"Build It or Not": Normative and Positive Theories of Private-Public Partnerships*

David Martimort[†] and Jerome Pouyet[‡]

January 11, 2006

Abstract

This paper analyzes whether building infrastructures which are socially useful and managing those assets are two tasks which should be bundled or not. In a complete contracting framework, we first show that the two tasks should be performed altogether by the same firm when a better design of the infrastructure helps also to save on operating costs (positive externality). Otherwise (negative externality), the two tasks should be kept split apart and undertaken by different units. In incomplete contracting environments where the quality of the infrastructure may be hard to describe in advance, we isolate conditions under which the traditional form of public provision of services and the more fashionable public-private partnership optimally emerge. Finally, we take a political economy perspective to study how the decision to bundle or not tasks may be affected under the threat of capture.

Journal of Economic Literature Classification Number: H11.
Keywords: Public-Private Partnership, Bundling/Unbundling, Agency Costs, Capture.

1 Introduction

One of the most intriguing issues in modern industrial organization consists in delineating the optimal division of labor between the public and the private spheres. In that respect, the recent privatization wave which took place over the eighties and nineties in most industrial countries and which was also advocated by international agencies for developing countries certainly testifies that this question is at the heart of most major reforms. Even though defenders of full privatization schemes can still be found nowadays in the most liberal spheres, an unequivocal commitment to privatization is often viewed as an excessive response to the inefficiency of the public sector (if any) even when privatization is accompanied by a convenient regulatory

*We are grateful to several members of Veolia Institute for helpful discussions which have motivated this research. We thank also Marc Ivaldi, Jan-Eric Nilsson and Jean Tirole for helpful comments on a previous version.

†University of Toulouse (IDEI, GREMAQ) and Institut Universitaire de France. Address: IDEI, Manufacture des Tabacs, Bât. F, 21 Allée de Brienne, 31000 Toulouse, France. Phone: +33(0)561128614. Fax: +33(0)561128637. E-mail: `martimor@cict.fr`.

‡Ecole Polytechnique and University of Toulouse (IDEI). Address: Département d'Economie, Ecole Polytechnique, 91128 Palaiseau Cedex, France. Phone: +33(0)169332646. Fax: +33(0)169333858. E-mail: `jerome.pouyet@polytechnique.edu`

environment. Most scholars and public-decision-makers advocate thus for a more pragmatic approach which consists in promoting efficient (or at least as efficient as possible) partnerships between the public and the private sectors for the provision of major services and public goods to the general public.[1] Only tasks where the private sector has a comparative advantage should thus really be delegated to the private sphere.

To understand the optimal pattern of delegation, it is useful to keep in mind that most public services (like water management, waste disposal services, public transportation, prison management) require in fact to perform a complex pattern of tasks. Those activities necessitate indeed, first to build some major infrastructures and second to manage those assets as efficiently as possible. Delegation to the private sector takes thus place *de facto* in a *multitask environment*.[2]

The traditional form of public procurement used in most industrial countries has so far been based on some kind of unbundling. First, the government designs the characteristics and quality attributes of the infrastructure to be built. Second, the government chooses a private *builder* to build those assets on its behalf but retains ownership on those assets. Finally, the government chooses an *operator*, who may be either public or private, to manage those assets and provide the public service.

More recently, several initiatives around the world[3] and various legal reforms[4] have proposed an alternative form of procurement, the so-called *private-public partnerships*, in which the government takes a more minimalist stance. In that alternative way of proceeding, the government chooses a private consortium which is in charge of both designing the quality attributes of the infrastructures, building those assets[5] and finally managing them as efficiently as possible.

Compared with the more traditional form of procurement, that PPP alternative is thus characterized by two important features. First, the two tasks of building and managing assets are now bundled altogether. Second, the ownership pattern is also quite different.

Taking first a normative point of view, the first objective of this paper is to understand why and under which circumstances those two alternative forms of procurement are optimal. Of course, this issue is really relevant only in a framework where the delegation of tasks to the private sector also comes with some agency problem.[6]

To make the analysis interesting, we will thus envision the case where those efforts are non-verifiable. Delegation raises first of all a moral hazard problem.[7]

[1]See United Nations Development Programme, 1998.

[2]See Holmström and Milgrom (1991).

[3]For instance, Berger (1985) traces the references to partnerships between the public and the private sectors in the U.S. to the Carter administration and its willingness to include private actors in the development of urban projects in areas of very costly public funds and huge public deficits. Daniels and Trebilcock (2002) offer a nice overview of some issues raised by public-private partnerships in Canada.

[4]See the June 2004 text prepared by the Raffarin government in France for instance.

[5]This stage implicitly includes also the financing of the infrastructure.

[6]Otherwise, the first-best levels of efforts both in enhancing the quality of the assets and in saving on operating costs could be achieved with simple forcing contracts, thereby making the organizational issue of whether to bundle or not the two tasks irrelevant.

[7]See Holmström (1979), Shavell (1979) and Grossman and Hart (1983).

The issue we analyze is whether agency costs exhibit *economies of scope or not* when tasks are bundled. We will argue that the pattern of ownership and its impact on incentives is *not* the most important ingredient to understand the optimal form of procurement. Instead, what is crucial to understand why the two tasks of building and managing should be managed altogether is the sign of the externality that a good infrastructure design exerts on operating costs. The key reason for bundling is thus to be found on technology. Two cases are a priori feasible and are documented by practitioners.[8] First, a better design of the infrastructure may help to save on operating costs, the case of a positive externality. Second, a better design may also require to learn new procedures for managing assets and thus increase operating costs, the case of a negative externality. In the first case, we show that the two tasks should be performed by the same firm which is better able to internalize the positive externality that raising the quality of the assets has on operating costs. Intuitively, under moral hazard, there is a trade-off between providing incentives to the builder to improve the quality of the infrastructure and giving him insurance against adverse shocks on the realized quality. This trade-off calls for reducing the power of his incentives so that the builder exerts less than the first-best effort. This decreased quality of the assets may increase excessively the operating costs and thus exerts a negative externality on the operator if building and managing assets are unbundled. The builder and the operator should thus be integrated as a single entity. The optimal organizational form exhibits thus an important feature of the modern public-private partnership. Otherwise, i.e., in the case of a negative externality, the two tasks should be split because solving the agency problem on one task exacerbates the incentive problem on the other.

That argument behind the choice of the optimal organizational form is thus unrelated to the ownership issue. In practice, ownership nevertheless matters. The quality attributes of an infrastructure may be hard to specify in advance so that complete contracting with a builder may be difficult or even impossible. In an incomplete contracting environment, the sole source of incentives to improve the quality of assets is ownership. Of course, this impossibility of writing complete contracts has also some impact on the risk borne by private owners which may be excessive. We will thus view the ownership allocation as a specific form of contracts with imperfect incentives alignment (because assets are privately owned, the owner may not internalize the full social value of his investment in enhancing the quality of the infrastructure) and imperfect insurance properties.

When incentives for building are so rigid (at least not as flexible as under complete contracting) and can only be provided by allocating ownership, the decision whether to bundle or not the two tasks may help to improve quality-enhancing effort. For instance, when the private owner does not have enough private incentives to improve the quality of the assets, making him also responsible for the management of these assets fosters incentives in the case of a positive externality. *A contrario*, when private incentives are excessive, bundling tasks may not be a good idea even when the externality is positive. In that incomplete contracting environment, the modern

[8] For instance, the report made by the French Cour des Comptes following the Roissy Airport Terminal E2 crash reports that an important issue was that Aéroport de Paris cumulated several 'hats' as an owner of the infrastructure, a designer, and a builder. It was argued that this bundling of tasks induced a sacrifice on the quality of the infrastructure.

form of public-private partnerships emerges when private owners have rather weak incentives to enhance assets quality compared with what would be socially optimal. On the other hand, the traditional form of procurement emerges when the externality is negative and uncertainty on the realized quality of the assets is too large to let private owners bear such risks.

Although the normative arguments above have certainly some appeal, they do not explain the fierce opposition to the modern form of public-private partnerships that is sometimes found among practitioners and political decision-makers. Opponents often argue that this organizational form may increase the scope for capture[9] of the decision-maker so that the possible efficiency gains from bundling may be offset by these influence costs. In fact, as the decision-maker may find either bundling or unbundling both optimal depending on the realization of the externality between tasks, he may exert his discretion to favor the industry by this organizational choice. To analyze those political economy environments, we must significantly extend the scope of our analysis. First, the decision-maker must have private information on the level of externality so that manipulations of his decision can be made at the expense of the general public. Second, the operator willing to integrate backwards into infrastructure building must also withdraw some rent from doing so and, here again, some sort of private information is again needed.[10] Now, the political economy drawback from the bundling decision becomes clearer. Because bundling is called for in the case of a positive externality, it raises also incentives to improve operating costs. Under adverse selection, this is a source of a greater information rent.[11] Even when the externality is negative and unbundling is socially optimal, the operator has an incentive to bribe a (non-benevolent) decision-maker to integrate backwards and also build the infrastructure by himself. When the social cost of such collusion is taken into account, bundling may not be as attractive.

Let us now turn to a review of the literature. Two papers address issues close to ours: Bennet and Iossa (2002) and Hart (2003). Both papers *fully* lie in the realm of the property rights literature à la Grossman and Hart (1986) and derive inefficiencies in assets quality-enhancing and cost-saving efforts from the hold-up problem that arises when no contract at all can be written and only ex post negotiation between the government and the operator and/or builder is feasible. Although it is ex post efficient, this negotiation generates payoffs which depend on the threat point defined by the ownership structure.[12] By a reasoning close to the one we will make in our complete contracting environment, a positive externality may somewhat weaken the hold-up problem on *both* tasks and calls thus for integration. Although similar in spirit, our findings should nevertheless be distinguished and contrasted. First, even though, we are quite sympathetic with the idea that the quality of assets may be hard to describe in advance so that complete contracts with a builder may be difficult to enforce,[13] we are much more skeptical on the use of this paradigm when

[9] In Libération dated June 21th 2004, Arnaud Montebourg, an impetuous young leader of the French socialist party argued that PPPs had a *"caractère opaque and corrupteur"* (a feature of opacity and corruption).

[10] The pure moral hazard model analyzed in the first part of the paper does not generate any rent to the builder and operator.

[11] See Laffont and Tirole (1993, Chapter 1) for instance.

[12] See also Hart, Shleifer and Vishny (1997) for such an analysis.

[13] Indeed, we use this idea in Section 4 below.

it comes to analyze the relationship between the government and the operator. Operating costs are readily observable and often used in practice to contract for service provision. This suggests that the role of ownership has been (by a large extent) overemphasized so far. More basic agency problems may actually explain much of the organizational forms which emerge. However we will argue that the distortions due to ownership allocations are superimposed on top of those more basic insights. Second, because the property rights approach deliberately de-emphasizes informational issues, it cannot endogenize the stake for capture and address the political economy issues which are so crucial to any positive theory of public-private partnership. This is where lies a second important insight available within our framework.

The paper is organized as follows. Section 2 presents the model. Section 3 addresses the respective optimality of bundling and unbundling tasks in a complete contracting environment where both the builder and the operator receives a linear scheme function of their own performance only. This means that, although the operator's cost may reveal some information on the builder's effort, costs are not used to compensate the builder. Section 4 tackles the ownership issue. Section 5 generalizes our findings to the case where the cost realizations can also be used to compensate the builder. We stress there a "moral hazard in teams" problem à la Holmström (1982) since costs reflect now both the operator and the builder's individual effort which increase the benefits of bundling those tasks in case of a positive externality. Section 6 discusses the political economy of the model. Section 7 concludes. Proofs are relegated to an Appendix.

2 The Model

We are interested in understanding conditions under which the two tasks of building an infrastructure and managing those assets should be merged and provided by the same firm.[14]

Let us denote by $\mathcal{B}$ (resp. $\mathcal{O}$) the builder (resp. the operator) of this infrastructure. A merger of those two firms, if it is the chosen organizational structure, will be denoted accordingly as $\mathcal{B} - \mathcal{O}$.

Both firms are symmetric,[15] and have CARA utility function $v(\cdot)$ with r being the degree of risk-aversion. Both the activities of building and managing assets are subject to moral hazard. Although the builder exerts a non-verifiable effort e_1 to improve the intrinsic quality of the infrastructure, only a rough observable (the realized quality) is available for contracting

$$\tilde{q} = e_1 + \tilde{\varepsilon},$$

where $\tilde{\varepsilon}$ is a random shock which is normally distributed with zero mean and variance σ_{ε}^2. Contracts with the builder can specify a compensation $z(q)$ for each observed level of quality but they cannot stipulate the intrinsic quality of the infrastructure

[14] Of course, this focus on two tasks only is made for capturing the essence of the argument. In the real word, one has often to distinguish between designing a project, building the corresponding infrastructure and managing those assets.

[15] The symmetry assumption is again made for simplicity only.

e_1.

The government (sometimes called the principal) withdraws a benefit $S \times q$ from building an infrastructure with realized quality q.[16]

Operating costs $\tilde{c}$ are also observable and contractible but they again reflect only imperfectly the operator's non-verifiable cost-reducing effort e_2. We postulate the following relationship:

$$\tilde{c} = \tilde{\eta} - e_2 + \delta e_1, \tag{1}$$

where $\tilde{\eta}$ is a random variable which is normally distributed with mean η_0 and variance σ_η^2. Costs being observable, they are reimbursed by the principal who can thus specify a cost-reimbursement rule $t(c)$ for the operator.

Exerting effort e_i costs $\psi(e_i) = \frac{e_i^2}{2}$ to the concerned agent.[17] Note that, in the case of a merger, those disutility functions are additive to avoid any systematic bias against bundling in the comparison of both organizational structures. For simplicity, we also assume that both firms face the same disutility function.

Importantly, the operating costs are related to the quality of the infrastructure (see equation (1)). Two cases are of interest and may arise in practice:

- *Positive externality,* $\delta < 0$: An infrastructure with a higher quality may allow to reduce operating costs. This happens when, for instance, newly built infrastructures make operating tasks easier.

- *Negative externality,* $\delta > 0$: An infrastructure with a higher quality may require to innovate in some of the operating tasks or to learn new job processes. This certainly increases operating costs at least in the short-run.

In practice, both cases are equally likely to be faced by practitioners. The sign of this externality plays actually a major role in comparing organizational structures as we will see below.

Contracts. We follow Holmström and Milgrom (1987) in motivating the use of linear schemes in this environment.[18] The compensation of an agent depends thus linearly of the contracting observable variables.

Under *unbundling*, $\mathcal{B}$ and $\mathcal{O}$ are respectively offered contracts of the form

$$t(q) = b + aq,$$

[16] The quality of the infrastructure may include the delay in building it. It should be clear that the intrinsic quality of an infrastructure may not be fully observable. Let us give two examples. Before its crash, very few people could have guessed that Roissy terminal E2 was not well constructed and could crash at any time. In the case of water treatment, although the quality of water can be tested and specified in the contract, the quality of the supply network is certainly not. Only rough estimates like the number and frequency of the leakages are available.

[17] The assumption of symmetry could again be relaxed at the cost of an increased notational burden.

[18] We are not of course in a pure Holmström and Milgrom (1987) environment because there are two sequential tasks, operating assets taking place after their building. It is not known to us whether there exists a dynamic version of our static model à la Holmström and Milgrom (1987) whose limit would justify the use of linear contracts. However, we are relatively confident on the robustness of our result to a largest space of (possibly) nonlinear schemes.

and

$$z(c) = \beta - \alpha c.$$

Parameters b and β are fixed-fee payments whereas a and α are piece-rate parameters. Note that each agent's reward is linked only to the realization of the performance related to his own task. In other words, contracts of the form $t(q,c) = b + aq + a'c$ for the builder and $z(c) = \beta - \alpha c + \alpha' q$ for the operator are ruled out. In this respect, it is interesting to note that *a priori* the compensation of the builder should be linked with the realized operating costs since the quality of the infrastructure chosen by the builder affects those costs and cost realizations provide information on the intrinsic quality of the infrastructure. In practice, the payment of the infrastructure to the builder takes place before costs realize so that such a general scheme may not be feasible when payments cannot be delayed. We will thus focus on the case where $a' = 0$ although our results on the costs and benefits of bundling tasks could be generalized to the more complex environments where delayed payments are available. On the other hand, note that there is no value in making the compensation of the operator depend on the observable quality of the infrastructure. Doing so would only increase the risk borne by the risk-averse builder operator without any positive incentive effect on his effort supply. Section 5 analyzes this case of enlarged contract spaces.

Under bundling, the merger $\mathcal{B} - \mathcal{O}$ receives a linear scheme:

$$t(q,c) = B + aq - \alpha c,$$

where B is an aggregate fixed-fee. One can view the total payments $t(\cdot)$ as being delayed until the operating costs are realized. Alternatively, this payment can be decomposed into two different parts: one being offered after the realized quality has been observed, the other being delayed until costs are observed. To induce efforts and participation of the merged agent, only the inter-temporal transfer matters.[19]

Complete Information Benchmark. Suppose that efforts e_1 and e_2 are both verifiable. The principal can thus use forcing contracts to implement any such effort pair. Then, the first-best efforts can be chosen and full insurance provided to both firms by offering them fixed-fees which cover their respective disutility costs.

This first-best pair $\{e_1^*, e_2^*\}$ solves:

$$\max_{(e_1,e_2)\in\mathbb{R}_+^2} \mathbb{E}_{\tilde{\varepsilon},\tilde{\eta}} \left\{ S\tilde{q} - \tilde{c} - \psi(e_1) - \psi(e_2) \right\},$$

or

$$\max_{(e_1,e_2)\in\mathbb{R}_+^2} (S-\delta)e_1 + e_2 - \psi(e_1) - \psi(e_2);$$

one immediately finds $e_1^* = S - \delta$ and $e_2^* = 1$. We will assume $S > \delta$ to maintain an interior solution for the builder's effort. Of course that condition always holds in the case of a positive externality. It holds for a negative externality if the social return on quality is large enough: a quite natural assumption to have a meaningful analysis.

[19] One can also adjust fixed-fees in each period to make this inter-temporal contract robust to the possibility that the agent leaves the relationship after having built the infrastructure.

Of course, the organizational structure is *irrelevant* in this complete information context. Whether bundling or unbundling is chosen yields the same first-best outcome.

3 Moral Hazard and Organizational Choices

Let us now turn to the case where efforts are non-verifiable. For simplicity, we first focus on the case of unbundling.

Unbundling. The builder wants to maximize the certainty-equivalent of his expected utility, namely:

$$\max_{e_1 \in \mathbb{R}_+} b + ae_1 - \psi(e_1) - \frac{r\sigma_\varepsilon^2}{2}a^2.$$

The builder's marginal incentives to exert effort are thus given by the slope a of the incentive scheme:

$$a = \psi'(e_1) = e_1. \tag{2}$$

The fixed-fee payment b is chosen by the principal to extract the builder's expected utility[20] and one finds:

$$b = \frac{e_1^2}{2}(r\sigma_\varepsilon^2 - 1). \tag{3}$$

Similar computations can be made for the operator who wants to maximize:

$$\max_{e_2 \in \mathbb{R}_+} \beta - \alpha(\eta_0 - e_2 + \delta e_1) - \psi(e_2) - \frac{r\sigma_\eta^2}{2}\alpha^2.$$

His marginal incentives are thus given by:

$$\alpha = \psi'(e_2) = e_2; \tag{4}$$

the optimal fixed-fee payment is:

$$\beta = e_2\eta_0 + \frac{e_2^2}{2}\left(r\sigma_\eta^2 - 1\right) + \delta e_1 e_2 \tag{5}$$

to extract all the operator's expected profit.

Note that the externality between the two tasks of building and operating assets does not affect the marginal incentives of the builder. Only the fixed-fee he receives must be adapted to take into account this externality.

Under moral hazard and separation, the principal wants to maximize:

$$\max_{\beta,\alpha,b,a,(e_1,e_2)\in\mathbb{R}_+^2} S\mathbb{E}_{\tilde{\varepsilon}}\{\tilde{q}\} - \mathbb{E}_{\tilde{\eta}}\{\tilde{c}\} - \beta + \alpha\mathbb{E}_{\tilde{\eta}}\{\tilde{c}\} - b - a\mathbb{E}_{\tilde{\varepsilon}}\{\tilde{q}\},$$

subject to constraints (2) to (5).

[20] Normalizing the builder's (and below the operator's) outside opportunities at zero.

Rewriting this problem with efforts as the only variables, we get the expression of the principal's problem under unbundling as:

$$(P^u): \max_{(e_1,e_2)\in\mathbb{R}^2_+} W^u(e_1,e_2,\delta) \equiv (S-\delta)e_1 + e_2 - \frac{e_1^2}{2}(1+r\sigma_\varepsilon^2) - \frac{e_2^2}{2}(1+r\sigma_\eta^2).$$

The optimal efforts $\{e_1^u, e_2^u\}$ are thus given by:[21]

$$e_1^u = \frac{S-\delta}{1+r\sigma_\varepsilon^2} < e_1^*, \tag{6}$$

and

$$e_2^u = \frac{1}{1+r\sigma_\eta^2} < e_2^*. \tag{7}$$

Efforts are still positive but they are now below the first-best. Indeed, for each risk-averse agent, there is a trade-off between providing the agent with enough incentives to exert effort and reducing the risk he bears for insurance reasons.[22]

Because of the one-sided externality in our model, the builder's effort e_1^u depends on δ but not the operator one's effort e_2^u.

Bundling. Under bundling, the merged entity $\mathcal{B}-\mathcal{O}$ can now better internalize the impact of raising the quality of the infrastructure on the operating costs. To see how, note that the merged entity now maximizes:

$$\max_{(e_1,e_2)\in\mathbb{R}^2_+} B - \alpha(\eta_0 - e_2 + \delta e_1) + ae_1 - \psi(e_1) - \psi(e_2) - \frac{r\sigma_\eta^2}{2}a^2 - \frac{r\sigma_\varepsilon^2}{2}\alpha^2$$

which admits the following first-order conditions:

$$a - \alpha\delta = e_1, \tag{8}$$
$$\alpha = e_2. \tag{9}$$

Equations (8) and (9) illustrate the role of a joint provision of incentives on the two tasks. When the externality is positive, a bonus α on cost reduction helps not only to reduce cost by exerting more operating cost effort (see (9)) but also improves incentives on quality enhancing (see (8)). The reverse happens for a negative externality. The intuition is straightforward: when the externality is negative, the principal dealing with a single agent cannot provide incentives on two efforts which go in opposite directions.[23]

The fixed-fee B is then used by the principal to extract $\mathcal{B}-\mathcal{O}$'s expected profit

[21] The second-order conditions are trivially satisfied.

[22] See Grossman and Hart (1983), Shavell (1979) and Holmström (1979) for this standard trade-off between insurance and incentives.

[23] This conflict between performing two opposite tasks at same time is reminiscent of Dewatripont and Tirole (1999) and Gromb and Martimort (2004). Both papers analyze why the same agent cannot gather two pieces of information which may conflict with each other.

so that, under integration, the principal's problem can be written as:

$$(P^b): \max_{(e_1,e_2)\in\mathbb{R}^2_+} W^b(e_1,e_2,\delta) \equiv (S-\delta)e_1 + e_2 - \frac{e_1^2}{2} - \frac{r\sigma_\varepsilon^2}{2}(e_1+\delta e_2)^2 - \frac{e_2^2}{2}(1+r\sigma_\eta^2), \tag{10}$$

whose optimum $\{e_1^b, e_2^b\}$ is given by:[24]

$$e_1^b = \frac{(S-\delta)(1+r\sigma_\eta^2+\delta^2 r\sigma_\varepsilon^2) - \delta r\sigma_\varepsilon^2}{(1+r\sigma_\eta^2)(1+r\sigma_\varepsilon^2)+\delta^2 r\sigma_\varepsilon^2}, \tag{11}$$

$$e_2^b = \frac{1+r\sigma_\varepsilon^2 - (S-\delta)\delta r\sigma_\varepsilon^2}{(1+r\sigma_\eta^2)(1+r\sigma_\varepsilon^2)+\delta^2 r\sigma_\varepsilon^2}. \tag{12}$$

To keep the analysis interesting, we will assume that $e_k^b \geq 0$ (for $k \in \{1,2\}$) which necessarily holds when $\delta < 0$ (positive externality) but also when δ is positive but small compared with S (case of a sufficiently weak negative externality).

Having determined the optimal payments and incentives under both organizational structures, it remains to compare bundling and unbundling. The next proposition emerges directly from the previous analysis.[25]

Proposition 1. *Assume that efforts are non-verifiable, bundling is the optimal organizational structure if and only if $\delta < 0$ (positive externality). Effort are ranked as follows:*

$$e_1^b > e_1^u \text{ and } e_2^b > e_2^u \Leftrightarrow \delta < 0.$$

The intuition behind this proposition is straightforward. When a better intrinsic quality of the infrastructure makes it easier to reduce operating costs, the two tasks should be performed altogether by the same firm. Indeed, this firm better internalizes the impact of any quality-enhancing effort on reducing the operating cost. Under moral hazard on the quality-enhancing effort, the trade-off between incentivizing the first task of building assets and providing insurance to the builder calls for moving towards lower powered incentives and thereby reducing this quality-enhancing effort.[26] When the externality between both tasks is positive, this low-powered incentives on quality-enhancing does not reduce of operating costs unless the two tasks are integrated.

When the externality is negative, reducing operating costs calls for lowering also the quality of the infrastructure. If the two tasks of building and managing assets were merged, the principal would induce an inefficiently low level of quality just to save also on operating costs. A better provision of incentives can be obtained by simply separating the two tasks of building and managing assets. Then, the principal is no longer asking the agents to perform well on two conflicting tasks. Incentives are better provided by having agents being focused on one task each.

The analysis above gives us a more general insight: the choice of an organizational structure affects agency costs and should be made with an eye on how it

[24] The second-order conditions are trivially satisfied.

[25] Remember that agents get no rent in every configurations.

[26] It is well-known that the second-best level of effort in a pure moral hazard environment may not always be below its first-best level (see Laffont and Martimort (2002, Chapter 5) for instance). However, the lessons of the linear-CARA model à la Holmström and Milgrom (1987, 1991) are now well-admitted in the profession and capture the 'Folklore intuition'.

helps reducing those costs. Under bundling, the incentive problem on each task is weakened (resp. exacerbated) when the externality is positive (resp. negative).[27]

Remark. The reader will have recognized a standard reasoning of the multi-task incentives literature. Improving incentives on one task may thwart incentives on another task if the two tasks are somewhat substitutes (case of a positive externality). Instead of this substitutability coming from the agent's disutility function as in Holmström and Milgrom (1991), it comes here from the equivalent role that quality-enhancing and operating costs-saving efforts play to reduce the observable operating costs.

A second important by-product of bundling in the case of a positive externality is that the second of this task is also better incentivized. Indeed, when tasks are kept separated, both the operator and the builder contribute to lowering operating costs. Their efforts can be viewed as (sequential) contributions to a public good and are thus provided at too low a level. This free-riding of the operator on the builder can be avoided under integration and operating costs are further reduced. We will see on Section 5 how this free-riding is exacerbated when the space of contracts is enlarged and allows to compensate the builder also as a function of the realized operating costs.

4 Ownership and Organizational Form

We have so far assumed that the perceived quality of the infrastructure q was observable and verifiable and could thus be used in any contract linking the government and the builder.

Let us now suppose that this variable is itself non-verifiable ex ante. The only incentive scheme between the builder and the government consists in allocating ownership rights on the assets. Of course, ex post, once the realized quality q is observed, the government and the agent can bargain over the realized gains from trade.

We will assume that whoever owns the assets enjoys a return Pq by disposing on the assets in case the ex post negotiation breaks down. Because the built assets may have a greater social value than their value for the sole owners, we will have $S = E + P \geq P$ where E is captures the externality impact of the infrastructure. Several origins can be found to this discrepancy between the social and the private values of the assets. Indeed, first once built, assets could be redeployed to other social uses than initially thought. Second the infrastructure may have a positive impact on employment and this is found worth by the principal.

For both the cases of bundling and unbundling, we may wonder what is the optimal ownership structures. Our goal in this section is thus to envision whether the incompleteness of the contracts modeled by assuming the non-verifiability of the perceived quality q affects the choice of bundling tasks or not and, if it does so, in which directions those distortions go.

[27]Holmström and Milgrom (1994) and Athey and Roberts (2001) argue also that the firm should be viewed as resulting from a joint optimization over incentive schemes and over organizational issues. In a pure adverse selection framework, Baron and Besanko (1992, 1999), Dana (1993) and Gilbert and Riordan (1994) have also shown that bundling tasks and having a single agent privately informed on cost parameters related to each task dominates unbundling.

Whatever the organizational structure chosen, the only feasible contracts with the builder consist now in allocating assets ownership.[28] Of course, on top of this allocation, the government has still to decide of an ex ante price to be paid to the builder to induce his participation. On the other hand, contracts with the operator keep the general linear form used above. By jointly making those two different assumptions on the two tasks, we capture what seems to be a major feature of most real-world partnerships: the difficulty to verify quality[29] and the fact that costs instead are readily observable, verifiable and used in cost-sharing agreements.[30,31]

To understand the implications of ownership, it is useful to see it as a "simple" contract fixing the marginal incentives to innovate to either 0 under government ownership or to P under builder ownership. In doing so, we thus assume that the government has all bargaining power in the ex post negotiation that takes place with the builder once the perceived quality $\tilde{q}$ is realized.[32]

With that specification in mind, it becomes easy to compute the quality-enhancing effort of the builder under both ownership structures and under both organizational forms.

Government Ownership. Let us first suppose that unbundling has been chosen. The builder has no incentive to innovate whatsoever and thus exerts no effort. Social welfare can be written as

$$W_G^u(e_2) = e_2 - \frac{e_2^2}{2}(1 + r\sigma_\eta^2), \tag{13}$$

where e_2 is the operator's cost-saving effort.

Let us now turn to the case of a bundling. We must distinguish between the case of a positive externality and the case of a negative one.

When $\delta > 0$ (negative externality), the merged entity $\mathcal{B}-\mathcal{O}$ has still no incentive to enhance quality and $e_1 = 0$ just like under unbundling. Social welfare $W_G^b(e_2)$ is still given by (13).

We thus obtain immediately.

Proposition 2. *Assume that there is a negative externality between building and operating assets. Under government ownership, bundling and unbundling yield the same outcome.*

---

[28] We will assume that only deterministic ownership structures are relevant.

[29] See Hart, Shleifer and Vishny (1997) and Hart (2003) for similar assumptions.

[30] Water management, waste disposals, transports, etc. are examples in order there.

[31] Contrary to what is assumed in Hart, Shleifer and Vishny (1997) for instance.

[32] This allocation of bargaining power ex post is thus the same as ex ante, making this choice particularly attractive in our context. Had we instead assumed Nash bargaining ex post (as for instance in Grossman and Hart (1986)), the builder and the government would fix an ex post transfer price T equal to

$$\arg\max_{\tilde{T}} (S - \tilde{T} - P)(\tilde{T} - P) = \frac{S}{2}.$$

This is also the overall payoff of the builder (namely $\tilde{T} - P + P$). Denoting $P' = \frac{S}{2}$ and replacing P by this P' in all the analysis below would make it also valid for a more equal ex post bargaining power than the one we postulate.

When $\delta < 0$ (positive externality), the merged entity $\mathcal{B}-\mathcal{O}$ may find it beneficial to increase the quality of the infrastructure even though he does not own it, simply because this is a way of reducing operating costs. In fact, given a slope α of the cost-reimbursement rule, e_1 is now fixed so that $-\alpha\delta = e_1$ whereas $\alpha = e_2$.

Since the merged entity bears no risk linked to the realized quality of the infrastructure when it is not the owner, social welfare can then be written as

$$W_G^b(e_2, \delta) = \left\{-\delta(S-\delta)e_2 - \frac{\delta^2 e_2^2}{2}\right\} + \left\{e_2 - \frac{e_2^2}{2}(1 + r\sigma_\eta^2)\right\}. \quad (14)$$

The first bracketed term is the social value of the quality-enhancing effort when the incentives for doing so come only from the willingness of the merged entity to reduce his operating cost. Assuming that $|\delta|$ is small enough, this is a positive term when evaluated at the effort level $e_2^u = \frac{1}{1+r\sigma_\eta^2}$ which maximizes (13). The second bracketed term is nothing else than the expression for $W_G^u(e_2)$. Henceforth, we immediately get the following proposition.

Proposition 3. *Assume that there exists a positive externality between building and operating assets. Then, for $|\delta|$ small enough and under government ownership, bundling strictly dominates.*

Since explicit incentives on quality-enhancing and implicit incentives through ownership are both absent, the only way to induce quality-enhancing effort is to bundle tasks so that the builder enjoys some benefit of exerting effort e_1 through the reduction of operating costs it induces.

Builder ownership. Under unbundling, when the builder owns the assets, his quality-enhancing effort is given by

$$P = e_1,$$

where P is the marginal private returns from holding the assets. As an owner enjoying the random private returns form owning the assets, the builder will also bear some risk and must be compensated for doing so by receiving an ex ante risk-premium $\frac{1}{2}r\sigma_\varepsilon^2 P^2$ so that he prefers becoming an owner rather than not participating at all.

Social welfare under unbundling expressed again as a function of the operator's effort can thus be written as:

$$W_B^u(e_2, \delta) = (S-\delta)P - \frac{P^2}{2}(1 + r\sigma_\varepsilon^2) + e_2 - \frac{e_2^2}{2}(1 + r\sigma_\eta^2). \quad (15)$$

Of course, this expression is still maximized for e_2^u.

Under bundling, the merged entity chooses a level of quality-enhancing effort which takes into account the impact on operating costs. This yields:

$$P - \alpha\delta = e_1$$

(where we assume that δ is small enough to ensure a positive effort supply). The operating-costs-saving effort is still given by $e_2 = \alpha$.

Social welfare under bundling can finally be written as:

$$W_B^b(e_2,\delta) = (S-\delta)(P-\delta e_2) - \frac{1}{2}(P-\delta e_2)^2(1+r\sigma_\varepsilon^2) + e_2 - \frac{e_2^2}{2}(1+r\sigma_\eta^2). \quad (16)$$

Let denote by e_{2b}^B the maximand of this expression.

The comparison of (15) and (16) immediately yields:

Proposition 4. *Assume that there exists a positive externality between building and operating assets. Under builder ownership and if* $P \le \frac{S-\delta}{1+r\sigma_\varepsilon^2} + \delta e_2^u$*, bundling strictly dominates; if* $P \ge \frac{S-\delta}{1+r\sigma_\varepsilon^2} + \delta\frac{e_{2B}^b}{2}$*, unbundling strictly dominates.*

The intuition behind this proposition is straightforward. When ownership by itself does not give enough incentives to the builder to improve the quality of the assets compared with the complete contracting outcome, bundling improves those incentives by making the builder more eager to save also on operating costs. A contrario, when ownership already provides too much incentives to increase quality, bundling can only worsen the outcome by increasing the over-supply of effort on the first task. Comparing now (14) and (16), we immediately get:

Proposition 5. *Assume that there exists a positive externality between tasks, that uncertainty on quality is small enough (σ_ε^2 small) and that the private benefits from ownership are also small enough, then bundling and builder ownership is the optimal organizational form.*

When uncertainty on quality is small, the builder does not need to be given a large ex ante risk-premium to participate. As long as ownership provides enough incentives (but still not too much) to the builder to improve assets quality under integration, the latter should not only own the assets but also manage them. When quality is highly uncertain, the principal needs to pay a much larger premium to induce the builder to participate as an owner. He may then be optimal to keep assets under public ownership, leaving all incentives for enhancing quality from the desire of the merged entity $\mathcal{B}-\mathcal{O}$ to save on operating costs.

Proposition 5 highlights conditions under which the most common form of private-public partnership emerges. Integration helps to improve incentives on quality-enhancing effort when ownership of the assets alone does not suffice. The cost of private ownership is however the risk-premium left to the builder to induce him to participate. Only when this cost is small enough does the private ownership structure emerge.

A contrario, let us find conditions under which public ownership and separation dominates. This will correspond to the more traditional form of public procurement where two different agents are called for at the building and operating stages. We already know from Proposition 2 that separation and integration are equivalent under government ownership and when the externality is negative: no incentives on quality-enhancing can even been provided. The hope for unbundling to strictly dominate in this case thus vanishes. Nevertheless, we have:

Proposition 6. *Assume that there exists a negative externality between tasks and that the private benefits from ownership are large enough, namely* $P > 2\frac{S-\delta}{1+r\sigma_\varepsilon^2}$*, then public ownership and unbundling is the optimal organizational form.*

With a negative externality, the only way to incentivize effort on quality-enhancing is to give ownership to the builder. Again, the cost of ownership is the risk-premium borne by the owner. When the private benefits of ownership are too high, this cost exceeds the social benefit of a positive effort in quality-enhancing. Public ownership is then preferred.

5 Linking the Builder's Compensation to the Operator's Cost

As in Section 3, we consider now that the perceived quality of the infrastructure can be described in advance and thus can be included in any contracts linking the government and the operator as well as the government and the builder. We also consider that more complex contracts can be implemented under unbundling: under that organizational structure, the contract offered to a given agent is still linear but can now also depend on the other agent's realized action. This possibility allows to reach a weakly higher welfare under unbundling since the space of contracts is enlarged. Hence, under a negative externality, unbundling still dominates bundling; we now compare these organizational choices assuming a positive externality (i.e., $\delta < 0$).

The transfer to the builder writes now as:

$$t(q, c) = b + aq + a'c.$$

The payment to the operator is now:

$$z(q, c) = \beta - \alpha c + \alpha' q.$$

Since the externality is one-sided in our context, the possibility to conditionalize the payment to the operator to the realized quality is useless for the government: this would merely increase the risk faced by the operator thereby leading to increase the risk-premium needed to ensure his participation. In the following, we shall consider that $\alpha' = 0$.[33] Under unbundling, the problem of the operator is thus unchanged.

By contrast, linking the transfer to the builder on the operator's cost (through delayed payments for instance) may allow the government to make the builder internalizes the externality it creates on the operator. The problem of the builder becomes:

$$\max_{e_1 \in \mathbb{R}_+} b + ae_1 + a'(\eta_0 - e_2 + \delta e_1) - \psi(e_1) - \frac{r}{2}(a^2\sigma_\varepsilon^2 + a'^2\sigma_\eta^2).$$

The builder's marginal incentive to enhance the infrastructure quality is now given by:

$$a = e_1 - a'\delta. \tag{17}$$

As is usual by now, the principal sets the fixed payment so as to extract all the

[33] This can be easily shown formally.

expected rent of the builder, or:

$$b = \frac{r}{2}[\sigma_\varepsilon^2(e_1 - a'\delta)^2 + \sigma_\eta^2 a'^2] - e_1\left(\frac{e_1}{2} - a'\delta\right) - a'\delta(\eta_0 - e_2 + \delta e_1). \quad (18)$$

Welfare under unbundling writes thus as follows:

$$\max_{a',(e_1,e_2)\in\mathbb{R}_+^2} W^u = (S-\delta)e_1 + e_2 - \frac{e_1^2}{2} - \frac{e_2^2}{2} - \frac{r\sigma_\eta^2}{2}e_2^2 - \frac{r}{2}\left[(e_1 - \delta a')^2\sigma_\varepsilon^2 + a'^2\sigma_\eta^2\right]. \quad (19)$$

Remind that welfare under bundling is given by:

$$\max_{(e_1,e_2)\in\mathbb{R}_+^2} W^b = (S-\delta)e_1 + e_2 - \frac{e_1^2}{2} - \frac{e_2^2}{2} - \frac{r\sigma_\eta^2}{2}e_2^2 - \frac{r}{2}\left[(e_1 + \delta e_2)^2\sigma_\varepsilon^2\right]. \quad (20)$$

When $a' = 0$, as in Section 3, we immediately observe that bundling is preferred to unbundling as soon as $\delta < 0$.

Still considering the case of a positive externality, the welfare comparison is more ambiguous when the transfer to the builder can be made contingent to operating costs under unbundling: on the one hand, this additional parameter allows to improve the incentive to increase the quality-enhancing effort of the builder; on the other hand, this increased incentive makes the builder bear a higher risk related to the uncertainty on the operating cost. Loosely speaking, under unbundling the quality-improving effort is better incentivized but the risk premium associated to the uncertainty on operating costs must be paid twice.[34]

In general, the comparison between bundling and unbundling depends in a complex way on the various parameters. Nevertheless, we obtain the following proposition.

Proposition 7. *Assume that efforts are non-verifiable and that under unbundling the payment to the builder can be made dependent on the operator's cost. Then, bundling is still optimal when the externality is weakly positive.*

Remind that an integrated firm already internalizes the externality between the building and the operating stages. Hence, when the externality is weakly positive bundling is preferred to unbundling as it allows to reduced the payment to the builder without distorting too much the incentive to enhance the quality of the infrastructure with respect to the first-best.

6 The Political Economy of PPPs

So far, the decision to bundle or not the two tasks was assumed to be taken by a decision-maker who was a social welfare maximizer. Opponents to public-private partnerships have often argued that those forms of procurement increase the scope for capture of the decision-maker by private interests. We now turn to this issue by introducing political economy considerations in our model.

[34]Comparing (19) and (20), we immediately observe that unbundling is preferred to bundling when σ_η goes towards zero.

In fact, the bare-boned model analyzed in Section 3 already provides some hints to understand why and when an operator wants to influence a (possibly non-benevolent) policy-maker to favor bundling rather than unbundling even though that decision may not be the socially optimal one. Indeed, we know from Proposition 1 that, under bundling and with a positive externality, the optimal incentive scheme offered to the operator is higher-powered than under unbundling. Formally, $\alpha^b = e_2^b > \alpha^u = e_2^u$. In the pure moral hazard model used so far, these higher-powered incentives are not the source of any rent for the operator whose ex ante participation constraint is always saturated. The fixed-fees are adapted in accordance. From the seminal work of Laffont and Tirole (1993), we nevertheless know that high-powered incentives may also give an excessive information rent to the operator in adverse selection contexts. Those rents create then the incentives of the operator to manipulate the decision-maker's decision so that he chooses more often integration than what is socially optimal. Rents constitute the stake of any capture of this decision-maker.

Of course, for this manipulation to be feasible and attractive for the decision-maker two further ingredients are needed. First, the decision-maker must be non-benevolent and attracted by the prospects of withdrawing private benefits from conceding some favors to the operator. Second, the decision-maker and the operator must share some piece of private information which is not available to the general public and that piece of information must be the source of information rent for the operator.

In our context, that piece of information from which the decision-maker gets discretion is the degree of externality between the two tasks. By hiding evidences on the fact that the externality between building and operating assets is negative and requires then unbundling, the decision-maker may let the operator enjoys some extra information rent. This of course has a social cost which must be taken into account at the time of evaluating whether integration is the most preferred organizational form from a social welfare point of view.

Remark. To make the political economy model described below more transparent, we depart from the ownership considerations discussed in Section 4 completely. Indeed, as argued above, ownership problems arise in an incomplete contracting environment but that incompleteness is not needed to understand the stake of the operator in manipulating the public decision on whether to bundle or not. What really matters is the link between the information rent of the operator and the organizational structure.

To extend the scope of our previous model in a political economy context, let us suppose that the level of the externality $\tilde{\delta}$ is a random variable taking values in $\{-\bar{\delta}, \bar{\delta}\}$ (where $\bar{\delta} > 0$) with respective probabilities ν and $1-\nu$. We assume that $\tilde{\delta}$ is a piece of information learned by both the decision-maker and the operator who may possibly collude to hide this information to the general public. Otherwise, the decision-maker observes no signal at all.

Let us also assume that the mean η_0 of the shock $\tilde{\eta}$ on operating costs is also a random variable taking values in $\{\underline{\eta}_0, \bar{\eta}_0\}$ with respective probabilities p and $1-p$ (with $\Delta\eta_0 = \bar{\eta}_0 - \underline{\eta}_0 > 0$). The operator with cost $\underline{\eta}_0$ can be viewed as the most "efficient" one since the distribution of his cost first-order stochastically dominates that of the $\bar{\eta}_0$-operator. That realization takes place after δ has been learned by the decision-maker and the operator. This is private information on η_0 which generates a rent for the operator.

6.1 Benevolent Decision-Maker

Let us first analyze the impact of asymmetric information on η_0 in the case where the decision-maker is benevolent and reveals truthfully any information he may have on δ to the general public so that the efficient organizational form is chosen.

In this environment, an incentive mechanism is a menu $\{\alpha(\hat{\eta}_0), \beta(\hat{\eta}_0), a(\hat{\eta}_0), b(\hat{\eta}_0)\}$ (resp. $\{\alpha(\hat{\eta}_0), a(\hat{\eta}_0), B(\hat{\eta}_0)\}$) under unbundling (resp. bundling) where $\hat{\eta}_0$ is the operator's report on η_0. According to the Revelation Principle,[35] there is no loss of generality in restricting the analysis to such truthful mechanisms. Given such a mechanism, the operator picks the contract corresponding to the realized shock η_0. Then, the operator and the builder choose their respective effort levels according to the organizational structure which prevails.

Unbundling. When the operator reports a realized shock $\hat{\eta}_0$, he chooses an effort $e_2 = \alpha(\hat{\eta}_0)$ whereas the builder chooses $e_1 = a(\hat{\eta}_0)$. The operator gets thereby a certainty equivalent of his expected utility which is worth:

$$\hat{U}_{\mathcal{O}}(\eta_0, \hat{\eta}_0) = \beta(\hat{\eta}_0) - \alpha(\hat{\eta}_0)(\eta_0 - \alpha(\hat{\eta}_0) + \delta a(\hat{\eta}_0)) - \frac{\alpha^2(\hat{\eta}_0)}{2} - \frac{r\sigma_\varepsilon^2 \alpha^2(\hat{\eta}_0)}{2}.$$

Denoting $\hat{U}_{\mathcal{O}}(\eta_0, \eta_0) = U_{\mathcal{O}}(\eta_0)$, the relevant adverse selection incentive constraint of a low-cost operator can be written as:

$$U_{\mathcal{O}}(\underline{\eta}_0) \geq U_{\mathcal{O}}(\bar{\eta}_0) + \alpha(\bar{\eta}_0)\Delta\eta_0, \tag{21}$$

whereas the participation constraint of a high cost operator is:

$$U_{\mathcal{O}}(\bar{\eta}_0) \geq 0. \tag{22}$$

Of course, these two constraints are binding at the social optimum so that $U_{\mathcal{O}}(\underline{\eta}_0) = \alpha(\bar{\eta}_0)\Delta\eta_0$ and $U_{\mathcal{O}}(\bar{\eta}_0) = 0$.[36] Finally, the socially optimal contract under unbundling when the realized externality is δ solves the reduced-form problem:

$$\max_{\alpha(\cdot), a(\cdot)} p[W^u(a(\underline{\eta}_0), \alpha(\underline{\eta}_0), \delta) - \alpha(\bar{\eta}_0)\Delta\eta_0] + (1-p)W^u(a(\bar{\eta}_0), \alpha(\bar{\eta}_0), \delta).$$

The optimization is straightforward. The effort level of an efficient operator is not distorted away from the case where η_0 is common knowledge. Only the power of the operator's incentive scheme if he claims being inefficient diminishes to reduce the adverse selection information rent of an efficient operator.

[35] See Green and Laffont (1977) and Myerson (1979).

[36] This is a standard result of two-type adverse selection models. See Laffont and Martimort (2002, Chapter 2) for instance.

We have indeed:

$$a^u(\underline{\eta}_0, \delta) = a^u(\bar{\eta}_0, \delta) = e_1^u, \tag{23}$$

$$\alpha^u(\underline{\eta}_0, \delta) = e_2^u > \alpha^u(\bar{\eta}_0, \delta) = \frac{1 - \frac{p}{1-p}\Delta\eta_0}{1 + r\sigma_\eta^2}. \tag{24}$$

We assume $1 > \frac{p}{1-p}\Delta\eta_0$ to maintain a positive effort by the operator even under adverse selection and we make also explicit the dependence of the solution on δ when needed.

Remark. Note that the incentive scheme offered to the builder serves no screening purpose and thus induces the same quality-enhancing effort as in Section 3.

Bundling. The merged entity $\mathcal{B} - \mathcal{O}$ chooses effort levels on both tasks which are respectively given by $e_2 = \alpha(\hat{\eta}_0)$ and $e_1 = a(\hat{\eta}_0) + \delta\alpha(\hat{\eta}_0)$ when he reports having a realized average costs $\hat{\eta}_0$.

The merged entity $\mathcal{B} - \mathcal{O}$ gets thus a certainty equivalent of his expected utility worth:

$$\begin{aligned} \hat{U}_{\mathcal{B}-\mathcal{O}}(\eta_0, \hat{\eta}_0) \quad = \quad & B(\hat{\eta}_0) - \alpha(\hat{\eta}_0)\left(\eta_0 - \alpha(\hat{\eta}_0) + \delta(a(\hat{\eta}_0) + \delta\alpha(\hat{\eta}_0))\right) \\ & + a(\hat{\eta}_0)(a(\hat{\eta}_0) + \delta\alpha(\hat{\eta}_0)) - \frac{\alpha^2(\hat{\eta}_0)}{2} - \frac{1}{2}(a(\hat{\eta}_0) + \delta\alpha(\hat{\eta}_0))^2 \\ & - \frac{r\sigma_\varepsilon^2}{2}(a(\hat{\eta}_0) + \delta\alpha(\hat{\eta}_0))^2 - \frac{r\sigma_\eta^2}{2}\alpha^2(\hat{\eta}_0). \end{aligned}$$

Denoting $U_{\mathcal{B}-\mathcal{O}}(\eta_0) = \hat{U}_{\mathcal{B}-\mathcal{O}}(\eta_0, \hat{\eta}_0)$, incentive compatibility and participation constraints become respectively

$$U_{\mathcal{B}-\mathcal{O}}(\underline{\eta}_0) \geq U_{\mathcal{B}-\mathcal{O}}(\bar{\eta}_0) + \alpha(\bar{\eta}_0)\Delta\eta_0, \tag{25}$$

and

$$U_{\mathcal{B}-\mathcal{O}}(\bar{\eta}_0) \geq 0. \tag{26}$$

Note that these constraints take expressions which are quite similar to the case of unbundling.

Both constraints are again binding at the social optimum so that

$$U_{\mathcal{B}-\mathcal{O}}(\underline{\eta}_0) = \alpha(\bar{\eta}_0)\Delta\eta_0 \quad \text{and} \quad U_{\mathcal{B}-\mathcal{O}}(\bar{\eta}_0) = 0.$$

Formally, the optimal contract under bundling solves now:

$$\max_{\{\alpha(\cdot), a(\cdot)\}} p[W^b(a(\underline{\eta}_0), \alpha(\underline{\eta}_0), \delta) - \alpha(\bar{\eta}_0)\Delta\eta_0] + (1-p)W^b(a(\bar{\eta}_0), \alpha(\bar{\eta}_0), \delta).$$

Again, only the bonus $\alpha(\bar{\eta}_0)$ is used to extract the costly information rent of the most efficient operator.

This leads to the solution:

$$a^b(\underline{\eta}_0,\delta) = e_1^b \gtrless a^b(\bar{\eta}_0,\delta) = \frac{(S-\delta)(1+r\sigma_\eta^2+\delta^2 r\sigma_\varepsilon^2) - \delta r\sigma_\varepsilon^2(1-\frac{p}{1-p}\Delta\eta_0)}{(1+r\sigma_1^2)(1+r\sigma_\varepsilon^2)+\delta^2 r\sigma_\varepsilon^2}, \quad (27)$$

$$\alpha^b(\underline{\eta}_0,\delta) = e_2^b > \alpha^b(\bar{\eta}_0,\delta) = \frac{(1+r\sigma_\varepsilon^2)\left(1-\frac{p}{1-p}\Delta\eta_0\right) - (S-\delta)\delta r\sigma_\varepsilon^2}{(1+r\sigma_\eta^2)(1+r\sigma_\varepsilon^2)+\delta^2 r\sigma_\varepsilon^2}, \quad (28)$$

where, again, we make explicit the dependence of the optimal bonuses on the realized value of the externality δ.

Gathering the results of the optimizations both with bundling and unbundling, we observe that the only role of adverse selection is to diminish the social benefit of inducing a cost-saving effort by the inefficient operator. Instead of being equal to 1 as before, this social benefit must be reduced to take into account the socially costly information rent left to the most efficient operator. The corresponding *virtual social benefit* becomes $1-\frac{p}{1-p}\Delta\eta_0$.

Interestingly, these distortions are independent of the sign of the externality between building and managing assets. Since the optimal organizational choice does not depend on the social benefits of both tasks but only on the sign of the realized externality δ which is made publicly available by the decision-maker at no cost for society when the latter is benevolent, we can immediately conclude by applying the results of Proposition 1.

Proposition 8. *Assume that the operator has private information on the average costs η_0 and that the decision-maker is benevolent. Then, the optimal organizational form is still bundling (resp. unbundling) for a positive (resp. negative) externality.*

Asymmetric information on η_0 *per se* is not enough to modify the basic insights of Section 3 as far as the framework involves a benevolent decision-maker.

6.2 Non-Benevolent Decision-Maker

Let us now assume that the decision-maker is non-benevolent and may be captured by the industry, most noticeably by the privately informed operator who withdraws some information rent from participating to the mechanism. That decision-maker is thus now viewed as a strategic player with his own incentives. In particular, he must be induced to reveal to the public the realized value of $\tilde{\delta}$.

Let us suppose that a negative externality $\bar{\delta}$ may be manipulated and publicly reported as being a positive one. Instead, the reverse manipulation is supposed not to be feasible.[37]

When the decision-maker hides the realized negative externality $\bar{\delta}$ to the general public and reports instead a positive externality $-\bar{\delta}$, the decision whether to separate the two tasks is unduly modified into a decision to bundle them. Through this modification, the operator increases then his expected information rent by an amount:

$$p\Delta\eta_0(\alpha^b(\bar{\eta}_0,-\bar{\delta}) - \alpha^u(\bar{\eta}_0,\bar{\delta})).$$

[37] The information structure is thus such that $\tilde{\delta}$ is partially verifiable in the sense of Green and Laffont (1986).

This stake of capture is in fact positive when evaluated at the optimal incentive schemes of Section 5.1 since it is proportional to the difference in the efforts made by an inefficient operator between the cases of bundling and unbundling, namely $e_2^b - e_2^u$, and that quantity is positive as one can see from Proposition 1.

We will assume that the non-benevolent decision-maker has all bargaining power in the collusive side-deal with the operator. Before the operator knows η_0, the decision-maker makes a take-it-or leave it offer, asking for a bribe equal to $p\Delta\eta_0(\alpha^b(\bar{\eta}_0, -\bar{\delta}) - \alpha^u(\bar{\eta}_0, \bar{\delta}))$ against a manipulation of the information he publicly releases on $\delta = \bar{\delta}$.

Following Tirole (1986) and Laffont and Tirole (1993), we will assume that the decision-maker enjoys an ex ante private benefit

$$k(1-\nu)p\Delta\eta_0(\alpha^b(\bar{\eta}_0, -\bar{\delta}) - \alpha^u(\bar{\eta}_0, \bar{\delta}))$$

for that manipulation.

The parameter $1-k$ represents the dead weight-loss of capture associated to the fact that side-deals are unofficial side-contracts which are enforced only by repetition, "words of honor", etc or which entail non-monetary transfers between the colluding partners. The parameter k is thus related to the institutional environment.

Note that the stake of capture is reduced by distorting downward $\alpha^b(\bar{\eta}_0, -\bar{\delta})$ and by increasing $\alpha^u(\bar{\eta}_0, \bar{\delta})$. Of course, this stake fully disappears if $\alpha^b(\bar{\eta}_0, -\bar{\delta})$ is less than $\alpha^u(\bar{\eta}_0, \bar{\delta})$.

Preventing capture of the decision-maker is socially costly. The agency cost

$$k(1-\nu)p\Delta\eta_0 \max\{0, \alpha^b(\bar{\eta}_0, -\bar{\delta}) - \alpha^u(\bar{\eta}_0, \bar{\delta})\}$$

must thus be subtracted from social welfare before evaluating the optimal incentive schemes.

Expected social welfare can thus be written as:

$$\begin{aligned}\nu\Big\{p\left(W^b(a^b(\underline{\eta}_0, -\bar{\delta}), \alpha^b(\underline{\eta}_0, -\bar{\delta}), -\bar{\delta}) - \alpha^b(\bar{\eta}_0, -\bar{\delta})\Delta\eta_0\right) + (1-p)W^b(a^b(\bar{\eta}_0, -\bar{\delta}), \alpha^b(\bar{\eta}_0, -\bar{\delta}), -\bar{\delta})\Big\} \\ +(1-\nu)\Big\{p\left(W^u(a^u(\underline{\eta}_0, \bar{\delta}), \alpha^u(\underline{\eta}_0, \bar{\delta}), \bar{\delta}) - \alpha^u(\bar{\eta}_0, \bar{\delta})\Delta\eta_0\right) + (1-p)W^u(a^u(\bar{\eta}_0, \bar{\delta}), \alpha^u(\bar{\eta}_0, \bar{\delta}), \bar{\delta})\Big\} \\ -k(1-\nu)p\Delta\eta_0 \max\{0, \alpha^b(\bar{\eta}_0, -\bar{\delta}) - \alpha^u(\bar{\eta}_0, \bar{\delta})\}. \qquad (29)\end{aligned}$$

Note that, in writing this expression of expected social welfare, we have taken into account that the efficient decision rule on whether to bundle or not tasks is taken. Of course, another way of avoiding capture would be to change the decision rule, deciding for instance to always either unbundle or bundle the tasks irrespectively of the level of the externality. Next proposition summarizes some features of the optimization.

Proposition 9. *Under the threat of capture:*

- *It is never optimal to bundle tasks when the externality is negative;*
- $\alpha^b(\bar{\eta}_0, -\bar{\delta})$ *(resp.* $\alpha^u(\bar{\eta}_0, \bar{\delta})$*) is reduced (resp. increased) under the threat of capture. There exists* $\bar{\delta}_0 > 0$ *such that for* $\bar{\delta} < \bar{\delta}_0$*, capture is not a concern.*

The possibility to manipulate the information about the externality confers some discretionary power to the decision-maker: when the externality is negative, he might instead reveal to the public that it is positive thereby leading to bundling rather than unbundling of the building and operating stages; this in turn might favor an efficient operator and, more generally. The rents thereby generated are the stakes of capture of the decision-maker. The previous proposition shows that the possibility of capture does not change the decision to bundle or not the different tasks. However, it does change the provision of incentives to the builder: under bundling (respectively, unbundling) a builder is less (respectively, more) incentivized in order to make the concealment of the externality less attractive: the collusive stake might even be null at equilibrium, leading to no equilibrium incentive compensation to the decision-maker.

7 Conclusion

The presence of an externality between the building of an infrastructure and the provision of services using that infrastructure naturally raises the question of the optimal organization of these tasks. Bundling of the builder and the operator allows to internalize the externality, thereby leading to a higher welfare when the externality is positive. By contrast, when the externality is negative, keeping the tasks separated is socially preferable. Hence, a simple technology-driven reason is at the heart of the decision to bundle or unbundle the various activities.

In an incomplete contract framework in which contracts cannot be conditional to the quality of the infrastructure, we have studied the role of ownership allocation. In a nutshell, providing the builder with the ownership of the infrastructure allows to improve the builder's incentives to enhance the infrastructure quality. If ownership does not confer the builder with a sufficiently strong incentive to improve the infrastructure quality, then bundling might be used. Depending on the private benefits for to builder to own the infrastructure and the risks associated to the different activities, the private-public partnership -bundling and builder ownership- might perform better than the more traditional form of public procurement - unbundling with government ownership. Further work is required to refine these results and to understand how competition -for the building stage, the operation stage or both- affects the decision to bundle or unbundle the activities.

Appendix

A.1 Proof of Proposition 1

Simple manipulations show that:

$$
\begin{aligned}
e_1^b - e_1^u &\propto \delta[-1 - r(1+\delta^2 - \delta S)\sigma_\varepsilon^2],\\
e_2^b - e_2^u &\propto -\delta[S + r(S-\delta)\sigma_\eta^2].
\end{aligned}
$$

The proposition follows.

A.2 Proof of Proposition 2

Immediate.

A.3 Proof of Proposition 3

Immediate.

A.4 Proof of Proposition 4

Simple manipulations show that:

$$
\begin{aligned}
W_B^u(e_2,\delta) &= (S-\delta)P - \frac{1}{2}P^2(1+r\sigma_\varepsilon^2) + [e_2 - \frac{e_2^2}{2}(1+r\sigma_\eta^2)],\\
W_B^b(e_2,\delta) &= (S-\delta)(P-\delta e_2) - \frac{1}{2}(P-\delta e_2)^2(1+r\sigma_\varepsilon^2) + [e_2 - \frac{e_2^2}{2}(1+r\sigma_\eta^2)]\\
&= W_B^u(e_2,\delta) - \delta e_2[S-\delta-(P-\delta\frac{e_2}{2})(1+r\sigma_\varepsilon^2)]. \qquad \text{(A1)}
\end{aligned}
$$

Notice also that:

$$
\frac{\partial W_B^b}{\partial e_2}(e_2,\delta) = \frac{\partial W_B^u}{\partial e_2}(e_2,\delta) - \delta\left[S-\delta-(P-\delta e_2)(1+r\sigma_\varepsilon^2)\right]. \qquad \text{(A2)}
$$

Hence, we have:

$$
\frac{\partial W_B^b(e_2^u,\delta)}{\partial e_2} = -\delta\left[S-\delta-(P-\delta e_2^u)(1+r\sigma_\varepsilon^2)\right]. \qquad \text{(A3)}
$$

When $P \leq \frac{S-\delta}{1+r\sigma_\varepsilon^2} + \delta e_2^u$, and $\delta < 0$, the r.h.s. of (A3) is positive. Thus, since $W_B^b(\cdot)$ is concave in e_2, we have:

$$
\begin{aligned}
\max_{e_2\in\mathbb{R}_+} W_B^b(e_2,\delta) &= W_B^b(e_{2B}^b,\delta),\\
&> W_B^b(e_2^u,\delta) = W_B^u(e_2^u,\delta) - \delta e_2^u[S-\delta-(P-\delta\frac{e_2^u}{2})(1+r\sigma_\varepsilon^2)],\\
&\geq \max_{e_2\in\mathbb{R}_+} W_B^u(e_2), \qquad \text{(A4)}
\end{aligned}
$$

since when $\delta < 0$ and $P \leq \frac{S-\delta}{1+r\sigma_\varepsilon^2} + \delta e_2^u$, then $S-\delta-(P-\delta\frac{e_2^u}{2})(1+r\sigma_\varepsilon^2) > 0$.

Using (A2), we have also:

$$
\frac{\partial W_B^u(e_{2B}^b,\delta)}{\partial e_2} = \delta[S-\delta-(P-\delta e_{2B}^b)(1+r\sigma_\varepsilon^2)],
$$

where

$$e_{2B}^b = \arg\max_{e_2 \in \mathbb{R}_+} W_B^b(e_2, \delta) = \frac{-\delta(S-\delta) + \delta P(1 + r\sigma_\varepsilon^2) + 1}{1 + r\sigma_\eta^2 - \delta^2(1 + r\sigma_\varepsilon^2)}.$$

Therefore:

$$\begin{aligned}\max_{e_2 \in \mathbb{R}_+} W_B^u(e_2, \delta) = W_B^u(e_2^u, \delta), & \\ & > W_B^u(e_{2B}^b, \delta) = W_B^b(e_{2B}^b, \delta) - \delta e_{2B}^b [S - \delta - (P - \delta \frac{e_{2B}^b}{2})(1 + r\sigma_\varepsilon^2)], \\ & > W_B^b(e_{2B}^b, \delta) = \max_{e_2 \in \mathbb{R}_+} W_B^b(e_2, \delta)\end{aligned}$$

provided that $S - \delta - (P - \delta \frac{e_{2B}^b}{2})(1 + r\sigma_\varepsilon^2) \leq 0$ or $P \geq \frac{S-\delta}{1+r\sigma_\varepsilon^2} + \delta \frac{e_{2B}^b}{2}$.

A.5 Proof of Proposition 5

We observe that

$$W_B^b(e_2, \delta) = W_G^b(e_2, \delta) + (S - \delta)P + P\delta e_2(1 + r\sigma_\varepsilon^2) - \frac{P^2}{2}(1 + r\sigma_\varepsilon^2) - \frac{\delta^2 e_2^2}{2} r\sigma_\varepsilon^2.$$

Let denote $e_{2G}^b = \arg\max_{e_2 \in \mathbb{R}_+} W_G^b(e_2, b)$. We have for σ_ε close to zero:

$$W_B^b(e_{2G}^b, \delta) = W_G^b(e_{2G}^b, \delta) + P\left[S - \delta + \delta e_{2G}^b - \frac{P}{2}\right].$$

Then, when $P < 2[S - \delta + \delta e_{2G}^b]$, bundling and buyer ownership dominates.

A.6 Proof of Proposition 6

Immediate.

A.7 Proof of Proposition 8

Immediate.

A.8 Proof of Proposition 7

Under unbundling, the problem of the principal is:

$$\max_{\alpha,,\beta,a,a',b,(e_1,e_2) \in \mathbb{R}_+^2} (S - \delta - a)e_1 + e_2 + (\alpha - a')(\eta_0 - e_2 + \delta e_1) - b - \beta,$$

subject to the constraints (4), (5), (17) and (18).

Solving for the first-order conditions associated to the three free parameters e_1, e_2 and a', the optimal effort levels under unbundling are given by:

$$e_1^u = \frac{(S-\delta)(\delta^2\sigma_\varepsilon^2 + \sigma_\eta^2)}{\sigma_\eta^2 + \sigma_\varepsilon^2(\delta^2 + r\sigma_\eta^2)},\ e_2^u = \frac{1}{1 + r\sigma_\eta^2}.$$

The optimal marginal transfers are equal to:

$$\alpha = e_2^u,\ a' = \frac{\delta(S-\delta)\sigma_\varepsilon^2}{\sigma_\eta^2 + \sigma_\varepsilon^2(\delta^2 + r\sigma_\eta^2)},\ a = e_1^u - a'\delta.$$

We also have: $\frac{\partial^2 W}{\partial e_1^2} = -(1+r\sigma_\varepsilon^2)$, $\frac{\partial^2 W}{\partial e_2^2} = -(1+r\sigma_\eta^2)$, $\frac{\partial^2 W}{\partial a'^2} = -r(\delta^2\sigma_\varepsilon^2 + \sigma_\eta^2)$, $\frac{\partial^2 W}{\partial e_1 \partial e_2} = 0$, $\frac{\partial^2 W}{\partial e_2 \partial a'} = 0$, $\frac{\partial^2 W}{\partial e_1 \partial a'} = \delta r \sigma_\varepsilon^2$. One can then check that the Hessian associated to the maximization problem is negative semi-definite at equilibrium.

Finally, tedious but straightforward computations show that:

$$\lim_{\delta \to 0} W^b(e_1^b, e_2^b) - W^u(e_1^u, e_2^u, a') = 0,$$

$$\lim_{\delta \to 0} \frac{d}{d\delta}[W^b(e_1^b, e_2^b) - W^u(e_1^u, e_2^u, a')] = -\frac{rS\sigma_\varepsilon^2}{(1+r\sigma_\varepsilon^2)(1+r\sigma_\eta^2)} < 0.$$

A.9 Proof of Proposition 9

Note first that one may always choose $\alpha^b(\bar{\eta}_0, -\bar{\delta}) = \alpha^u(\bar{\eta}_0, \bar{\delta})$ so that collusion is costless and nevertheless still benefits from a positive externality under bundling in state $-\bar{\delta}$. Hence, bundling when $\delta = -\bar{\delta}$ is always optimal.

Let us now consider the case where the optimal bonus $\tilde{\alpha}^b(\bar{\eta}_0, -\bar{\delta})$ and $\tilde{\alpha}^u(\bar{\eta}_0, \bar{\delta})$ in front of capture are such that $\tilde{\alpha}^b(\bar{\eta}_0, -\bar{\delta}) > \tilde{\alpha}^u(\bar{\eta}, \bar{\delta})$ so that there is a positive stake of capture.

Optimizing yields:

$$\tilde{\alpha}^b(\bar{\eta}_0, -\bar{\delta}) = \frac{(1+r\sigma_\varepsilon^2)\left(1 - \frac{p}{1-p}\Delta\eta_0\left(1 + k\left(\frac{1-\nu}{\nu}\right)\right)\right) + (S+\bar{\delta})\bar{\delta}r\sigma_\varepsilon^2}{(1+r\sigma_\eta^2)(1+r\sigma_\varepsilon^2) + \bar{\delta}^2 r\sigma_\varepsilon^2} < \alpha^b(\bar{\eta}_0, -\bar{\delta}),$$

and

$$\tilde{\alpha}^u(\bar{\eta}_0, \bar{\delta}) = \frac{1 - \frac{p}{1-p}\Delta\eta_0(1-k)}{1+r\sigma_\eta^2} > \alpha^u(\bar{\eta}_0, \bar{\delta}). \tag{A5}$$

Of course, capture is a concern as long as $\tilde{\alpha}^b(\bar{\eta}_0, -\bar{\delta}) > \tilde{\alpha}^u(\bar{\eta}_0, \bar{\delta})$, i.e., there is a positive stake of capture. Let us suppose that

$$1 > \frac{p}{1-p}\Delta\eta_0\left(1 + \frac{k(1-\nu)}{\nu}\right)$$

so that $\tilde{\alpha}^b(\bar{\eta}_0, -\bar{\delta})$ for sure is a positive number. Then, note that as $\bar{\delta}$ is small enough

$$\tilde{\alpha}^b(\bar{\eta}_0, -\bar{\delta}) \underset{\bar{\delta}\to 0}{\sim} \frac{1 - \frac{p}{1-p}\Delta\eta_0\left(1 + \frac{k(1-\nu)}{\nu}\right)}{1+r\sigma_\eta^2} < \tilde{\alpha}^u(\bar{\eta}_0, \bar{\delta}), \tag{A6}$$

and thus for $\bar{\delta}$ small enough the stake of capture disappears.

References

Athey, S. and J. Roberts, (2001), "Organizational Design: Decision Rights and Incentive Contracts", *American Economic Review*, Papers and Proceedings, 91: 200-205.

Baron, D. and D. Besanko, (1992), "Information, Control and Organizational Structure", *Journal of Economics and Management Strategy*, 1: 237-275.

Baron, D. and D. Besanko, (1999), "Informational Alliance", *Review of Economic Studies*, 66: 743-768.

Bennet, J. and E. Iossa, (2002), "Building and Managing Facilities for Public Services", Mimeo Brunel University.

Berger, R., (1985), "Private Sector Initiatives in the Reagan Era: New Actors Rework on Old Theme?", in *The Reagan Presidency and the Governing of*

America, 181-211, L. Salomon and M. Lund (eds.), The Urban Institute Press, Washington D.S.

Dana, J., (1993), "The Organization and Scope of Agents: Regulating Multiproduct Industries", *Journal of Economic Theory*, 59: 288-310.

Daniels, R. and M. Trebilcock, (2002), "An Organizational Analysis of the Public-Private Partnership in the Provision of Public Infrastructure", in *Public-Private Policy Partnerships*, P. Vaillancourt Rosenau (ed.) MIT Press, Cambridge.

Dewatripont, M. and J. Tirole, (1999), "Advocates", *Journal of Political Economy*, 107: 1-39.

Gilbert, R. and M. Riordan, (1995), "Regulating Complementary Products : A Comparative Institutional Analysis", *Rand Journal of Economics*, 26: 243-256.

Green, J. and J.J. Laffont, (1977), "On the Revelation of Preferences for Public Goods", *Journal of Public Economics*, 8: 79-93.

Green, J. and J.J. Laffont, (1986), "Partially verifiable information and mechanism design", *Review of Economic Studies*, 53: 447-456.

Gromb, D. and D. Martimort, (2004), "The Organization of Delegated Expertise", mimeo IDEI.

Grossman, S. and O. Hart, (1983), "An Analysis of the Principal-Agent Problem", *Econometrica*, 51: 7-45.

Grossman, S. and O. Hart, (1986), "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration", *Journal of Political Economy*, 94: 691-719.

Hart, O., (2003), "Incomplete Contracts and Public Ownership: Remarks and an Application to Public-Private Partnership", *Economic Journal*, 113: 69-76.

Hart, O., A. Shleifer and R. Vishny, (1997), "The Proper Scope of Government: Theory and Applications to Prisons", *Quarterly Journal of Economics*, 112: 1119-1158.

Holmström, B., (1979), "Moral Hazard and Observability", *The Bell Journal of Economics*, 10: 74-91.

Holmström, B., (1982), "Moral Hazard in Teams", *Bell Journal of Economics*, 13: 324-340.

Holmström, B. and P. Milgrom, (1987), "Aggregation and Linearity in the Provision of Intertemporal Incentives", *Econometrica*, 55: 303-328.

Holmström, B. and P. Milgrom, (1991), "Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership and Job Design", *Journal of Law, Economics and Organization*, 7: 24-52.

Holmström, B. and P. Milgrom, (1994), "The Firm as an Incentive System", *American Economic Review*, 84: 972-991.

Laffont, J.J. and D. Martimort, (1998), "Collusion and Delegation", *Rand Journal of Economics*, 29: 280-305.

Laffont, J.J. and D. Martimort, (2002), *The Theory of Incentives: The Principal-Agent Model*, Princeton University Press.

Laffont, J.J. and J. Tirole, (1993), *A Theory of Incentives in Regulation and Procurement*, MIT Press, Cambridge.

Mookherjee, D. and M. Tsumagari, (2004), "The Organization of Supplier Networks: Effects of Delegation and Intermediation", *Econometrica*, 72: 1179-1219.

Myerson, R., (1979), “Incentive Compatibility and the Bargaining Problem”, *Econometrica*, 47: 71-73.

Severinov, S., (1999), “Optimal Organization: Centralization, Decentralization or Delegation”, mimeo University of Wisconsin.

Shavell, S., (1979), “On Moral Hazard and Insurance,” *Quarterly Journal of Economics*, 93: 541-562.

Tirole, J., (1986), “Hierarchies and Bureaucracies: on the Role of Collusion in Organizations”, *Journal of Law, Economics and Organization*, 2: 181-214.