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# Corruption and optimal regulation under common agency

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## Abstract

I show that it is optimal to separate non-benevolent regulators when regulated projects are large. Separation prevents regulators from coordinating to appropriate all of the agent's informational rent when they know the type of the latter; therefore, there is a trade-off between saving on informational rent and efficiency, since the game between the regulators induced by separation causes further distortions when compared to the allocation under one regulator. When the informational rent at stake is large due to the size of the project, separation is the optimal institutional answer.

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*JEL classification:* D73; D78; D82; D8

*Keywords:* Regulation; Contract theory; Corruption

## Resumo

Mostro que separar reguladores não-benevolentes é a resposta institucional ótima quando os projetos regulados são grandes. Como separação impede que os reguladores se coordenem para se apropriar de toda a renda informacional do agente quando sabem o tipo desse último, há um trade-off entre poupança de renda informacional e eficiência alocativa, pois o jogo entre os reguladores induzido pela separação gera distorção em relação à alocação com um único regulador. Quando a renda informacional em questão é grande, vale a pena a divisão de reguladores.

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*Códigos JEL:* D73; D78; D82; D8

*Palavras-chave:* Regulação; Teoria de Contratos; Corrupção

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## 1. Introduction

The objective of this paper is to discuss, based on the theory of common agency, optimal regulatory schemes when corruption is a concern. I try to give an answer, from a normative viewpoint, to why actual regulatory structures are

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frequently more complex and diversified than predicted by regulation theory. The basic model of regulation, which builds on the principal–agent framework, presents the regulator as the principal in a problem where the agent is responsible for a socially relevant project. The literature on contract theory and common agency shows that, under fairly general conditions, the best contract is centralized: it is written by only one regulator. There is an efficiency loss under multiple regulators. The question that motivates this paper may be rewritten as: why several activities in the world are under the responsibility of multiple regulators? If this actually means multiple principals, then this multiplicity is regarded by the literature as sub-optimal.

The literature on capture offers an answer.<sup>1</sup> It may be optimal to separate regulators when they may collude with the agent in order to appropriate public resources. A simple way to model this effect is to drop the assumption of complete contracts,<sup>2</sup> which may be written by the regulators themselves, possibly corrupt. In this case, the resulting coordination problem may be beneficial as it decreases the rent lost to corruption. One problem with this model is that if the regulator is corrupt, he will not write a contract that maximizes social welfare in the first place. [Laffont and Martimort \(1999\)](#) justified this approach based on a model in which the agent's type may be unveiled due to some technology operated by regulators. These latter are corrupt, while the central authority that writes the contracts is benevolent. Their paper shows that separating monitoring technologies among regulators increases welfare. However, their model assumes centralized contracting: only the central authority writes contracts, and the middleman is defined as the regulator. The contribution of the present paper is to determine under which conditions it is worth to split not only monitoring technologies, but also the power to write contracts.

The motivation for a model of incomplete contracts lies in the fact that actual regulatory agencies are responsible not only for transferring information for a benevolent representative of society, who would ultimately write all contracts in the country, in all fields. This representative, if it exists, must transfer at least part of the power to write contracts to specific departments that are responsible for dealing with information restrictions.

In this context, I show that separation is not necessarily better than integration of regulators. Still, separation is the optimal choice as long as it decreases corruption (with respect to integrated regulators) in the sense of [Laffont and Martimort \(1999\)](#). Therefore, it may be the best institutional answer in some cases. I relate the choice of the optimal regulatory structure to the size of regulated projects.

Separation is more beneficial for large projects, whilst integration is better for small ones. This result is in line with a fact observed in several societies: larger projects are submitted to a more complex bureaucracy. A tribe of Indians does not reproduce the governmental structure of a country in small scale; it has a much simpler bureaucratic structure. When a project is large, the problem of corruption is worsened, since the rent at stake is also large. Hence, it may be better to accept some lack of coordination among bureaucracies so that the problem of corruption is smaller. Naturally the division of bureaucracies due to technical specialization plays a role, but corruption is also a driving force.

The present paper relates to two major strands in the literature that help understand the internal organization of governments. The first is the literature on multiple principals, or common agency. [Bernheim and Whinston \(1986\)](#) established, in a moral hazard framework, a basic result: under asymmetric information, the equilibrium under competing principals is less efficient than the equilibrium under centralized contracting. This happens because each principal free-rides on the payment made by the others to elicit effort from the agent.<sup>3</sup> [Martimort \(1992\)](#) and [Stole et al. \(1991\)](#) extended this result to an adverse selection setting, as in the setup I use.<sup>4</sup> Moreover, I use the delegation principle developed in [Martimort and Stole \(2002\)](#) as it is not possible to apply directly the Revelation Principle under multiple principals. [Martimort and Stole \(2009\)](#) established the differences in intrinsic common agency games, as studied in the present paper, in which the agent must decide between all contracts or no contract, and delegated agency, in which further distortions arise as the agent may choose only some contracts. [Bond and Gresik \(1996\)](#) and [Calzolari \(2001\)](#)

<sup>1</sup> See [Martimort \(1996\)](#) for a detailed discussion.

<sup>2</sup> In capture models, the assumption of centralized contracting is usually set in a three-layer model: the benevolent principal writes the contract; the privately-informed agent implements the project; and the corrupt regulator (a middleman) may learn the agent's type and pass this information on to the principal under the correct incentives.

<sup>3</sup> Under complete information, there are multiple equilibria, including the first-best allocation.

<sup>4</sup> For a complete discussion of common agency games, see [Martimort \(2007\)](#).

applied the theory of common agency to the regulation of multinational firms, a study that lends itself naturally to the multi-principal setup since national governments are separated.<sup>5</sup>

The second strand is the literature on capture. Laffont and Tirole (1991) developed the three-layer model to study collusion between a privately-informed agent and intermediaries employed by the principal to bridge the informational gap.<sup>6</sup> They showed that the principal may benefit from this arrangement even if the intermediary is non-benevolent, meaning that he would like to collude with the agent instead of passing information on to the regulator, as long as the proper non-collusion constraints are taken into account. This is the base model used by Laffont and Martimort (1999), mentioned above, to justify that splitting this bridging task among different intermediaries improves welfare if it is possible to keep the structure of centralized contracting unaffected.<sup>7</sup> Martimort (1999) provided a normative reason for the existence of multiple principals and is thus closest to the present paper: if regulators play a Stackelberg game and have limited commitment, then splitting regulatory powers makes renegotiation harder and increases welfare.

The paper proceeds as follows. Section 2 presents the base model and reviews traditional results. Section 3 adds the structure that generates a trade-off between separation and integration of regulators. Section 4 presents the main result, whose proof is left to the appendix, and Section 5 briefly concludes.

## 2. Model

A social planner wants to implement a project  $q$  with social benefit  $V(q, \alpha) \equiv V^1(q, \alpha) + V^2(q, \alpha)$ , in which  $V^i$  is strictly increasing and concave and continuously differentiable such that  $V_{qq} \gg -\infty$ . The parameter  $\alpha$  affects the marginal benefit of  $q$  on  $V^i$  such that  $V_{q\alpha}^i \geq \eta > 0$  for some  $\eta \in \mathbb{R}$ . There is only one agent able to produce  $q$  with the cost function  $c(q, \theta)$  such that  $c_q, c_{qq}, c_{q\theta}, c_{qq\theta} > 0$ . As usual,  $\theta$  is the agent's private information and has a continuous density  $f > 0$ , distribution  $F$  and support  $[\underline{\theta}, \bar{\theta}]$  such that  $\bar{\theta} > \underline{\theta}$ . Assume also  $(d/d\theta)((F(\theta)/f(\theta))) > 0$ . The agent's reservation utility is zero. For each monetary unit spent on the project, society pays  $1 + \lambda$  (tax distortion). All these assumptions are common knowledge.

The planner may choose between two regulatory structures. Under *integration*, only one principal regulates the agent. Under separation, this task is split between two principals.

### 2.1. Integration

In this case, the objective function of the regulator is simply social welfare:

$$SW = V(q, \alpha) - (1 + \lambda)t + U \tag{2.1}$$

where  $t$  is the transfer to the agent and  $U$  is the agent's utility.<sup>8</sup>

The objective function of the agent is:

$$U(q, \theta) = t - c(q, \theta) \tag{2.2}$$

In this context, the revelation principle fully applies. In order to maximize social welfare, the principal may restrict himself to direct truth-telling mechanisms: it is enough to choose a function  $(q(\theta), t(\theta))$  that induces the agent to produce and to reveal his true type. Therefore, the agent's utility may be rewritten as:

$$U(\theta, \hat{\theta}) = t(q(\hat{\theta})) - c(q(\hat{\theta}), \theta)$$

where  $\hat{\theta}$  is the announced type.

The timing of the game is as follows:

$t = 0$ : the agent observes  $\theta$

<sup>5</sup> Some recent contributions include Martimort and Moreira (2010), which allowed for asymmetric information between principals, and Pavan and Calzolari (2010), who studied truthful revelation mechanisms for simultaneous common agency games.

<sup>6</sup> See Laffont and Tirole (1993), chapter 11, for an overview. For a more recent review of regulatory capture, see Ernesto Dal (2006).

<sup>7</sup> These two papers consider one-shot relationships between an agent and one or more principals, possibly mediated by an intermediary. See Martimort (1999) for an extension to a dynamic setting, which allows for the study of regulatory cycles. As for the design of collusion-proof contracts among one principal and several agents in a two-layer hierarchy, see Laffont and Martimort (1997).

<sup>8</sup> The regulator's objective function is a reduced form of the social welfare function. For details, see Laffont and Tirole (1993).

$t = 1$ : the regulator offers a menu of contracts  $(q(\theta), t(\theta))_\theta$

$t = 2$ : the agent decides whether to participate

$t = 3$ : if the agent participates, he picks a contract

$t = 4$ : production takes place and transfers are made according to the contract.

The problem may be rewritten as follows. The principal maximizes the expected value of social welfare over  $\theta^9$ :

$$\underset{q(\theta), t(\theta)}{\text{Max}} E[V(q(\theta), \alpha) - (1 + \lambda)t + U(\theta, \theta)] \quad (2.3)$$

subject to participation and incentive constraints:

$$U(\theta, \theta) \geq 0, \quad \forall \theta \quad (2.4)$$

$$U(\theta, \theta) \geq U(\theta, \hat{\theta}), \quad \forall \theta, \hat{\theta} \quad (2.5)$$

Eqs. (2.4) and (2.5) boil down to<sup>10</sup>:

$$U(\theta, \theta) = \int_{\theta}^{\bar{\theta}} c_{\theta}(q(x), x) dx \quad (2.6)$$

$$\dot{q}(\theta) \leq 0 \quad (2.7)$$

The integral on the right-hand side of (2.6) represents the informational rent that must be given up so that a type- $\theta$  agent will reveal his type. To save on notation, define:

$$\Phi(q, \theta) \equiv \int_{\theta}^{\bar{\theta}} c_{\theta}(q(x), x) dx \quad (2.8)$$

Therefore, (2.2) and (2.8) imply that the transfer must be:

$$t(\theta) = c(q(\theta), \theta) + \Phi(\theta) \quad (2.9)$$

Plugging (2.9) into (2.3), it is possible to rewrite the social welfare function as<sup>11</sup>:

$$SW^{\text{int}}(q, \alpha) = E[V(q(\theta), \alpha) - (1 + \lambda)c(q(\theta), \theta) - \lambda\Phi(q, \theta)] \quad (2.10)$$

Therefore, the regulator's problem is:

$$\underset{q(\cdot)}{\text{Max}} SW^{\text{int}}(q, \alpha)$$

subject to (2.7). The solution to this problem is characterized by<sup>12</sup>:

$$V_q(q^{\text{int}}, \alpha) = (1 + \lambda)c_q(q^{\text{int}}, \theta) + \lambda \frac{F(\theta)}{f(\theta)} c_{q\theta}(q^{\text{int}}, \theta) \quad (2.11)$$

which is both necessary and sufficient.

## 2.2. Separation

In this case, two principals regulate the agent.  $V^i$  represents the benefit of the project in the jurisdiction of regulator  $i$ . One may think, for example, that  $V^1$  captures environmental impacts while  $V^2$  measures the benefit of new infrastructure. Notice that both principals regulate the same variable  $q$ .<sup>13</sup> The objective function of each principal is:

$$V^i(q, \alpha) - (1 + \lambda)t^i + U$$

<sup>9</sup>  $E[\cdot]$  will denote the expected value with respect to the distribution  $F$ .

<sup>10</sup> For details, see Laffont and Martimort (2002).

<sup>11</sup> The assumptions on  $V(\cdot, \cdot)$  and  $c(\cdot, \cdot)$  imply the concavity of this functional.

<sup>12</sup> Again, the reference is Laffont and Martimort (2002).

<sup>13</sup> This means that it is a public common agency game.

where  $t^i$  is the transfer from principal  $i$  to the agent.

The agent's utility function becomes:

$$U(q, \theta) = t^1 + t^2 - c(q, \theta)$$

The revelation principle does not apply directly under multiple principals. However, it is possible to use the delegation principle of [Martimort and Stole \(2002\)](#) and restrict attention to the space of non-linear tariffs. The timing is analogous to the previous case. The only difference is in  $t = 1$ : both regulators simultaneously offer a menu of contracts instead of only one.

Moreover, the restrictions in the problem of each regulator do not change. In particular, the agent's informational rent is unchanged.<sup>14</sup> Therefore, transfers are such that:

$$t^1(\theta) + t^2(\theta) = c(q(\theta), \theta) + \Phi(q, \theta) \quad (2.12)$$

Therefore, each regulator solves:

$$\text{Max}_{q(\theta), t^i(\theta)} E[V^i(q(\theta), \alpha) - (1 + \lambda)t^i(q(\theta)) + U(\theta, \theta)]$$

subject to (2.7) and (2.12). The solution is given by the following condition<sup>15</sup>:

$$V_q(q^{sep}, \alpha) = (1 + \lambda)c_q(q^{sep}, \theta) + 2\lambda \frac{F(\theta)}{f(\theta)} c_{q\theta}(q^{sep}, \theta) \quad (2.13)$$

Comparing (2.11) and (2.13), one can see that  $q^{sep} \neq q^{int}$  since the last term of the equation, related to the informational rent received by the agent, changes. By construction,  $q^{int}$  is the only *argmax* of the social welfare function, which is strictly concave, when the agent holds private information; hence, separating regulators increases the efficiency loss compared to integration. This result comes from the free-riding problem between the two principals: each regulator wants to minimize his own transfer to the agent. The additional common agency distortion arises as each principal fails to internalize the effect of decreasing the transfer on the other principal.

This benchmark shows that additional structure is needed if separation is to be optimal. The next section extends the model in that direction.

### 3. Informational rent and corruption

Non-benevolent regulators may be modelled in different ways. I follow [Martimort \(1996\)](#) and use a reduced-form model to describe how separating non-benevolent regulators may increase welfare. I assume that the informational rent decreases under separation of regulators. This may be justified as follows.<sup>16</sup>

Contract theory models usually have two layers, or two types of participant: a principal and an agent.<sup>17</sup> A way to model corruption is to add a third layer: a middleman between them.<sup>18</sup> The role of this middleman is to convey information from the agent to the principal. Specifically, this new participant has access to a technology that allows him to find out the agent's type with a given probability, which is strictly positive but lower than one. If the principal could run this technology, he would be able to achieve the first-best whenever he learnt the agent's type, and implement the second-best allocation whenever he failed to find it out. Ex-ante, the informational rent would decrease. However, such a technology is not operated by the principal directly. This may be due to the regulator's lack of expertise, or because his constitutional task is only to write contracts. In any case, it is necessary to use a middleman to apply it. If the middleman's objectives and the principal's were perfectly aligned, the previous result would go unchanged: the expected informational rent would decrease due to this technology.

<sup>14</sup> If the equilibrium information rent increased, there would be unilateral incentive to deviation. For details, see [Martimort \(2007\)](#).

<sup>15</sup> For details, see [Martimort \(2007\)](#).

<sup>16</sup> Section 2 of [Martimort \(1996\)](#) presented an *ad hoc* model to discuss a similar effect, while Section 3 describes a full-fledged model and refers to a working version of [Laffont and Martimort \(1999\)](#) for a complete discussion.

<sup>17</sup> For a complete discussion, see [Laffont and Martimort \(2002\)](#).

<sup>18</sup> See [Laffont and Tirole \(1993\)](#), chapter 11.

Corruption is modelled by assuming that the principal and the middleman interests' are not aligned. Specifically, the middleman considers the following option: whenever he unveils the agent's type, he may make the following offer to the agent: instead of reporting the type to the principal, the middleman may state that the technology failed (an event that occurs with strictly positive probability) and the agent's type remains unknown. The agent and the middleman then split the informational rent that this false report generates whenever the agent's type is but the lowest one. Corruption is the collusion of the middleman and the agent – in other words, the middleman is captured by the agent.

If the principal is to benefit from the monitoring technology, he must induce the middleman to report truthfully in at least some states of the nature. Under some mild assumptions, it is possible to show that once additional truth-telling restrictions (for the middleman) are added, the principal obtains, *ex ante*, a higher payoff.<sup>19</sup> Furthermore, [Laffont and Martimort \(1999\)](#) showed that separating the monitoring technology between two middlemen decreases the expected informational rent. The reasoning is as follows. Each separate middleman evaluates individually a different aspect of the agent's technology. In a model of centralized contracting, the division of middlemen makes the “no-collusion” restrictions less severe than under integration. This result is similar to a prisoner's dilemma: the middlemen are not able to coordinate in order to achieve the best result from the point of view of the coalition made up by them. There are states of nature in which they cannot reap all of the agent's informational rent.<sup>20</sup>

My focus is not on the actual (endogenous) decrease in corruption generated by the separation of middlemen. This decrease may be computed, in expected terms, for different technologies and contractual arrangements – i.e., separation or integration of regulators. For the purpose of the present paper, it is sufficient to assume that separation decreases the expected informational rent by some degree; I assume that the expected rent given up to corruption, irrespective of how they are divided between the agent and the middlemen, is scaled down by an exogenous factor  $k < 1$  when the monitoring technologies are separated. This factor may be seen as an upper bound on the endogenous decrease generated under separation of middlemen for given monitoring technologies.

Furthermore, I assume that it is necessary to separate principals in order to split monitoring technologies. In other words, I consider the impact of dropping the assumption of centralized contracting. The question becomes: what happens when it is necessary to split the power to write contracts between different principals if one wants to split the use of monitoring technologies between different middlemen? Each regulator receives a report about the firm made by only one middleman.

Imposing this restriction amounts to making the space of contracts more incomplete. In order to justify it, one must explain why this setup may be actually plagued by incompleteness. A regulator may be able to evaluate information and write contracts concerning a given variable, but may be unable to reproduce these tasks when it comes to a decomposition of this variable. An obvious reason is expertise: the regulator may evaluate aggregate information, but not the diverse pieces of information that build it up.

The preceding discussion may be summarized in the following assumption.

**Assumption 1.** Under separation of principals, the informational rent decreases by a factor  $k < 1$ .

The reduced-form model I use is then simply a two-layer hierarchy structure in which the informational rent decreases under multiple principals. Instead of fully modelling the middleman's objective function<sup>21</sup> and the additional truth-telling incentive compatibility constraints in order to compute the actual decrease in the expected information rent, it is enough to assume  $k < 1$ .<sup>22</sup>

This may be seen as a complementary approach to [Laffont and Martimort \(1999\)](#). They assume that splitting technologies generates no frictions to the exogenous contracting framework: the cost of adding a new middleman is zero in the sense that the centralized contracting structure is unaffected. Since the additional middleman has a

<sup>19</sup> See [Laffont and Tirole \(1993\)](#), chapter 11.

<sup>20</sup> Formally, [Laffont and Martimort \(1999\)](#) modelled the agent's type as a two-dimensional parameter:  $\theta = (\theta_1, \theta_2)$ . There are two technologies to evaluate  $\theta$ . The first reveals  $\theta_1$  with probability  $r \in (0, 1)$ ; the second reveals  $\theta_2$  with probability  $s \in (0, 1)$ . When these technologies are split between two middlemen, the constraints are softened.

<sup>21</sup> In the full-fledged three-layer model, the middleman's payoff is simply the amount of bribe he receives from the agent. For a complete reference, see [Laffont and Tirole \(1993\)](#), chapter 11, or [Laffont and Martimort \(1999\)](#).

<sup>22</sup> Some early contributions of two-layer hierarchy models to study collusive behaviour are [Dana \(1993\)](#), [Baron and Besanko \(1992\)](#) and [Gilbert and Riordan \(1995\)](#).

strictly positive benefit to the (unique) principal, it follows that splitting monitoring technologies increases welfare as it decreases the rent that is given up to implement any allocation, without costs; the main contribution of [Laffont and Martimort \(1999\)](#) is to endogenize  $k$ . On the opposite direction, I make the assumption that splitting technologies has a strictly positive benefit to the principal, and proceed to endogenize the optimal contracting structure.

The agent’s payoff is the same as presented in the previous section, while the principal’s payoff is changed by considering the ex-ante informational rent  $k\Phi(q(\theta), \theta)$ . It is worth noticing that if the middleman were not corrupt, or if the principal could operate the monitoring technology directly, then the expected informational rent would decrease by some factor  $k^* < k$ . The difference  $[k - k^*]\Phi > 0$  is the expected loss to corruption. In the current setup, however,  $k^*$  is immaterial as the principal can never achieve it; the relevant information is  $[1 - k]\Phi > 0$ , which represents the actual gain from introducing the middlemen – i.e., the decreased corruption.

The other assumptions made in the previous section remain. In what follows, I will revisit the two cases presented in the previous section. Without loss of generality and for the sake of simplicity, I will assume that the existence of middlemen does not generate any benefit under centralized contracting – this is the case, for example, if there are no transaction costs for bribery.

### 3.1. Integration

The only difference with respect to the previous section concerns the presence of middlemen able to evaluate the agent’s type. The regulator solves the same problem, but counts on a middleman that operates the monitoring technology. Since I assumed no transaction costs in bribery, this middleman is useless, as well as the monitoring technology: the agent and the middleman will collude whenever the latter finds out the agent’s type. Social welfare is still given by (2.10) and the equilibrium, by (2.11).

### 3.2. Separation

Now each regulator has a middleman to evaluate a different aspect of the agent’s technology. Not only are regulatory tasks split (as in the previous section) but also monitoring technologies. In this case, the coordination problem between the middlemen is beneficial to society because it causes allows “informational savings”, as discussed in the beginning of this section. According to assumption 1, the expected rent society must give up (to the agent and the middlemen) is now  $k\Phi(q, \theta)$ .

The factor  $k$  captures how much society saves under separation. A trade-off follows: under separation, the problem of informational rent is milder, but additional allocative distortions arise. The interpretation of this trade-off is based on the issue of lower coordination under separation: it leads both to less corruption and to greater distortions.

Now one may define welfare under separation for a given scheme  $q(\theta)$ <sup>23</sup>:

$$SW^{sep}(q, \alpha, k) = E[V(q(\theta), \alpha) - (1 + \lambda)c(q(\theta), \theta)] - \lambda k\Phi(q(\theta), \theta) \tag{3.1}$$

Proceeding as in the previous section, one may characterize the equilibrium under separation:

$$V_q(q^{sep}, \alpha) = (1 + \lambda)c_q(q^{sep}, \theta) + 2\lambda k \frac{F(\theta)}{f(\theta)} c_{q\theta}(q^{sep}, \theta) \tag{3.2}$$

When compared to expression (2.11), one may see that the last term of Eq. (3.2) is multiplied by  $2k$ , which subsumes both the common agency distortion and the decrease in the informational rent given up to the agent. If  $k = 1/2$ , separation causes no distortion with respect to the second best (the equilibrium under integration) and decreases the informational rent; therefore, it is strictly better than integration. If  $k > 1/2$ , the common agency distortion is always downwards (i.e.,  $q^{sep} < q^{int}$  for all  $\theta \neq \underline{\theta}$ ) and a non-trivial trade-off arises<sup>24</sup>. In the limit  $k = 1$ , separation does only harm.

At this point, it is not possible to compare directly (2.10) and (3.1), meaning that it is not possible to tell which structure is the most appropriate for  $k \in (1/2, 1)$ . The next section establishes a criterion.

<sup>23</sup> Again, this will be a concave functional.

<sup>24</sup> If  $k < 1/2$ , there is no trade-off since production increases under separation when compared to integration and the total informational rent decreases. The result is the next section follows trivially. In the limit  $k = 0$ , private information becomes moot. The first-best is implementable, although it is not the only equilibrium. For details, see [Bernheim and Whinston \(1986\)](#).



#### 4. Separation of regulators and the size of projects

The basic intuition of this paper is that the choice between separation and integration should depend on the size of the regulated project. However, there is no satisfactory measure of size. Instead of building such a measure, I will refer to the parameter of marginal benefit  $\alpha$  since it is directly related to the optimal size of the project under any contractual structure: notice that (2.11) and (3.2) imply that both  $q^{sep}$  and  $q^{int}$  are increasing in  $\alpha$ . All else being equal, a higher value of  $\alpha$  is associated to larger projects.

The choice between separation and integration should depend on how much informational rent is spent. In large projects, the informational rent is large, and it is worth to accept some additional inefficiency, so that society should choose separated regulators. In small projects, this informational saving may be nearly irrelevant so that incurring in the distortion caused by separation is not worthwhile. The following proposition summarizes this discussion.

**Proposition 1.** *The difference between welfare under multiple regulators and welfare under one regulator is increasing in the size of the project and is positive for sufficiently large projects.*

**Proof.** See appendix.  $\square$

It is worth discussing the conditions behind this result. Separation is the optimal choice when the rent at stake is large; therefore, it depends on the efficiency of spiting regulators in fighting corruption, or on a low value of  $k$ . But this is exactly what makes the coordination problem between regulators mild, as one can see in Eq. (3.2). This double role of  $k$  drives the result.

Formally, this result is due to the fact that welfare under separation is not evaluated at the argument that maximizes it for a given  $k$  – the common agency equilibrium is a third-best due to the distortion generated by the free-riding problem. Defining  $\Delta = SW^{sep}(q^{sep}(\alpha, k, \theta), \alpha, k) - SW^{int}(q^{int}(\alpha, k), \alpha)$  as the difference between welfare under separation and under integration of regulators, one may compute the following derivative:

$$\frac{\partial \Delta(\alpha, k)}{\partial \alpha} = E \left[ V_{\alpha}(q^{sep}, \alpha) - V_{\alpha}(q^{int}, \alpha) + \lambda k \frac{F(\theta)}{f(\theta)} c_{q\theta}(q^{sep}, \theta) \left( \frac{\partial q^{sep}(\alpha, k)}{\partial \alpha} \right) \right]$$

The first two terms in brackets on the right-hand side of this expression capture the direct impact of  $\alpha$  on the difference  $\Delta$ . Since  $q^{int}$  is by construction the argmax of  $V$  under integration, the envelope theorem implies that there is no indirect impact:  $\frac{\partial SW^{int}(\alpha, k)}{\partial q^{int}} \frac{\partial q^{int}(\alpha, k)}{\partial \alpha} = 0$ . If  $q^{sep}$  were the argmax of  $V$  under separation, then by the same token one would have  $\frac{\partial SW^{sep}(\alpha, k)}{\partial q^{sep}} \frac{\partial q^{sep}(\alpha, k)}{\partial \alpha} = 0$  and the whole expression would reduce to  $E[V_{\alpha}(q^{sep}, \alpha) - V_{\alpha}(q^{int}, \alpha)]$ . This is strictly negative since  $q^{sep} < q^{int}$  for  $k > \frac{1}{2}$  and  $V_{\alpha q} > 0$ . However, the common agency distortion makes  $\frac{\partial SW^{sep}(\alpha, k)}{\partial q^{sep}} \frac{\partial q^{sep}(\alpha, k)}{\partial \alpha} > 0$  and, as shown in the appendix, it follows that the derivative  $\frac{\partial \Delta(\alpha, k)}{\partial \alpha}$  becomes strictly positive, and bounded away from zero, if  $\alpha$  is large enough. It follows that  $\Delta$  is positive for large projects even if it is negative for small ones.

In short, the proposition above says that it is optimal to have one regulator for small projects and multiple regulators for large projects. Intuitively, it is worth paying the price of an additional loss of efficiency (when compared to the second best) when there is a large gain in terms of a lower expected informational rent (corruption included).

This result suggests an explanation for the complexity of actual regulatory and bureaucratic structures and its relation with regulated projects. The multi-principal nature of governments may be an optimal answer to the threat of corruption, but only when it comes to large projects.

#### 5. Conclusion

The objective of this paper is to contribute to the understanding of complex regulatory structures. It has been established in the literature that when regulatory corruption is a concern, splitting tasks may be optimal, in spite of the efficiency loss due to the coordination problem resulting from this division. This paper suggests an answer to when it is actually optimal to have multiplicity of principals. Since separating non-benevolent regulators induces uncertainty in the amount of rent each one can appropriate, separation allows society to save on informational rent. The trade-off between this positive effect and the common agency distortion is not trivial, but it is possible to draw a line: in large projects, the rent at stake is too large and society should accept some efficiency loss by dividing regulators.

**Appendix A.**

**Proof of Proposition 1.** The strategy of the proof is as follows. I define  $\Delta$  as the difference between welfare under separation ( $SW^{sep}$ ) and welfare under integration ( $SW^{int}$ ) of regulators. This difference depends both on  $\alpha$  and  $k$ . The first step is to show that  $\Delta$  is increasing in  $\alpha$  for some  $k > \frac{1}{2}$ : the larger the project, the more beneficial separation is when compared to integration. This is accomplished simply by computing the derivative  $\frac{\partial \Delta(\alpha, k)}{\partial \alpha}$  and showing that it is strictly positive. The second step is to show that this difference becomes positive if  $\alpha$  is large enough, implying that separation is the best contractual structure above a threshold for  $\alpha$ . This is accomplished by showing that the derivative  $\frac{\partial \Delta(\alpha, k)}{\partial \alpha}$  is bounded below by a strictly positive number; hence the difference  $\Delta$  increases at least as fast as an increasing linear function (whose slope is the lower bound of the derivative). Since an increasing linear function is unbounded above and goes to infinity as the argument  $\alpha$  increases, the difference  $\Delta$  eventually becomes positive.

Define:

$$\Delta(\alpha, k) = SW^{sep}(q^{sep}(\alpha, k, \theta), \alpha, k) - SW^{int}(q^{int}(\alpha, k), \alpha) \tag{6.1}$$

For notational simplicity, define  $q^{sep} \equiv q^{sep}(\alpha, k, \theta)$  and  $q^{int} \equiv q^{int}(\alpha, k)$ .

*Step 1:* there is a value of  $k$  such that  $\Delta(\alpha, k)$  is increasing in  $\alpha$ .

Apply the envelope theorem to (2.11) and (3.2) to get:

$$\frac{\partial \Delta(\alpha, k)}{\partial \alpha} = E \left[ V_{\alpha}(q^{sep}, \alpha) - V_{\alpha}(q^{int}, \alpha) + \lambda k \frac{F(\theta)}{f(\theta)} c_{q\theta}(q^{sep}, \theta) \left( \frac{\partial q^{sep}(\alpha, k)}{\partial \alpha} \right) \right]$$

Using the implicit function theorem to compute  $\frac{\partial q^{sep}(\alpha, k)}{\partial \alpha}$ , it is possible to rewrite the expression above as:

$$\frac{\partial \Delta(\alpha, k)}{\partial \alpha} = E \left[ V_{\alpha}(q^{sep}, \alpha) - V_{\alpha}(q^{int}, \alpha) + \lambda k \frac{F(\theta)}{f(\theta)} c_{q\theta}(q^{sep}, \theta) \left( \frac{V_{q\alpha}(q^{sep}, \alpha)}{(1 + \lambda)c_{qq}(q^{sep}, \theta) + 2\lambda k \frac{F(\theta)}{f(\theta)} c_{qq\theta}(q^{sep}, \theta) - V_{qq}(q^{sep}, \alpha)} \right) \right]$$

Let  $B$  be the infimum in  $(\alpha, k, \theta)$  of

$$\left( \frac{V_{q\alpha}(q^{sep}, \alpha)}{(1 + \lambda)c_{qq}(q^{sep}, \theta) + 2\lambda k \frac{F(\theta)}{f(\theta)} c_{qq\theta}(q^{sep}, \theta) - V_{qq}(q^{sep}, \alpha)} \right)$$

Given the assumptions on  $V(\cdot, \cdot)$  and  $c(\cdot, \cdot)$ , one has  $B > 0$ . Therefore, it suffices to show that there is  $k$  such that

$$E \left[ V_{\alpha}(q^{sep}, \alpha) - V_{\alpha}(q^{int}, \alpha) + \lambda k \frac{F(\theta)}{f(\theta)} c_{q\theta}(q^{sep}, \theta) B \right] > 0 \tag{6.2}$$

But (2.11) and (3.2) imply that

$$\lim_{k \rightarrow \frac{1}{2}} q^{sep} = q^{int} \tag{6.3}$$

Moreover, the expression in brackets in (6.2) is integrable in  $\theta$  (in the measure  $f$  on support  $[\underline{\theta}, \bar{\theta}]$ ). Therefore, the dominated convergence theorem applies and one gets:

$$\lim_{k \rightarrow \frac{1}{2}} \frac{\partial \Delta(\alpha, k)}{\partial \alpha} = \frac{\lambda B}{2} E \left[ c_{q\theta}(q^{int}, \theta) \frac{F(\theta)}{f(\theta)} \right]$$

Let

$$E \left[ c_{q\theta}(q^{int}, \theta) \frac{F(\theta)}{f(\theta)} \right] \equiv \zeta$$

Since  $c_{q\theta}(q^{int}, \theta)$  is strictly positive for all  $\theta \neq \underline{\theta}$ , one has  $\zeta > 0$ . Hence

$$\lim_{k \rightarrow \frac{1}{2}} \frac{\partial \Delta(\alpha, k)}{\partial \alpha} = \frac{\lambda B \zeta}{2} > 0$$

By continuity, there is a set  $(\frac{1}{2}, \bar{k})$  with strictly positive measure where  $\frac{\partial \Delta(\alpha, k)}{\partial \alpha} > 0$ .

*Step 2:* there is  $\alpha^*$  such that  $\Delta(\alpha, k) > 0$  for all  $\alpha > \alpha^*$ .

It is enough to show that  $\frac{\partial \Delta(\alpha, k)}{\partial \alpha}$  has a lower bound  $L > 0$ . Consider the arbitrary interval  $[0, \bar{\alpha}]$ . (6.3) implies that

$$\frac{\partial \Delta(\alpha, k)}{\partial \alpha} \geq E \left[ V_{\alpha}(q^{sep}, \alpha) - V_{\alpha}(q^{int}, \alpha) + \frac{\lambda k}{2} \frac{F(\theta)}{f(\theta)} c_{q\theta}(q^{sep}, \theta) B \right] + E \left[ \frac{\lambda k}{2} \frac{F(\theta)}{f(\theta)} c_{q\theta}(q^{sep}, \theta) B \right]$$

Define, for each  $\bar{\alpha}$ ,  $k(\bar{\alpha})$  such that for every  $k \in (\frac{1}{2}, k(\bar{\alpha}))$  and every  $\alpha \in (0, \bar{\alpha})$ , one has:

$$E \left[ V_{\alpha}(q^{sep}, \alpha) - V_{\alpha}(q^{int}, \alpha) + \frac{\lambda k}{2} \frac{F(\theta)}{f(\theta)} c_{q\theta}(q^{sep}, \theta) B \right] \geq 0$$

as shown in step 1. Moreover,  $k \geq \frac{1}{2}$  implies

$$E \left[ \frac{\lambda k}{2} \frac{F(\theta)}{f(\theta)} c_{q\theta}(q^{sep}, \theta) B \right] \geq \frac{\lambda B}{4} E \left[ \frac{F(\theta)}{f(\theta)} c_{q\theta}(q^{sep}, \theta) \right]$$

Let

$$E \left[ \frac{F(\theta)}{f(\theta)} c_{q\theta}(q^{sep}, \theta) \right] = \bar{\zeta}$$

Again, the term in brackets is strictly positive except in a zero-measure set, implying  $\bar{\zeta} > 0$ . Therefore,

$$E \left[ \frac{\lambda k}{2} \frac{F(\theta)}{f(\theta)} c_{q\theta}(q^{sep}, \theta) B \right] \geq \frac{\lambda B \bar{\zeta}}{4}$$

Hence,

$$\frac{\partial \Delta(\alpha, k)}{\partial \alpha} \geq \frac{\lambda B \bar{\zeta}}{4} > 0$$

for every  $k \in (\frac{1}{2}, k(\bar{\alpha}))$ . Since this inequality holds for every  $\bar{\alpha}$ , the result follows.

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