The Subsidiarity Bias in Regulation

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Abstract

We study the choice of the regulatory structure when a firm engages in different activities for different countries. Under decentralization regulatory contracts suffer from two opposite distortions: the competition between regulatory authorities leads to too high-powered contracts; however, with a dispersed ownership structure, contracts tend to be too low-powered. For sufficiently substitutable activities, decentralization always leads to an inefficient drift towards fixed-price contracts. Nonetheless, when regulators have private agendas and possess the discretion to distort their policy to gain the support of some interest groups, decentralization may be preferred to centralization as competition between regulatory authorities eradicates their discretionary power.

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1 Introduction

What is the proper level of decentralization for public policy and in particular regulation? This question is very lively debated in federal states such as the USA or Brazil, as well as in the European Union. It is a special case of a more general debate about the desirability of multiple governments, with spatial specialization when we deal with decentralization, with domain specialization when we are concerned with a regulator per industry, or with functional specialization when we discuss the separation of regulation and competition policy. In Europe, the concept of subsidiarity has been put forward to express the idea that decentralization is desirable unless it entails too high coordination costs.

Regulation of the same firm by several regulators is a very common phenomenon, sometimes in the context of a monopoly, sometimes in the context of an oligopoly. One can distinguish for a firm engaged in both activities the case of multi-industry regulators who for example regulate both gas and electricity (such as the state regulators in the USA) to be contrasted with the case of industry specific regulators. There is also for water utilities the situation of multi-functional regulation, i.e. regulation of prices, quality and environmental effects, to be contrasted with separate regulators for price, quality and environment as it is in the United Kingdom.

Even though our model could be developed with this type of interpretation in mind, we will focus on the opposition between centralized regulation (like federal regulation in the USA) and decentralized regulation (like state regulation in the USA). One may also envision more complex institutional designs in which some dimensions of activity are centrally controlled while others are decentralized.

For example, firms like GTE or some Baby Bells operate over different states and have their local telephony monopolies regulated by different state regulators; one could conceive of centralizing this type of regulation. In Europe, the mergers taking place in telecommunications or electricity are quickly leading us to a situation where an operator will be a dominant player in several countries regulated by different regulators (like EDF in France and Italy or France Telecom in France and Poland).

From a theoretical perspective, the optimality of the decentralization of public decision-making is an empty question in a world of complete contracts with benevolent decision-makers. Indeed, in such a setting, a centralized organization can always replicate the outcome of a decentralized one. We must introduce a degree of incompleteness (in the

informational structures, in the sets of instruments or in the objectives) to create a trade-off between centralization and decentralization. Some recent papers have discussed this trade-off with a clear view of its foundation in terms of contractual limitations[1].

In Caillaud, Jullien and Picard (1996) the focus is on the decentralization of industrial policies from the European level to the national level. If some variables are more likely to be observed at the national level they show that it is always optimal to decentralize part of the activities even in the presence of externalities between countries. Seabright (1996) introduces the notion of accountability to justify the possible superiority of decentralization. In his model, decentralization increases the accountability of the politicians in charge of decision-making and this effect can balance the non internalized externalities. Klibanoff and Poitevin (1997) rely on the lack of commitment power of the central government to favor decentralization which induces a direct bargaining between regions. Also, Olsen and Torsvik (1993) and Martimort (1999) show that having several regulators who leave more rents to the regulated agent carrying substitute activities is a commitment device. Laffont and Martimort (1998) show that the threat of collusion may lead the central government to delegate its authority when communication constraints alone would not yield this result. Laffont and Zantman (1999) base the trade-off on the better informational structures of local politicians which are the joint products of local politics. Dewatripont and Tirole (1999) and Laffont and Martimort (1999) show in different contexts how a duality of regulators or supervisors is useful to provide incentives for regulators in charge of tasks which create negative externalities the ones on the others.

In this paper we develop a simple regulatory model to debate some pros and cons of decentralization or subsidiarity for the regulation of natural monopolies. Local favoritism, multiprincipal externalities and political economy under incomplete information are the main ingredients of the trade-offs we study. More precisely, we use the regulatory setting of Laffont and Tirole (1993) in which a firm is in charge of two procurement activities.[2] Each regulator wants the firm to realize a country-specific project, and each project requires a specific effort from the firm which has private information about its cost characteristics.

[1]See also Sah and Stiglitz (1986), Hart and Moore (1999), Gilbert and Picard (1996) for organizational theories based on bounded rationality or implicit communication costs.

[2]Similar results could be obtained with a regulation model with variable quantities as Laffont and Tirole (1986) as well as with oligopolistic industries such as Auriol and Laffont (1992) or Dana and Spier (1994).

This informational advantage yields an (information) rent to the firm. Given that our major goal is to provide a class of cases for which decentralization may dominate centralization for political economy reasons, we will mostly confine our analysis to symmetric cases. However, we will comment on various interesting asymmetries.

Under centralization, a unique regulator coordinates both decisions, whereas under decentralization each activity is regulated independently. With benevolent regulators suffering from asymmetric information with respect to the firm, decentralization suffers from two distortions. The first one is related to the multiprincipal design of the model. Because the actions taken by the firms are substitutes, each regulator is led to increase the effort he requires from the firm in equilibrium: this is the competition effect. The second effect is due to our specification of the ownership structure of the firm. We assume that in each country some of the citizens hold some shares in the firm. Hence, the rent of the firm goes back to the shareholders of each country. Under centralization, the regulator takes into account the effect of his regulation on the whole rent of the firm that belongs to the consumers of both countries. However, under decentralization, each regulator cares only about the consumers and shareholders of his country. As a result, decentralization leads the regulators to induce a too low effort level: this is the shared-rent externality.

When efforts are sufficiently substitutable we show that the competition effect is dominant and in the limit this can lead the regulators to offer fixed-price contracts in equilibrium: decentralization makes rent extraction impossible and the firm earns a large rent from the non coordination of the regulations.

Next, we consider that regulators may be captured. As in Laffont (1996) we consider a random majority model and assume that the regulators act in favor of the majority in power. In this case, we show that decentralization might be preferred as it reduces the discretionary power of the decision-makers. In a similar spirit Bardhan and Mookherjee (1999) recently use a political economy framework à la Grossman and Helpman (1996) to show that corruption may be as serious in decentralized or centralized government.

Tax competition has a lot in common with the competition between regulators. Huizinga and Nielsen (1996a) develop a model of taxation in which majority voting determines the mix of profit, investment and saving taxes. The role of foreign ownership (which determines the strength of the shared-rent externality) is studied. Huizinga and Nielsen (1996b) use this framework to analyze the need for capital income taxation in a federation of countries. Overtaxation may occur because of the shared-rent externality effect,

but an undertaxation may result from an externality of domestic tax policy on the foreign supply of savings[3].

Olsen and Osmundsen (2001)[4] is closer to our modeling. They use a common agency model to describe tax competition between two jurisdictions with respect to a large multinational enterprise (MNE). This firm has private information about its efficiency and its allocation of investment across the two jurisdictions is similar to our allocation of efforts across the two national projects. Each local government is a benevolent social maximizer and they study in detail the role of the shared-rent externality. Their Proposition 1 characterizing the symmetric non cooperative equilibrium is similar to our Proposition 4 in stressing the role of the cost of public funds and the shared-rent externality in determining the underinvestment or overinvestment due to the multiprincipal externality. Their Proposition 2 shows that both profits and (often) welfare are maximized for equal distribution of ownership across the two jurisdictions.

The structure of the paper is as follows. The next section introduces the model with benevolent regulators. In Section 3, we show that decentralization is equivalent to centralization when regulators are under complete information vis-à-vis the firm. In Sections 4 and 5 we compare centralization and decentralization under asymmetric information. Section 6 does the same comparison when the objectives of the regulators are biased in favor of some citizens. Section 7 concludes. All the proofs are gathered in appendices.

2 The model

We take a partial equilibrium approach and consider two countries (or regions) $i = 1, 2$ in which a firm is realizing a project with (gross) value S_i for the consumers of country i[5].

The firm can provide an effort e_i in order to reduce the cost associated with project i. The cost function of the firm for project i is $C_i = \beta - e_i$ where β is the intrinsic efficiency parameter of the firm. We assume that the efficiency of the firm is the same for both projects. Parameter β can take values in $[\underline{\beta}, \overline{\beta}]$ according to a common knowledge

[3]A taxation model closer to our model would entail an overtaxation due to the rent-externality effect and, for example, an inefficiency of taxation due to a corrupt tax administration which would favor decentralization (and undertaxation) but would reduce corruption by reducing the tax revenues.

[4]See also the references therein to the common agency literature.

[5]Throughout the paper, we will assume that S_i is sufficiently large so that each regulator does not want to shut down the realization of the project for some types of firm.

probability distribution with density $f(.)$ and cdf $F(.)$ satisfying the monotone hazard rate condition ($\frac{d}{d\beta}\frac{F(\beta)}{f(\beta)} \geq 0$). In order to obtain explicit solutions we will sometimes illustrate our solutions in the case of a uniform distribution on $[1, \frac{3}{2}]$[6].

The cost reducing efforts create a disutility to the firm equal to

$$\psi(e_1, e_2) = \frac{1}{2}(e_1^2 + e_2^2) + \gamma e_1 e_2.$$

We assume that $\frac{\partial^2 \psi}{\partial e_1 \partial e_2} = \gamma > 0$, or equivalently that the two efforts are substitutes from the point of view of the firm[7]. Note that the firm cannot manipulate costs[8]. Accounting separation can be perfectly implemented but the firm can decide to allocate unobservable effort in a way that maximizes its rent. Parameter γ belongs to $[0, 1]$ and a high value of this substitutability index means that effort can be easily substituted from one project to the other (and conversely). Note that the disutility function is increasing and convex in both efforts.

The effort levels stand for any unobservable (for the regulators) inputs used by the firm; that the firm can substitute one effort to the other simply means that the firm can reallocate these inputs from one project to the other. For instance, consider that the firm uses two types of labor, one with a high productivity, the other with a low productivity and that the productivity of labor is known by the firm only. In this case, the firm is led to allocate the most productive labor on the project with the highest marginal gain. One could also conceive that a given type of labor is more suited to a given project (when there is a specificity of tasks for instance). In this case, there would be some frictions in the process of reallocation of these inputs. That the reallocation of unobservable inputs might be imperfect is captured by the imperfect substitutability in our model.

We also assume that regulator i, denoted by P_i, fully reimburses the (observable) cost C_i of activity i[9]and does not observe the realized cost on the other activity. The gain of the firm is then given by

$$U = t_1 + t_2 - \psi(e_1, e_2)$$

[6]This support is chosen to ensure the positivity of effort and cost levels.

[7]As Olsen and Osmundsen (2001) we focus on the case of substitute activities which is the most relevant here (see Martimort (1992) and Mezzetti (1997) for common agency models with complement activities). Treating the case of complements would require a different $\psi(.)$ function since this one is not compatible with positive marginal disutility of effort for all possible levels if $\gamma < 0$.

[8]See Laffont and Tirole (1993), chapter 12, for a model of regulation with cost padding.

where t_i is the net transfer given by P_i.

In country i, P_i contracts with the firm for the realization of the (country specific) project. When the regulatory structure is splitted like that, we assume that the contracts are secret (P_i does not observe the contract proposed by regulator P_j to the firm), and that regulators offer simultaneously contracts to the firm.

Each regulator must finance the realization of his project. In our partial equilibrium approach, the shadow cost of public funds $\lambda > 0$ captures the distortionary effects of taxation[10]. Regulator P_i maximizes the welfare in country i, equal to the net surplus of the consumers/taxpayers plus a (so far) arbitrary sharing of the firm's rent, given by

$$SW_i = S_i - (1+\lambda)(t_i + C_i) + \delta_i U \quad i = 1, 2$$

with $\delta_1 + \delta_2 = 1$, $\delta_i \geq 0$, $i = 1, 2$. These shares reflect the distribution of ownership between the consumers of the two countries.

As is usual in the multiprincipal literature, we assume that if the firm decides to realize a project, it must also realize the other project. If it refuses to participate at all then the firm receives a reservation utility normalized to 0[11].

3 Full information benchmarks

In this section, we assume that the firm's efficiency is publicly known; this implies that the effort provided by the firm is also observable. We start with the case of a common regulator (centralization) and then proceed with the situation where the two regulators behave in a non cooperative way (decentralization).

3.1 Centralized regulation

In this situation, a single regulator called P_c wants to maximize the sum of the welfares in the two countries. Since he knows the efficiency parameter of the firm, he has only to ensure that the firm is willing to participate. In other words, this regulator solves the

[9] This is just an accounting convention.

[10] We assume it is the same for both countries.

[11] This is the *intrinsic* common agency setting as coined by Bernheim and Whinston (1986). See Olsen and Osmundsen (1999) for a model of *delegated* common agency.

following program

$$\begin{cases} \max\limits_{\{t,e_1,e_2\}} \sum_{i=1}^{2} SW_i \\ \text{subject to } U \equiv t - \psi(e_1, e_2) \geq 0 \quad \forall \beta \in [\underline{\beta}, \overline{\beta}]. \end{cases}$$

Immediate algebra yields the solution to this program:

Proposition 1 *Under centralization and complete information the optimal levels of effort are symmetric*[12] *and are given by*

$$e_1(\beta) = e_2(\beta) = e_*(\beta) = \frac{1}{1+\gamma}.$$

Moreover, the firm gets no rent.

The intuition is clear: the marginal disutility of each effort must be equal to its marginal cost saving effect. Because the public funds are costly it is optimal to leave no rent to the firm: the (unique) transfer is designed in such a way that the rent of the firm is equal to its reservation utility.

3.2 Decentralized regulation

When each regulator P_i knows the private information of the firm and when regulators behave in a non cooperative way, we are back to the previous situation. Indeed, each regulator can make the firm residual claimant of their relation, whatever the contract proposed to the firm by the other regulator. We conclude this subsection with the following proposition.

Proposition 2 *Under complete information, decentralization is equivalent to centralization*[13].

The coordination between regulators on how to share the payments to the firm is not described by the model: only the sum of the transfers is determined[14].

[12] Under centralization, when $\gamma = 1$ only the sum of the efforts is determined in equilibrium. This holds under complete and incomplete information.

[13] When the action undertaken by a regulator directly affects the welfare of the other regulator (not just through the rent of the firm), Martimort and Stole (1998) show that decentralization leads to multiple equilibria (under complete and asymmetric information). Hence, in this case decentralization yields different outcomes than centralization, even under complete information.

[14] This is due to the intrinsic common agency assumption. Had we assumed that the firm could decide to realize a project for only one country, the optimal efforts would not have been changed; however, each

4 Centralized regulation under asymmetric information

Asymmetric information has been recognized as being a major obstacle to first-best efficient regulation. Following the new regulatory economics, we model the regulatory process as a principal-agent problem in which the firm has a superior knowledge on its efficiency.

When the two regulators cooperate perfectly the problem is equivalent to a usual adverse selection problem with a two-dimensional action[15]. According to the Revelation Principle[16], we can restrict ourselves to direct and truthful contracts: the outcome of any regulation stipulating a transfer depending on the realized costs can be replicated by a regulatory contract in which the firm reveals truthfully its private information. These additional incentive compatibility constraints will undermine the efficiency of the regulation and force the regulators to move away from the first-best (full information) contract.

Let us now determine the requirements of incentive compatibility. We denote by

$$U(\beta;\tilde{\beta}) = t(\tilde{\beta}) - \frac{1}{2}[(\beta - C_1(\tilde{\beta}))^2 + (\beta - C_2(\tilde{\beta}))^2] - \gamma(\beta - C_1(\tilde{\beta}))(\beta - C_2(\tilde{\beta}))$$

the gain of a firm with true cost parameter β when it announces $\tilde{\beta}$ to the unique regulator. The firm will reveal truthfully its private information if

$$\beta \in \arg\max_{\tilde{\beta}} \quad U(\beta;\tilde{\beta}) \text{ or } \begin{cases} \dot{U}(\beta) = -(1+\gamma)[e_1(\beta) + e_2(\beta)] \\ \dot{e}_1(\beta) + \dot{e}_2(\beta) \leq 2 \end{cases}$$

where $U(\beta)$ is the rent of the firm with type β when it announces the truth to the regulator[17].

The centralized regulator must still ensure that the firm is willing to participate to the regulatory process, or that the firm earns a greater rent than its outside opportunity.

As is usual, we rewrite the objective function of the regulator in terms of efforts and rent instead of costs and transfer. The program of the centralized regulator can then be

transfer would have been defined uniquely. See Olsen and Osmundsen (1999) and Martimort and Stole (1998) for discussions about the implications of this assumption.

[15]See Laffont and Tirole (1993) for instance.

[16]See Gibbard (1973), Green and Laffont (1977) or Myerson (1979).

[17]As usual, the second-order condition $\dot{e}_1(\beta) + \dot{e}_2(\beta) \leq 2$ is ignored in a first step and checked ex post for the optimal solution.

stated as follows:

$$\begin{cases} \max\limits_{\{U(.),e_1(.),e_2(.)\}} \mathbf{E}_\beta\{S_1+S_2-(1+\lambda)[2\beta-e_1(\beta)-e_2(\beta)+\psi(e_1(\beta),e_2(\beta))]-\lambda U(\beta)\} \\ \text{subject to } \forall\beta\in[\underline{\beta},\overline{\beta}] \\ \dot{U}(\beta)=-(1+\gamma)[e_1(\beta)+e_2(\beta)] \\ \dot{e}_1(\beta)+\dot{e}_2(\beta)\leq 2 \\ U(\beta)\geq 0. \end{cases}$$

We give the solution in the following proposition.

Proposition 3 *Under asymmetric information and centralized regulation, the optimal levels of effort are symmetric and are given by*

$$e_1(\beta)=e_2(\beta)=e_c(\beta)=\frac{1}{1+\gamma}[1-(1+\gamma)\frac{\lambda}{1+\lambda}\frac{F(\beta)}{f(\beta)}].$$

Effort is distorted downwards, except for the most efficient firm. Indeed, because the rent decreases with the efficiency parameter, the effort provided by less efficient firms must be decreased in order to limit the rents of the more efficient ones. This is the standard trade-off between rent extraction and incentive to effort: on the one hand, for efficiency reasons the regulator would like to implement effort levels that are not too distorted with respect to their first-best levels; on the other hand, the higher the effort required from the firm, the larger the rent given up to the firm, and consequently the larger the social cost due to this rent. Also, all firms, except the most inefficient one, earn a positive rent. Asymmetric information forces the unique regulator to leave a positive, and socially costly, rent to the firm in order to obtain truthful revelation of the private information.

5 Decentralized regulation under asymmetric information

We first start with a description of the way we solve this multiprincipal problem. The methodology is borrowed from Martimort and Stole (1998). Then we compute the optimal contracts.

The literature on common agency has exhibited many failures of a direct application of the Revelation Principle. Once it becomes impossible to rely on direct mechanisms to characterize the outcome of the common agency game, one has to consider indirect mechanisms. A priori, these mechanisms are based on very general (and untractable) spaces. However, Martimort and Stole (1998) have shown that there is no loss of generality in restricting regulator P_i to use a non linear transfer based on the observable cost C_i incurred by the firm on activity i[18]. Differently stated, it is useless to consider a more complicated contract (that would include an extra-message sent by the firm).

Importantly, we know now that the optimal contract of a regulator for a given contract proposed to the firm by the other regulator belongs to this class of mechanisms. Also, from now on we will restrict ourselves to twice differentiable non linear deterministic transfers[19].

5.1 The problem of regulator P_1

In this subsection, we characterize the best-response of the regulator in country 1 to any contract proposed by the other regulator. First, for any non linear transfer $t_2(C_2)$ offered by P_2 we can apply the Revelation Principle to find P_1's best-response. However, different contracts proposed by P_2 affect differently the firm's incentives to produce for P_1 and therefore P_1's best-response. Consequently let us define the firm's indirect utility function as

$$\hat{U}^1(C_1,\beta) = \max_{C_2} \quad \{t_2(C_2) - \frac{1}{2}[(\beta - C_1)^2 + (\beta - C_2)^2] - \gamma(\beta - C_1)(\beta - C_2)\}.$$

This indirect utility function gives the maximal gain of a β-type firm (excluding the transfer received from regulator P_1) for a given cost C_1 on activity 1 when the firm chooses optimally its cost level C_2 on activity 2. Rewriting this function as $\hat{U}^1(\beta - e_1, \beta)$ we see that it determines the rate at which the firm must incur effort to compensate for a lie on β, and therefore its information rent. Hence, under decentralization there is an informational externality created by one regulator which affects the way the rival regulator must design his contract. For further reference, we denote by $C_2^*(C_1,\beta)$ the

[18]They call this result the *Taxation Principle*. This result hinges on the quasi-linearity of the firm's utility function with respect to monetary transfers.

[19]This restriction is standard in the common agency literature.

cost on activity 2 which satisfies the first-order condition[20]associated with the previous problem, that is

$$t_2'(C_2^*(C_1,\beta)) + \beta - C_2^*(C_1,\beta) + \gamma(\beta - C_1) = 0. \tag{1}$$

Given a contract offered to the firm by P_2, we can apply the Revelation Principle to find the implementable contracts from the point of view of P_1. A firm with type β will reveal its private information if

$$\beta \in \arg\max_{\tilde{\beta}} \quad U(\tilde{\beta};\beta) = t_1(\tilde{\beta}) + \hat{U}^1(C_1(\tilde{\beta}),\beta).$$

Local incentive compatibility implies[21]

$$\begin{cases} \dot{U}(\beta) = \hat{U}^1_{\beta}(C_1(\beta),\beta) \\ \dot{C}_1(\beta)\hat{U}^1_{1\beta}(C_1(\beta),\beta) \geq 0 \end{cases}$$

where $U(\beta)$ is now the rent of the firm in a truthful equilibrium. Immediate manipulations enable us to rewrite P_1's problem as

$$\begin{cases} \max\limits_{\{U(.),C_1(.)\}} \mathbf{E}_\beta\{S_1 - (1+\lambda)[C_1(\beta) - \hat{U}^1(C_1(\beta),\beta)] - (1+\lambda-\delta_1)U(\beta)\} \\ \text{subject to } \forall\beta \in [\underline{\beta},\overline{\beta}] \\ \dot{U}(\beta) = \hat{U}^1_{\beta}(C_1(\beta),\beta) \\ \dot{C}_1(\beta)\hat{U}^1_{1\beta}(C_1(\beta),\beta) \geq 0 \\ U(\beta) \geq 0. \end{cases}$$

If the equivalent of the Spence-Mirrlees condition, $\hat{U}^1_{1\beta}(C_1(\beta),\beta) \geq 0$, is satisfied, then the local second-order condition reduces to $\dot{C}_1(\beta) \geq 0$ and local incentive conditions are sufficient for global incentive compatibility. This condition cannot be postulated a priori as it depends endogenously on the contract proposed by the rival regulator. Hence, it must be checked ex post at the equilibrium.

[20]To consider the out of equilibrium behavior of the firm, the transfer $t_2(C_2)$ has to be extended for costs which may lie outside the set of equilibrium allocations in order that $C_2^*(C_1,\beta)$ be always defined by the first-order condition (1). See Martimort (1992) for the construction of such extensions.

[21]Subscripts on the indirect utility function denote without ambiguity partial derivatives.

Moreover, we have expressed the optimization behavior of the firm with respect to each regulator. It remains to check that it defines a global maximum for the firm (i.e. that the firm is effectively willing to accept simultaneously both contracts in equilibrium).

5.2 The ambiguous effect of decentralization

When regulators do not cooperate we obtain the following proposition. To obtain a symmetric equilibrium, we assume $\delta_1 = \delta_2 = \frac{1}{2}$.

Proposition 4 *Under decentralization with asymmetric information the optimal profiles of effort in a symmetric equilibrium are characterized by*

$$e_1(\beta) = e_2(\beta) = e_d(\beta) = \frac{1}{1+\gamma}[1 - (1+\gamma)\frac{\frac{1}{2}+\lambda}{1+\lambda}\frac{F(\beta)}{f(\beta)}\frac{1-\gamma+2\gamma\dot{e}_d(\beta)}{1+\gamma\dot{e}_d(\beta)}]$$

with initial condition $e_d(\underline{\beta}) = e_*(\underline{\beta})$ *and* $e_d(\beta) \leq e_*(\beta)$ *for all* β. *We have*[22]*:*

- *If efforts are strongly substitutable* ($\gamma \geq \frac{1}{1+2\lambda}$) *then* $e_d(\beta) \geq e_c(\beta)$ *for all* β*; therefore the rent of the firm is larger under decentralization than under centralization.*
- *If efforts are weakly substitutable then* $e_d(\beta) \leq e_c(\beta)$ *for all* β*; therefore the rent of the firm is larger under centralization than under decentralization.*
- *For intermediate values of the substitutability degree, efforts can be either lower or larger under centralization than under decentralization.*

To understand in depth the two effects at work, let us first consider the case of unrelated efforts (i.e. $\gamma = 0$). In this situation, the multiprincipal aspect disappears as the contract offered by one regulator does not affect the choice of effort (or cost) by the firm for the other regulator and the problems of the regulators become separable (up to the participation constraint of the firm).

However, even in this case, decentralization is not equivalent to centralization for the following reason. Under centralization, the regulator fully internalizes the impact of his regulation on the rent of the firm that entirely goes to the consumers of both countries: one unit of rent left to the firm has a social cost of $(1+\lambda) - 1 = \lambda$.

[22]For the last two cases, we assume that a common agency equilibrium exists, as in Olsen and Osmundsen (2001). More on this point in Appendix 8.3.

Under decentralization, this is no longer the case. As a given regulator is only interested in the welfare of the consumers in his country, he does not internalize the effect of his regulation on the fraction of the rent that accrues to the shareholders of the other country. As a consequence, under decentralization, P_i's perceived cost of one unit of rent given up to the firm is $(1+\lambda)-\delta_i$ which is larger than the social evaluation of the firm's rent under centralization. We call this effect the *shared-rent externality.*[23]

Let alone, the shared-rent externality has a clear impact on the regulatory contracts offered to the firm under decentralization. Indeed, as the centralized regulator attaches more weight to the firm's rent than each decentralized regulator, the efforts under centralization tend to be higher than those under decentralization (as rent extraction is more important under decentralization because the firm's rent is more costly for each regulator). Hence, the larger the firm's rent the larger the distortion due to decentralization. Obviously, this externality is present whatever the degree of substitutability of efforts.

Notice also that the larger the shadow cost of public funds λ, the less important the shared-rent externality becomes as the discrepancy between the weight attached to the firm's rent under centralization and decentralization decreases (relatively to the weight of the consumers' surplus).

Finally, notice that this effect would have disappeared had we assumed that the shareholders were not in the countries where the projects are realized[24].

Secondly, let us explain the effect of decentralization on the power of the incentive contracts when efforts are related (i.e. $\gamma \neq 0$). Under centralization, the unique regulator completely coordinates the choice of efforts and anticipates that a firm maximizing its profit will substitute one effort to the other in order to increase its rent.

Under decentralization, when regulator P_1 requires an effort from the firm he also anticipates, but cannot control for, that the firm will try to take advantage of the uncoordinated regulations by substituting one effort to the other. Then P_1 will require from the firm to exert more effort than under a centralized regulation. In equilibrium, these anticipations realize and indeed more effort is required by each regulator. Roughly speaking, regulators are competing for the firm and this behavior leads to an increase in the power

[23]Decentralization fails to internalize shared-rent externalities. It is an example of coordination failure due to decentralization.

[24]This assumption is often made in the multiprincipal literature.

of the incentive contracts offered in equilibrium. This is the *competition effect*.[25]

Obviously, the more substitutable the efforts from the point of view of the firm are, the larger the competition effect is and the larger the distortion due to decentralization is.

When both effects are taken simultaneously into account, the total distortion due to decentralization might become ambiguous as the two effects previously mentioned go in opposite directions. The shared-rent externality leads the decentralized regulators to offer lower-powered contracts while the competition effect induces them to propose higher-powered incentive regulations.

As stated in the proposition, one can nonetheless show that when $\gamma \geq \frac{1}{1+2\lambda}$, i.e., when efforts are sufficiently substitutable and/or the shadow cost of public funds is sufficiently large, decentralization always results in larger efforts than centralization: the competition effect dominates the shared-rent externality, and the firm earns a larger rent under decentralization. We give an illustration of this in the next subsection.

We give now an illustration of the role of the distribution of the firm ownership across countries. Focusing attention on the uniform case (for which efforts are linear in the efficiency level) we obtain the following corollary[26].

Corollary 1 *Under decentralization, in the uniform case, the larger the ownership share δ_i held by country i is, the larger is the effort level exerted by the firm for the project in this country.*

Indeed, the larger the share δ_i is, the smaller becomes the shared-rent externality from the point of view of regulator P_i. Hence, the stronger is the competition effect with respect to the shared-rent externality, leading to an increase in the effort level exerted by the firm in this country.

To conclude, we also show in appendix 8.4 that having an equal distribution of shares, i.e. $\delta_1 = \delta_2 = \frac{1}{2}$, maximizes total welfare under decentralization as in Olsen and Osmundsen (2001).

[25] It is a second type of coordination failure due to decentralization.

[26] We maintain the assumption that the whole firm's profit accrues to citizens of both countries, i.e. $\delta_1 + \delta_2 = 1$. See Olsen and Osmundsen (2001) for the implications of foreign ownership. As usual, in such 'asymmetric case' we assume that a common agency differentiable equilibrium exists.

5.3 The role of efforts allocation and the drift of regulatory contracts towards fixed-price contracts

As explained earlier, the competition effect depends mainly on the substitutability of efforts at the firm's level. When efforts are sufficiently substitutable, then decentralization leads to too large efforts.

One can also show that an increase in the degree of substitutability locally increases the effort of the more efficient firms. The possibility to allocate easily its efforts on one activity or the other hardens the competition effect. Competition between regulatory authorities attains then its paroxysm when efforts are perfectly substitutable and in this case, we can even prove the following result.

Proposition 5 *When efforts are perfectly substitutable ($\gamma = 1$) there exists an equilibrium in which both regulators offer a fixed-price contract to the firm*[27].

When P_2 offers a fixed-price contract to the firm, and when $\gamma = 1$, we show in appendix 8.5 that $\hat{U}^1_{1\beta}(C_1(\beta), \beta)$ is equal to 0. This implies that the second-order condition for implementability is (weakly) satisfied; however, this also implies that regulator P_1 can no longer distort the effort he requires to limit the firm's rent, and cannot trade-off rent extraction and efficiency.

This is a striking illustration of the drift of the regulatory contract. Efforts are equal to the first-best efforts but the rent given up to the firm by the regulators becomes very large. Competition between regulatory authorities leads to large inefficiencies and prevent them from distorting their policy.

In the next section, we will build on this insight.

[27] In the uniform case with perfectly substitutable efforts that we use in the next section there will be two candidate solutions to the differential equation characterizing the optimal effort under decentralization. However, for this case, the one that does not correspond to the fixed-price contract violates the implementability conditions. It is immediate to show that this is also the case for all the probability distributions with a linear hazard rate ($\frac{F(\beta)}{f(\beta)} = l(\beta - \underline{\beta})$, $l > 0$).

6 The choice of the regulatory structure under political uncertainty

Political economy has often challenged the view that the regulatory authority acts as a benevolent planner[28]. The goal of this section is to recognize that the authority in charge of the regulation in each country has a private agenda; we take the example of politicians who only seek to maximize their probability of being reelected[29]and look at the impact of decentralization in such a setting. Another interpretation is that the regulator(s) can be captured by some interest groups that try to distort the regulation in their own interest[30].

Again, since we want to exhibit an example where political economy distortions may favor decentralization, we will consider below an extremely simple model, the random majority model. More realistic political economy models could be easily constructed with for example the Bernheim and Whinston (1986) common agency model. What we only need is a fluctuation in the interest group which captures the regulatory decision, and leads to different rent extraction-efficiency trade-offs. One can be the industrialists who obtain from the regulator generous long term price-cap regulation yielding high information rents and the other the unions or the consumers who obtain quick revisions of the caps or distribution of the firm's "excessive" profits making price-cap regulation very close to cost-plus regulation. As we shall explain, centralization suffers from these policy fluctuations while competition between regulators mitigates these fluctuations at the cost of too high powered incentives.

Let us assume now that in the two regions there is a random proportion of shareholders (resp. non shareholders) denoted by α_i (resp. $1-\alpha_i$) $\in [0,1]$. The shareholders of the firm benefit from the rent of the firm while the non shareholders do not[31].

Before the value of α_i, $i=1,2$, is known, the constitution decides which regulatory

[28]See Buchanan(1965), Noll (1983) and Olson (1963) among others.

[29]See Laffont (1996).

[30]See Stigler (1971) for example and Bardhan and Mookherjee (1999) for a discussion of decentralization in terms of relative captures of local and central government.

[31]We consider that the institutional choice does not affect the repartition between shareholders and non shareholders. It would be interesting to have a richer modeling of the choice by citizens to hold shares or not and to understand how the institutional design affects this decision. This is left for future research.

structure (centralization or decentralization) to set up. However, this choice has to take into account that the regulators in place will act in a distortive way. In our static framework, we model this divergence between the objective of the regulator(s) and the interests of all the citizens by recognizing that the regulator(s) only care(s) about the majority in place.

Under decentralization, if $\alpha_i > \frac{1}{2}$, then there will be a (local) shareholder majority in region i. In this case the objective of the regulator in region i will take into account only the surplus of the shareholders in this region and the part of the rent of the firm that accrues to these shareholders. On the contrary, when $\alpha_i < \frac{1}{2}$ there will be a non shareholder majority and the regulator in place will only care about the surplus of the non shareholders. Accordingly, the objective function of the regulator of region i under decentralization is given by[32]

$$SW_{i,d} = \begin{cases} \alpha_i[S_i - (1+\lambda)(t_i + C_i)] + \frac{\alpha_i}{\alpha_1+\alpha_2}U & \text{if } \alpha_i > \frac{1}{2}, \\ (1-\alpha_i)[S_i - (1+\lambda)(t_i + C_i)] & \text{if } \alpha_i < \frac{1}{2}. \end{cases}$$

Under centralization, the unique regulator cares only about the (national) majority over both regions. His objective function is

$$SW_c = \begin{cases} \sum_{i=1}^{2} \alpha_i[S_i - (1+\lambda)(t_i + C_i)] + U & \text{if } \alpha_1 + \alpha_2 > 1, \\ \sum_{i=1}^{2} (1-\alpha_i)[S_i - (1+\lambda)(t_i + C_i)] & \text{if } \alpha_1 + \alpha_2 < 1. \end{cases}$$

To summarize, the different majorities have different stakes in the information rent of the firm, and the regulators have private agendas depending on the majority in power. Under centralization, the regulator will bias his regulation to favor the majority over both regions; on the contrary, decentralization makes the regulators compete against each other and act only in favor of the local majority. Notice also that both types of majority only differ in their treatment of the firm's rent.

The performances of these different regulatory structures have to be compared with respect to the utilitarian criterion defined as usual by

$$SW^u = \sum_{i=1}^{2} \{S_i - (1+\lambda)(t_i + C_i)\} + U.$$

[32]Letter 'd' (resp. 'c') stands for decentralization (resp. centralization).

In the following, we shall determine the profiles of effort implemented by each constitution. Observe that under a shareholder majority the rent of the firm is overvalued while under a non shareholder majority the rent of the firm is undervalued with respect to the utilitarian criterion.

For expositional purposes, we restrict attention to the uniform case with efforts perfectly substitutable for the firm ($\gamma = 1$)[33]. We also assume that $\alpha_1 = \alpha_2 = \alpha$ and that α takes the value $\alpha^* \in (\frac{1}{2}, 1)$ with probability $\frac{1}{2}$ and $1 - \alpha^*$ with probability $\frac{1}{2}$. Thus, when $\alpha = \alpha^*$ there is a local majority (of size α^*) of shareholders in region i; when $\alpha = 1 - \alpha^*$ there is a local majority (of size α^*) of non shareholders in region i. We also assume that $(1 + \lambda)\alpha^* - 1 > 0$ for rent extraction to be desirable under decentralization and centralization.

6.1 The profiles of effort

We can adapt our previous computations since only the weight of the firm's rent is changed in the objective function of the regulators. The optimal efforts are given in the next proposition.

Proposition 6 *The optimal profiles of effort are given by:*

- *Under centralization* $e_c(\beta) = \frac{1}{2}[1 - 2r_c(\beta - 1)]$ *where* $r_c = 1$ *under a non shareholder majority and* $r_c = \frac{(1+\lambda)\alpha^* - 1}{(1+\lambda)\alpha^*}$ *under a shareholder majority.*
- *Under decentralization* $e_d(\beta) = \frac{1}{2}$ *whatever the majority.*
- *With the utilitarian criterion* $e_u(\beta) = \frac{1}{2}[1 - 2\frac{\lambda}{1+\lambda}(\beta - 1)]$.

This proposition calls for some comments. Under centralization, the optimal profile of effort fluctuates with the majority in place. Under a shareholder majority the effort is larger than the one corresponding to the utilitarian criterion as the regulator in place accounts for the share of the firm's rent that goes to the actual majority[34]. On the

[33] One can show that our insights carry over to the situations in which efforts are sufficiently substitutable. Simulations for these cases are available at *http://www.enpc.fr/ceras/pouyet/working_papers.htm#Competition between Regulations.*

[34] More precisely, this is due to the fact that the centralized regulator only cares about the shareholders which implies that the relative weight of the firm's rent (with respect to the weight attached to the net consumers' surplus) is larger under centralization than with the utilitarian criterion.

contrary, under a non shareholder majority effort is distorted downwards with respect to its utilitarian level.

The decentralization of the regulatory powers leads to the striking result that the implemented efforts become insensitive to the majority in place. As explained earlier, this result comes from the perfect substitutability of the efforts provided by the firms which exacerbates the tension between the non cooperative regulators. This competition between institutions finally ends up with the regulators being led to offer fixed-price contracts without the possibility to match the will of the majority in place with the effort required from the firm: decentralization leads to uniform policies with respect to the political majority.

When the non shareholders have the majority, the effort is too low under centralization and too high under decentralization. By contrast, under a shareholder majority, both constitutions lead to too high effort levels.

Hence, the comparison between centralization and decentralization is ambiguous. On the one hand, centralization enables to implement efforts that limit the rent earned by the firm while decentralization always leaves a too large rent to the firm. On the other hand, centralization is more sensitive to the majority in place and leads to fluctuations in the levels of effort that favor the members of the majority. The comparison between centralization and decentralization hinges simultaneously on the proportion of shareholders/non shareholders and on the shadow cost of public funds, which gives a measure of the social cost of the firm's rent. Effort levels are represented in Figure 1.

Insert Figure 1 here

6.2 Welfare analysis

To assess the performances of centralization and decentralization, we must then compare the expected welfares of both countries under the different constitutions. For a given majority with size α^* that implements the profile of efforts $e(\beta, \alpha^*)$, the expected social welfare is given by

$$\mathbf{E}_\beta\{SW^u(e(\beta,\alpha^*))\} = \int_{\underline{\beta}}^{\overline{\beta}} \{S_1 + S_2 - (1+\lambda)[\psi(e(\beta,\alpha^*)) + 2(\beta - e(\beta,\alpha^*))] - \lambda U(\beta)\} dF(\beta).$$

Whatever the regulatory structure, the slope of the rent of the firm in a symmetric equilibrium is given by

$$\dot{U}(\beta) = -4e(\beta, \alpha^*)$$

which gives (after integration) in the uniform case

$$\mathbf{E}_\beta\{SW^u(e(\beta,\alpha^*))\} = S_1 + S_2 - \frac{5}{2}(1+\lambda) - 4\int_1^{\frac{3}{2}}\{(1+\lambda)e(\beta,\alpha^*)[e(\beta,\alpha^*)-1] + 2\lambda(\beta-1)e(\beta,\alpha^*)\}d\beta$$

Depending on the majority in place, the expected welfare under centralization is given by[35]

$$\begin{cases} SW^u_{c,s} & = S_1 + S_2 - \frac{1}{6}[13 + 14\lambda - \frac{2\alpha^*-1}{\alpha^{*2}(1+\lambda)}] \text{ with a shareholder majority,} \\ SW^u_{c,ns} & = S_1 + S_2 - \frac{13+14\lambda}{6} \text{ with a non shareholder majority.} \end{cases}$$

Under decentralization, because efforts are not dependent on the majority in place, the expected welfare of both countries is

$$SW^u_{d,s} = SW^u_{d,ns} = S_1 + S_2 - \frac{4+5\lambda}{2} \text{ whatever the majority.}$$

Then, the difference between the welfare under centralization and the one under decentralization is

$$\begin{cases} SW^u_{d,s} - SW^u_{c,s} & = \frac{1}{6}\frac{(1-\alpha^*)^2 - \alpha^{*2}\lambda^2}{\alpha^{*2}(1+\lambda)} \text{ under a shareholder majority,} \\ SW^u_{d,ns} - SW^u_{c,ns} & = \frac{1}{6}(1-\lambda) \text{ under a non shareholder majority.} \end{cases}$$

Then, we can state the following proposition.[36]

Proposition 7 *If the shadow cost of public funds is large ($\lambda \geq 1$) then centralization is preferred to decentralization. On the contrary, when the shadow cost of public funds is low ($\lambda \leq 1/\sqrt{2}$) then decentralization is preferred to centralization.*
For intermediate values of the shadow cost of public funds ($1/\sqrt{2} < \lambda < 1$), then decentralization (resp. centralization) is preferred to centralization (resp. decentralization) when the size of the majority is weak (resp. large).

[35] Letter 's' (resp. 'ns') stands for shareholder (resp. non shareholder) majority.
[36] The assumption $(1+\lambda)\alpha^* > 1$ implies that $(1-\alpha^*)^2 - \alpha^{*2}\lambda^2 < 0$.

This proposition confirms the intuitions derived from the comparison of the effort levels. Indeed, when the shadow cost of public funds is large, then the rent left to the firm has a large social cost. Moreover, under decentralization the competition between regulatory authorities provides the firm with excessive rent. These two effects work in favor of centralization and give the rationale for the first part of the proposition[37].

If the shadow cost is sufficiently low, the efficiency consideration tends to be more important than the rent extraction motive, and decentralization tends to be preferred since it eradicates the fluctuations of the effort level at a low social cost.

For intermediate values, the trade-off also depends on the size of the majority in power. The drawback of centralization is that the unique regulator only cares about the majority. Hence, when the size of the majority is small, the proportion of consumers disadvantaged by the centralized regulator tends to be relatively large and decentralization becomes the preferred constitution even though it provides the firm with too much rent (which has a low social cost if λ is not too large). Decentralization serves to limit the discretionary power of the regulators[38]. Figure 2 summarizes this last proposition.

Insert Figure 2 here

Let us now discuss the underlying decision whether or not to decentralize decision-making. For instance, one can take a more positive approach to institutional design and ask when decentralization may emerge from unanimous ex ante consent of citizens and not simply by appealing to social welfare maximization under the veil of ignorance.

Notice first that for a given majority, centralization will always be preferred to decentralization by that majority. Indeed, centralization enables the majority in place to better reap the gains of being empowered to design the regulatory policy (here the cost-reimbursement mechanism) according to their own preferences.

As a preliminary step, one can look at the decision to decentralize or not for the different types of citizens, assuming that each citizen knows whether he is a shareholder or not but does not know the measure of shareholders/non shareholders in the population. Let us denote by $SW_s^{c,ns}$ the welfare of shareholders under centralization when non shareholders have the majority; notations for the other cases are immediately adapted.

[37]If Less Developed Countries have a large shadow cost of public funds, then this tends to favor centralization over decentralization.

[38]With political economy distortions, one can easily check that having $\alpha^* = \frac{1}{2}$ (i.e. identical sizes of the different types of citizens) does no longer maximize total welfare under decentralization.

Then, the welfare difference between centralization and decentralization for a shareholder who doesn't know which majority will realize is

$$\mathbf{E}_\beta\left\{\frac{1}{2}\frac{1}{\alpha^*}SW_s^{c,s}+\frac{1}{2}\frac{1}{1-\alpha^*}SW_s^{c,ns}\right\}- \mathbf{E}_\beta\left\{\frac{1}{2}\frac{1}{\alpha^*}SW_s^{d,s}+\frac{1}{2}\frac{1}{1-\alpha^*}SW_s^{d,ns}\right\}=\frac{1-\alpha^*\left[3+2\lambda\right]+2(1-\alpha^*)\alpha^{*2}(1+\lambda)^2}{12(1-\alpha^*)\alpha^{*2}(1+\lambda)}; \quad (2)$$

similarly, we obtain for a non shareholder

$$\mathbf{E}_\beta\left\{\frac{1}{2}\frac{1}{1-\alpha^*}SW_{ns}^{c,s}+\frac{1}{2}\frac{1}{\alpha^*}SW_{ns}^{c,ns}\right\}- \mathbf{E}_\beta\left\{\frac{1}{2}\frac{1}{1-\alpha^*}SW_{ns}^{d,s}+\frac{1}{2}\frac{1}{\alpha^*}SW_{ns}^{d,ns}\right\}=\frac{2(1+\lambda)^2\alpha^{*2}-1}{12\alpha^{*2}(1+\lambda)}. \quad (3)$$

In our model, with the current specification of parameters, it turns out that non shareholders always prefer centralization over decentralization[39]. Indeed, in the decentralized regime, the regulators are led to implement the first-best effort levels, which leave the firm with a large rent, whatever the majority in place. Therefore, non shareholders prefer to centralize the decision-making process since they do not internalize the firm's rent.

In appendix 8.8, we show that shareholders will favor centralization over decentralization if the shadow cost of public funds is sufficiently large, or $\lambda \geq \overline{\lambda}(\alpha^*)$. Indeed, when the cost of public funds is large, so is the cost of the firm's rent for the majority in place.

But we also show that $\overline{\lambda}(\alpha^*)$ is increasing in α^* and goes toward infinity when α^* goes to 1: the larger is the size of the majority in place, the larger is the per capita gain for a shareholder to prevent the non shareholder majority from implementing its preferred policy, and the more shareholders will favor decentralization over centralization. Decentralization tends to be preferred by shareholders when it enables to reduce the risk to suffer from an unfavorable policy implemented by a majority of non shareholders. When the shadow cost of public funds is not too large, this choice is socially optimal.

Finally, let us consider that the decision to decentralize or not is made before each citizen knows its type. At this stage, since citizens are identical, they could agree on the constitution that maximizes their expected welfare; such constitution would leave no discretionary power to the politicians. However, this constitution must be conditional

[39]Under the assumption $(1+\lambda)\alpha^* > 1$, we have $2(1+\lambda)^2\alpha^{*2} > 1$.

on potentially unverifiable variables, such as the shadow cost of public funds or the proportions of the different types of citizens. When the variance of these variables is large enough, then the ex ante constitution that maximizes expected welfare might be dominated by the choice of political delegation (centralized or not) which has the advantage of more flexibility (i.e., knowledge of λ and α^*) but the inconvenient of more discretion. This trade-off has been studied by Boyer and Laffont (1999). We assume here that citizens must choose between centralization or decentralization given the choice of political delegation.

Then decentralization emerges from ex ante unanimous consent if[40]

$$\mathbf{E}_\beta \left\{ \frac{1}{4}\frac{1}{\alpha^*} SW_s^{c,s} + \frac{1}{4}\frac{1}{1-\alpha^*} SW_s^{c,ns} + \frac{1}{4}\frac{1}{1-\alpha^*} SW_{ns}^{c,s} + \frac{1}{4}\frac{1}{\alpha^*} SW_{ns}^{c,ns} \right\} -$$
$$\mathbf{E}_\beta \left\{ \frac{1}{4}\frac{1}{\alpha^*} SW_s^{d,s} + \frac{1}{4}\frac{1}{1-\alpha^*} SW_s^{d,ns} + \frac{1}{4}\frac{1}{1-\alpha^*} SW_{ns}^{d,s} + \frac{1}{4}\frac{1}{\alpha^*} SW_{ns}^{d,ns} \right\} = \frac{2(1-\alpha^*)\alpha^*(1+\lambda)-1}{12(1-\alpha^*)\alpha^*} \leq 0.$$

This enables us to state the following corollary.

Corollary 2 *Under unanimous ex ante consent, decentralization is preferred to centralization if the shadow cost of public funds is larger than a threshold $\tilde{\lambda}(\alpha^*)$. This threshold is increasing with the size of the future majority α^*.*

From a 'completely' ex ante perspective, this last expression simply trades off the preference of shareholders and non shareholders: Non shareholders prefer the centralized regime since decentralization provides the firm with too much rent. Shareholders tends to favor decentralization because it reduces the risk that a non shareholder majority implements a policy too different from the shareholders's preferred policy; this is particularly the case when the size of the future majority is large and when the shadow cost of public funds, that is the social cost of giving up an excessive rent to the firm, is low. Figure 3 summarizes this result.

Insert Figure 3 Here

Comparing Figure 2 and Figure 3 we observe that, with respect to the socially optimal choice of constitution, there is now a bias in favor of decentralization. Decentralization tends to be adopted more frequently since it protects citizens from the distortions caused by the discretionary power of politicians.

[40]This difference is proportional to the sum of (2) and (3).

7 Conclusion

We have compared the performances of centralization and decentralization of the regulatory powers using the new regulatory economics and without appealing to any informational advantage under decentralization or externalities between countries.

In this setting, the benefit of centralization of the regulatory power at a supranational level is to coordinate the regulations and to take into account the informational externality created by the link between both activities at the firm's level.

Decentralization is plagued by two opposite distortions. The first relates to the informational externality which translates into a competition effect when efforts are substitutes. The second comes from the fact that a regulator does not internalize the impact of his regulation and the fraction of the firm's rent that accrues to the shareholders of the other country.

Then, we introduced a bias in the objective of the regulator. Using the random majority model, in which the regulator only cares about the majority in place, we show that decentralization could perform better than centralization. Indeed, decentralizing the decision power modifies the rules of the political game played by the decision-makers and creates competition between regulators. In our setting, this competition eliminates the negative discretionary power of the regulators at the cost of providing the firm with excessive rent. Introducing a degree of 'competitiveness' (through, say, an unregulated fringe in each country producing an imperfectly differentiated product) in our model would just modify the equilibrium rent of the regulated firm but would not alter qualitatively our conclusions.

To conclude, different extensions would be worth investigating to enrich the debate of centralization versus decentralization. For instance, our model restricts attention to the case of substitutable activities; it would be interesting to study the case of complements, which is relevant, for instance, when the firm engages in research and development activities. Another area of future research would be to allow for different shadow costs of public funds across countries. This would require to consider a general equilibrium framework in which the cost of public funds would be derived endogenously as the result of an optimal taxation.

8 Appendices

8.1 Proof of Proposition 1 and 2

Under centralization, because the rent is socially costly, the regulator sets $U = 0$. Then replacing the value of the transfer in the objective function and optimizing with respect to efforts we obtain the first-best efforts.

Under decentralization the same methodology can be applied directly.

8.2 Proof of Proposition 3

As the rent is (strictly) decreasing in the efficiency parameter and because the rent is socially costly, the participation constraint amounts to $U(\overline{\beta}) = 0$. The Hamiltonian associated with the corresponding optimal control problem is

$$H = f(\beta)[S_1 + S_2 - (1+\lambda)(2\beta - (e_1(\beta) + e_2(\beta)) + \frac{1}{2}(e_1(\beta)^2 + e_2(\beta)^2) + \gamma e_1(\beta)e_2(\beta)) - \lambda U(\beta)] - \eta(\beta)(1+\gamma)[e_1(\beta) + e_2(\beta)].$$

Applying the Maximum Principle we get $\dot{\eta}(\beta) = \lambda f(\beta)$. Because there is no transversality condition at $\underline{\beta}$, $\eta(\underline{\beta}) = 0$ and we obtain $\eta(\beta) = \lambda F(\beta)$. Then optimizing with respect to $e_i(\beta)$ we obtain the optimal profiles of effort. Finally, under the monotone hazard rate assumption, $\frac{d}{d\beta}\frac{F(\beta)}{f(\beta)} \geq 0$, the second-order condition for implementability is satisfied.

8.3 Proof of Proposition 4

8.3.1 Preliminary results

Immediate computations yield: $\hat{U}_1^1(C_1, \beta) = (\beta - C_1) + \gamma(\beta - C_2^*(C_1, \beta))$, $\hat{U}_\beta^1(C_1, \beta) = -(1+\gamma)(\beta - C_1 + \beta - C_2^*(C_1, \beta))$, $\hat{U}_{1\beta}^1(C_1, \beta) = (1+\gamma)(1 + \frac{\partial C_2^*(C_1,\beta)}{\partial C_1})$, where $C_2^*(C_1, \beta)$ is defined by the first-order condition (1) associated with the indirect utility function of the firm vis-à-vis regulator P_2.

Differentiating (1) with respect to C_1 we obtain

$$[t_2''(C_2^*(C_1(\beta), \beta)) - 1]\frac{\partial C_2^*(C_1(\beta), \beta)}{\partial C_1} = \gamma. \tag{4}$$

In equilibrium, $C_2^*(C_1(\beta),\beta) = C_2(\beta)$. Substituting in (1) and differentiating with respect to β we also get

$$[t_2''(C_2(\beta)) - 1]\dot{C}_2(\beta) = -1 - \gamma(1 - \dot{C}_1(\beta)). \tag{5}$$

Using (4) and (5), we obtain

$$\hat{U}^1_{1\beta}(C_1(\beta),\beta) = (1+\gamma)\frac{1+\gamma-\gamma(\dot{C}_1(\beta)+\dot{C}_2(\beta))}{1+\gamma(1-\dot{C}_1(\beta))}.$$

8.3.2 The symmetric equilibrium

The optimal schedules of effort As $\hat{U}^1_\beta(C_1,\beta) < 0$ and because the rent is socially costly, the participation constraint amounts to $U(\overline{\beta}) = 0$. The Hamiltonian associated with the problem of regulator P_1 is

$$f(\beta)[S_1 - (1+\lambda)(C_1(\beta) - \hat{U}^1(C_1(\beta),\beta)) - (\frac{1}{2}+\lambda)U(\beta)] + \eta(\beta)\hat{U}^1_\beta(C_1(\beta),\beta).$$

Applying the Maximum Principle and using the fact that there is no transversality condition at $\underline{\beta}$ ($\eta(\underline{\beta}) = 0$), we obtain $\eta(\beta) = (\frac{1}{2}+\lambda)F(\beta)$. Finally, optimizing with respect to $C_1(\beta)$, considering a symmetric equilibrium and rearranging terms we obtain the optimal effort profiles.

Behavior of the solution in the neighborhood of $\underline{\beta}$ In order to compare the efforts under centralization and decentralization, we must first linearize the solution to the differential equation in the neighborhood of $\underline{\beta}$. We have

$$\dot{e}_d(\beta) = -\frac{1}{\gamma}\frac{(1+\gamma)e_d(\beta) - 1 + (1+\gamma)(1-\gamma)\frac{F(\beta)}{f(\beta)}\frac{\frac{1}{2}+\lambda}{1+\lambda}}{(1+\gamma)e_d(\beta) - 1 + 2(1+\gamma)\frac{F(\beta)}{f(\beta)}\frac{\frac{1}{2}+\lambda}{1+\lambda}}. \tag{6}$$

Let us use the following notations: $X = e_d(\beta) - e_d(\underline{\beta})$ and $Y = \beta - \underline{\beta}$. Immediate computations show that (6) can be rewritten as

$$\frac{dX}{dY} = -\frac{1}{\gamma}\frac{X + (1-\gamma)\frac{\frac{1}{2}+\lambda}{1+\lambda}Y}{X + 2\frac{\frac{1}{2}+\lambda}{1+\lambda}Y}.$$

Looking for a solution of the form $X = tY$, we must solve the following equation: $\gamma t^2 + (2\frac{\frac{1}{2}+\lambda}{1+\lambda}\gamma + 1)t + (1-\gamma)\frac{\frac{1}{2}+\lambda}{1+\lambda} = 0$. The two roots are given by

$$\underline{t}_d = -\frac{1 + 2\gamma\frac{\frac{1}{2}+\lambda}{1+\lambda} + \sqrt{\Delta}}{2\gamma} \text{ and } \overline{t}_d = \frac{-1 - 2\gamma\frac{\frac{1}{2}+\lambda}{1+\lambda} + \sqrt{\Delta}}{2\gamma}.$$

where $\Delta = 1 + 4\gamma^2\frac{\frac{1}{2}+\lambda}{1+\lambda}(1 + \frac{\frac{1}{2}+\lambda}{1+\lambda}) > 0$ is the discriminant. It is immediate to show that

- $\underline{t}_d$ does not satisfy the optimality conditions of the firm's maximization problem given by $t''(C(\beta)) - 1 \leq 0 \Leftrightarrow 1 + \gamma\dot{e}_d(\beta) \geq 0$ and $(t''(C(\beta)) - 1)^2 \geq \gamma^2 \Leftrightarrow 1 - \gamma + 2\gamma\dot{e}_d(\beta) \geq 0$.
- $\overline{t}_d < \dot{e}_*(\underline{\beta})$,
- $\overline{t}_d > \dot{e}_c(\underline{\beta}) = -\frac{\lambda}{1+\lambda} \Leftrightarrow \gamma > \frac{1}{1+4\lambda}$.

Comparative statics Let us consider the effect of an increase in the substitutability index γ on the optimal effort under non cooperative regulations. In the neighborhood of $\underline{\beta}$ immediate computations yield $Sg(\frac{d\overline{t}}{d\gamma}) = Sg(1 - \frac{1}{\sqrt{\Delta}}) > 0$. Hence efforts increase locally, and globally in the uniform case, around $\underline{\beta}$ when γ increases.

Let us now prove that $e_d(\beta) \leq e_*(\beta)$. First consider $\hat{\beta}$ such that $e_d(\hat{\beta}) = e_*(\hat{\beta})$. At $\hat{\beta}$ we have $\dot{e}_d(\hat{\beta}) = -\frac{1-\gamma}{2\gamma} \leq \dot{e}_*(\hat{\beta}) = 0$. Hence, for $\beta \in (\hat{\beta} - \epsilon, \hat{\beta})$ we have $e_d(\beta) > e_*(\beta)$, a contradiction.

Let us find the conditions such that $e_d(\beta) \geq e_c(\beta)\ \forall\beta$. Consider $\hat{\beta}$ such that $e_d(\hat{\beta}) = e_c(\hat{\beta})$. Equation (6) gives

$$\dot{e}_d(\hat{\beta}) = \frac{\gamma\lambda - \frac{1}{2}(1-\gamma)}{\gamma(1+\lambda)}.$$

Now assume that $\gamma\lambda - \frac{1}{2}(1-\gamma) \geq 0$ or $\gamma \geq \frac{1}{1+2\lambda}$. Then $\dot{e}_d(\hat{\beta}) \geq 0$ while $\dot{e}_c(\hat{\beta}) \leq 0$ which in turn implies that $\forall\beta \in (\hat{\beta} - \epsilon, \hat{\beta})$, $e_d(\beta) < e_c(\beta)$. However, this contradicts the fact that if $\gamma \geq \frac{1}{1+2\lambda} \geq \frac{1}{1+4\lambda}$ then $\overline{t}_d > \dot{e}_c(\underline{\beta})$. Note finally that this a sufficient condition only. This proves the first and the third point of Proposition 4.

Finally, notice that when $\gamma = 0$, the competition effect disappears. Therefore, in this case, $e_d(\beta) \leq e_c(\beta)\ \forall\beta$ since the firm's rent appears more socially costly to the decentralized regulators than to the centralized one. By continuity, this result holds in a neighborhood of $\gamma = 0$. This proves the second point of Proposition 4.

Second-order conditions In our working paper, we show that a sufficient condition to ensure that the implementability conditions and the optimality conditions for the firm is $e_d(\beta) \geq e_c(\beta)$, $\forall \beta$, which is satisfied if $\gamma \geq \frac{1}{1+2\lambda}$. When effort profiles do not satisfy this ranking, we cannot conclude and we must assume that a differentiable common agency equilibrium that satisfies these conditions exists. In the symmetric uniform case that we use later on, we show in our working paper (Laffont and Pouyet, 2001) that all these conditions are satisfied.

8.4 Proof of Corollary 1

For country i with an ownership share δ_i, the social welfare function can be rewritten as follows

$$SW_i = S_i - (1+\lambda)(C_i(\beta) - \hat{U}^i(C_i(\beta), \beta)) - (1+\lambda-\delta_i)U(\beta).$$

Define $r_{d,i} = \frac{1+\lambda-\delta_i}{1+\delta}$, $i = 1, 2$ with $\delta_1 + \delta_2 = 1$.

Under decentralization, the optimal profiles of effort under asymmetric information satisfy the following first-order conditions:

$$(\mathcal{S}) \quad \begin{cases} e_1(\beta) + \gamma e_2(\beta) & = 1 - r_{d,1}(1+\gamma)\frac{F(\beta)}{f(\beta)}\frac{1-\gamma+\gamma[\dot{e}_1(\beta)+\dot{e}_2(\beta)]}{1+\gamma\dot{e}_1(\beta)} \\ \gamma e_1(\beta) + e_2(\beta) & = 1 - r_{d,2}(1+\gamma)\frac{F(\beta)}{f(\beta)}\frac{1-\gamma+\gamma[\dot{e}_1(\beta)+\dot{e}_2(\beta)]}{1+\gamma\dot{e}_2(\beta)}, \end{cases}$$

with the initial conditions $e_1(\underline{\beta}) = e_2(\underline{\beta}) = e_*(\underline{\beta})$.

With a uniform distribution on $[1, \frac{3}{2}]$, $\frac{F(\beta)}{f(\beta)} = \beta - 1$. We will look at linear solutions of the form $e_i(\beta) = a_i(\beta - 1) + b_i$. Differentiating the equations in $(\mathcal{S})$ and solving we obtain a_i, $i = 1, 2$. Then, using the equations in $(\mathcal{S})$ we obtain b_i, $i = 1, 2$. We refer to our working paper for the detailed computations. Then, it is immediate to see that $\frac{\partial \dot{e}_i(\beta)}{\partial \delta_i} \geq 0$. Similarly, we show that

$$\frac{\partial SW_i}{\partial \delta_i} = 0 \Leftrightarrow \delta_i = \frac{1}{2},$$

and

$$\left.\frac{\partial^2 SW_i}{\partial \delta_i^2}\right|_{\delta_i = \frac{1}{2}} = -\frac{(1-\gamma)(1+\gamma)^2(1+\gamma+\lambda)}{12(1+\lambda)\sqrt{(1+\lambda)^2 + \gamma^2(1+2\lambda)(3+4\lambda)}} \leq 0.$$

8.5 Proof of Proposition 5

Assume that P_2 offers a fixed-price contract to the firm and that $\gamma = 1$. Then $\frac{\partial C_2^*(C_1,\beta)}{\partial C_1} = -1$ implying $\hat{U}_{1\beta}^1(C_1,\beta) = 0$ and $e_d(\beta) = e_*(\beta)$. This profile of efforts can be implemented with a fixed-price contract.

8.6 Proof of Proposition 6

Decentralization For region i with a majority of δ_i the social welfare function of the local regulator can be rewritten as follows:

$$SW_i = \delta_i[S_i - (1+\lambda)(C_i(\beta) - \hat{U}^i(C_i(\beta),\beta))] - [(1+\lambda)\delta_i - \frac{\alpha_i}{\alpha_1+\alpha_2}\mathcal{I}_{\{\alpha_i>\frac{1}{2}\}}]U(\beta).$$

where $\mathcal{I}$ is the indicator function. Define $r_{d,i} = \frac{(1+\lambda)\delta_i - \frac{\alpha_i}{\alpha_1+\alpha_2}\mathcal{I}_{\{\alpha_i>\frac{1}{2}\}}}{(1+\lambda)\delta_i}$ and $\delta_i = \alpha_i$ if $\alpha_i > \frac{1}{2}$ or $\delta_i = 1-\alpha_i$ if $\alpha_i < \frac{1}{2}$. Then, up to coefficient of the rent $U(\beta)$ in the social welfare function, the computations of the optimal profiles of efforts are similar. The implementability conditions are unchanged.

In the uniform case, we can apply the same methodology as in Section 8.4 and compute the optimal solutions. See our working paper for the detailed computations.

Centralization In the uniform case, with $\alpha_1 = \alpha_2 = \alpha$ and $(1+\lambda)\alpha^* > 1$, immediate computations (adapted from section 8.2) show that the optimal profiles of effort are given by

$$e_1(\beta) = e_2(\beta) = e_c(\beta) = \frac{1}{1+\gamma}[1 - (1+\gamma)r_c(\beta-1)],$$

where $r_c = \frac{(1+\lambda)\alpha^*-1}{(1+\lambda)\alpha^*}$ under a shareholder majority and $r_c = 1$ under a non shareholder majority.

8.7 Proof of Proposition 7

If $\lambda \geq 1$ then centralization is preferred whatever the majority.

Assume now that $\lambda < 1$. The difference between the expected welfare under decentralization and the expected welfare under centralization is proportional to

$$P(\alpha^*) = 2\alpha^{*2}(1-\lambda^2) - 2\alpha^* + 1. \tag{7}$$

We must have $(1+\lambda)\alpha^* > 1$ or $\lambda > \frac{1-\alpha^*}{\alpha^*}$, with $\alpha^* > 1/2$.

The discriminant associated to $P(\alpha^*)$ is $4(2\lambda^2 - 1)$. Consequently, if $\lambda^2 < 1/2$ then the discriminant is negative and $P(\alpha^*) > 0$ for all values of α^* and λ (as $1 - \lambda^2 > 0$ by assumption).

Assume now that $\lambda^2 > 1/2$. The largest of the two roots associated to P is $\frac{1+\sqrt{2\lambda^2-1}}{2(1-\lambda^2)}$, which is larger than 1 when $\lambda < 1$. On the contrary, the smallest of the two roots is $\tilde{\alpha}^*(\lambda) = \frac{1-\sqrt{2\lambda^2-1}}{2(1-\lambda^2)}$, and is smaller than 1. It is larger than 1/2 because $1 - \sqrt{2\lambda^2 - 1} \geq 1 - \lambda^2 \Leftrightarrow \lambda^2 \geq \sqrt{2\lambda^2 - 1} \Leftrightarrow (1-\lambda^2)^2 \geq 0$, which obviously holds. Finally notice that $\tilde{\alpha}^*(\lambda)$ is decreasing for $\lambda \in [1/\sqrt{2}, 1]$, $P(1/2) = 1/2(1-\lambda^2) > 0$ and $P(1) = 1 - 2\lambda^2 < 0$ from our assumptions.

If $\lambda^2 = 1/2$ then there is a unique solution: $\tilde{\alpha}^* = 1$.

8.8 Proof of Corollary 2

We do not repeat the computations of the welfare of the different types of citizens in the different possible configurations (shareholder/non shareholder majority, centralization/decentralization) which can be obtained by slightly modifying our previous computations.

Let us start with the case in which citizens know their type but do not know which majority will establish. Let G_s and G_{ns} be the difference in welfare for the shareholders and the non shareholders respectively between centralization and decentralization (see Equations (2) and (3) respectively).

It is immediate to check that $G_{ns} \geq 0$ and $G_{ns} \geq G_s$.

We have

$$G_s \geq 0 \Leftrightarrow 2\alpha^{*2}(1-\alpha^*)X^2 + (1-\alpha^*) - 2\alpha^* X \geq 0,$$

where $X = 1 + \lambda$. The discriminant associated to this polynomial expression is $4\alpha^{*2}[1 - 2(1-\alpha^*)^2] > 0$. The roots associated to this polynomial are given by $\frac{1 \pm \sqrt{1-2(1-\alpha^*)^2}}{2\alpha^*(1-\alpha^*)}$. The smallest of these roots is smaller than 1 and can then be discarded from the analysis.

Therefore, $G_s \geq 0$ is equivalent to $1 + \lambda \geq \frac{1+\sqrt{1-2(1-\alpha^*)^2}}{2\alpha^*(1-\alpha^*)}$, or $\lambda \geq \overline{\lambda}(\alpha^*)$. It is immediate to check that $\overline{\lambda}(\alpha^*)$ increases with α^* for $\alpha^* \in (\frac{1}{2}, 1)$.

Consider now the case in which citizens do not know their type when the decision to

decentralize or not is made. Then decentralization is preferred to centralization if

$$2(1-\alpha^*)\alpha^*(1+\lambda) \geq 1 \Leftrightarrow \lambda \geq \tilde{\lambda}(\alpha^*) \equiv \frac{1-2\alpha^*(1-\alpha^*)}{2\alpha^*(1-\alpha^*)},$$

with $\tilde{\lambda}(1/2) = 1/2$, $\lim_{\alpha^* \to 1} \tilde{\lambda}(\alpha^*) = +\infty$ and $\tilde{\lambda}'(\alpha^*) \geq 0$ for $\alpha^* \in (\frac{1}{2}, 1)$.

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