2}]$ and delegation of d_1^A and d_1^B to A and B for $\Delta\theta^2 \geq \frac{2\gamma^2}{1-8\rho^2}$.*

The striking result of this paper is the optimality of limited delegation in a repeated context. Delegation is limited to the first period (Gautier and Paolini, 2007) and across agents. Agents can be treated asymmetrically within the organization. The principal selects one delegate that will be responsible for the production of the signal and keeps control over the decisions concerning the other agent.

The quality of the signal produced by the agent depends on the degree of correlation. $Mb(1)$ is increasing in ρ: when the information are correlated the value of a unique signal is higher. Conversely, $Mb(2)$ decreases in ρ : the informational content of the second signal decreases with the degree of correlation. Figure 1 illustrates the optimal organizational structure as a function of the correlation parameter. Asymmetric treatment of the agents is more likely when the agents have correlated information. Note also that in a one period model, there is no learning associated with delegation and agents will be treated symmetrically.

In this model, we have analyzed a dynamic task allocation problem with externalities and asymmetric information. An alternative mechanism could be that the agents communicate to

[2]It is obvious if $\gamma^2 \leq \Delta\theta^2$. If $\gamma^2 > \Delta\theta^2$, the LCS is such that $d_1^l(\theta) \geq a^l + \theta^l$ and this makes the principal weakly worse-off. In this case, delegation of a second period decision should be envisaged. As we shall see, if $\gamma^2 > \Delta\theta^2$, the principal prefers to centralize all the decisions even if the LCS is $d_1^l(\theta) = a^l + \theta^l$. Hence, delegation of d_2^l is never an issue in this model.

the principal and the principal chooses the actions. Crawford and Sobel (1982) show that communication is not perfectly informative. In a message game both agents reveal their private information to the principal who then takes all decisions if $4\gamma^2 \leq \Delta\theta^2$. Clearly there exists a parameter set where communication fails and delegation is optimal. This confirms Dessein (2002) who recognizes that *"Delegation is typically a better instrument to use the local knowledge of the agent than communication."*

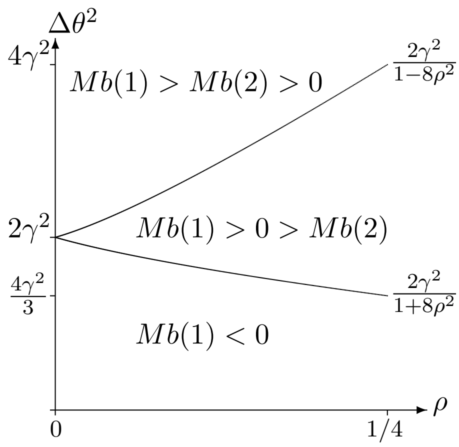

Figure 1: Optimal organization

A Proof of proposition ??

In a two-players game, IC selects the Riley outcome if there are only two states and if the payoff function satisfies the single crossing condition. To prove proposition **??**, we replicate the argument in this three-players game.

Suppose that agent k truly reveals his private information if he controls d_1^k. Then, whatever the choice of d_1^l by agent l, he will not be able to change the principal's belief about θ^k. Hence, the game played by agent l and the principal is similar to a two-players game. In this game, the standard sorting condition is satisfied; This is sufficient to kill all the pooling and the separating equilibria but the Riley outcome.

Suppose that agent k does not disclose his private information at period one either because he does not control d_1^k or because he plays a pooling equilibrium. In this case, disclosing the value of θ^l changes the principal's beliefs on both θ^l and θ^k. We must then identify the state θ_i in which the agent has no incentive to hide his private information (if it exists).

If agent l plays a pooling equilibrium, the second period decisions are: $d_2^k = \alpha^k + \frac{\theta_1+\theta_2}{2} - \gamma$, $k = A, B$. If, in state θ_i, the agent manages to signal his type, the second period decisions change to: $d_2^l = \alpha^l + \theta_i - \gamma$ and $d_2^k = \alpha^k + v_{ii}\theta_i + v_{ij}\theta_j - \gamma$, $i, j = 1, 2$. We must show that there exists a state $\theta_i \in \Theta$ in which the agent has would prefer to inform the principal. Replacing the decisions in the profit functions, we can show that such a state always exists. Consequently pooling equilibria are eliminated by IC.

If agent l plays a separating equilibrium, the second period decisions are: $d_2^l(\theta_i) = \alpha^l + \theta_i - \gamma$ and $d_2^k = \alpha^k + v_{ii}\theta_i + v_{ij}\theta_j - \gamma$. If, in state θ_i, the agent deviates, he changes the second period decisions to: $d_2^l = \alpha^l + \theta_j - \gamma$ and $d_2^k = \alpha^k + v_{ij}\theta_i + v_{ii}\theta_j - \gamma$, $i, j = 1, 2$. We must show that there exists at most one state $\theta_i \in \Theta$ in which such a deviation is profitable. Replacing the decisions in the profit functions, we can show that indeed, deviating cannot be profitable in both states. Hence, we have our standard sorting conditions and only the LCS survives IC.

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