"BUILD IT OR NOT": NORMATIVE AND POSITIVE THEORIES OF PUBLIC-PRIVATE PARTNERSHIPS

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ABSTRACT

This paper analyzes whether the two tasks of building infrastructures which are socially useful and managing those assets should be bundled or not. When performances contracts can be written, both tasks should be performed altogether by the same firm when a better design of the infrastructure helps also to save on operating costs. Otherwise, tasks should be kept split apart and undertaken by different units. In incomplete contracting environments, we isolate conditions under which either the traditional form of public provision of services or the more fashionable public-private partnership optimally emerges. The latter dominates when there is a positive externality but the private benefits from owning assets are small enough. Finally, we take a political economy perspective and study how incentive schemes are modified under the threat of capture of the decision-makers.

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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 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 array of tasks. Those activities necessitate indeed, first, to build some infrastructures and second to manage those assets as efficiently as possible. Delegation to the private sector takes thus place *de facto* in a *multi-task environment*.[2]

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

More recently, several initiatives around the world[3] and various legal reforms[4] have proposed an alternative form of procurement, the so-called *Public-Private 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 infrastructure, building those assets and finally managing them as efficiently as possible.

Compared with the more traditional form of procurement, the PPP alternative is thus characterized by two important features. First, the two tasks of building and managing assets are now bundled. 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 delegation of tasks to the private sector also comes with some agency problem.[5] To make the analysis interesting, we will thus envision the case where those efforts are non-verifiable and delegation comes with moral hazard. We ask then whether agency costs exhibit *economies of scope or not* when tasks are bundled. This analysis shows that ownership and its impact on incentives is *not* key to understand the optimal form of procurement. Instead, what is crucial to understand why the two tasks of building and managing should be bundled 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, not on ownership. This result is quite robust to the space of compensation schemes that can be used by the government and to the exact organizational form taken by the merger of two firms when tasks are bundled.

Two cases are a priori feasible and are documented by practitioners. First, a better design of the infrastructure may help to save on operating costs, the case of a positive externality.[6] 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.[7] In the first case, both 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 merged into a single entity. The optimal organizational form exhibits thus an important feature found in public-private partnerships. For a negative externality, the two tasks should be split because solving the agency problem on one task exacerbates the incentive problem on the other. This is reminiscent of the tasks separation occurring under standard procurement.

That argument behind the optimal organizational form is thus unrelated to the ownership issue. In practice, performance contracts are not always feasible and ownership matters. For instance, 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 to write. Ownership provides then incentives to improve quality. The allocation of ownership allocation can thus be viewed as a specific form of contracts with imperfect incentives alignment[8] and imperfect insurance properties.

When incentives for building can only be provided by allocating ownership, the decision whether to bundle or not the two tasks may help to improve the 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 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 influence costs. In fact, as a decision-maker may find either bundling or unbundling both optimal depending on the kind of externality between tasks, he may exert his discretion to favor the industry by this organizational choice. To analyze those issues, we must significantly extend our model. First, the decision-maker must have private information on the sign 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 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 brief review of the literature. Two papers address issues close to ours: Bennett 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-reducing 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 ex post efficient, this negotiation generates payoffs which depend on the threat points defined by the ownership structure.[12] By a reasoning close to the one we will make in our more complete contracting environment, a positive externality somewhat weakens 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] one may be more skeptical on the use of this paradigm when it comes to analyzing 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 might have been overemphasized so far. More basic agency problems may actually explain much of the organizational forms which emerge, even though the distortions due to ownership allocations can be superimposed. Second, because the property rights approach de-emphasizes informational issues, it cannot endogenize the stake for capture and address the political economy issues which are crucial to get any positive theory of public-private partnerships. This is where lies a second important insight available within our framework.

This paper belongs also to a broader theoretical literature which investigates task assignments in organizations in presence of agency problems. In pure moral hazard environments, Holmström and Milgrom (1991) showed that incentives on one task may destroy incentives on another when tasks are substitutes in the agent's cost function; a result which suggests that tasks should be split when there is a negative production externality.[14] Although the result that complementary tasks should be bundled altogether can also be found in Holmström and Milgrom (1990), Macho-Stadler and Perez-Castrillo (1993), Itoh (1994) and Ramakrishnan and Thakor (1991) under various forms, the specific context of public-private partnerships and most specifically the sequentiality of tasks imposes some specific assumptions on contracts under unbundling and a more thorough discussion of what is cooperation between separated entities than what the existing literature provides.[15] In particular, we will distinguish below between the case where the two tasks are bundled altogether and performed by the same agent, keeping his risk tolerance as given, and the case of a consortium where the two tasks are jointly performed. The first of these organizational choices focuses on the incentive effect of bundling tasks whereas the second one introduces risk-sharing benefits which are well-known from the literature.[16] From a methodological perspective, when considering the bundling of tasks, our analysis allows to clearly disentangle the impact on incentives from the benefit associated to improved risk-sharing. Schmitz (2005) investigates a sequential moral hazard model with limited liability as the source of the agency problem, no production externality but with the added twist that the outcome of the first project affects the cost of incentives on the second one. Finally, in pure adverse selection frameworks, Baron and Besanko (1992, 1999), Dana (1993), Gilbert and Riordan (1995), Laffont and Martimort (1998), Mc Afee and Mc Millan (1995), Mookherjee and Tsumagari (2004) and Dequiedt and Martimort (2004) have also discussed whether bundling tasks and having a single agent privately informed on cost parameters related to each task dominates unbundling when tasks are perfect complements.

The paper is organized as follows. Section 2 presents the model. Section 3 addresses the respective optimality of bundling and unbundling tasks when both the builder and the operator receive a compensation scheme which depends only on their own performance. This means that, although the operator's cost may reveal later on some information on the builder's effort, costs are not used to compensate the builder. Under bundling the two tasks are undertaken by a unique firm, the merger of the builder and the operator. Section 4 generalizes our findings to the case where the cost realizations can also be used to compensate the builder and delayed payments are feasible. Section 5 enters in more details into the process of merger formation. Within a consortium, two otherwise identical risk-averse firms perfectly coordinate their decisions and share risk. Again bundling is optimal for a positive externality but may also be so for a negative one. Section 6 tackles the ownership issue and isolates conditions under which either the more traditional form of procurement or the more novel form of public-private partnerships dominates. Section 7 discusses the political economy of the model. Section 8 briefly concludes by presenting alleys for further research. Proofs are relegated to an Appendix.

2 THE MODEL

We want to understand when the two tasks of building an infrastructure and managing those assets should be bundled and performed by the same firm.[17]

Let us denote by $\mathcal{B}$ (resp. $\mathcal{O}$) the builder of this infrastructure (resp. the operator). 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[18] and have CARA utility function with risk-aversion r. A merger $\mathcal{B} - \mathcal{O}$ is also assumed to have the same degree of risk aversion. A merger corresponds thus to the case where both tasks are a priori allocated to one of the two existing firms.[19,20]

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 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.[21] Contracts with the builder cannot stipulate the effort e_1.

The government (sometimes also called the principal) withdraws a benefit $S \times q$ (where $S > 0$) from building an infrastructure with realized quality q.[22] It has all bargaining power in designing the agents' compensation schemes.

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:

$$\tilde{c} = \tilde{\eta} - e_2 - \delta e_1, \qquad (1)$$

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 for the operator.

Exerting effort e_i costs $\psi(e_i) = \frac{e_i^2}{2}$ to the concerned agent.[23] 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 have the same reservation payoff exogenously normalized at zero.

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,* $\delta > 0$: Building an infrastructure of higher quality reduces operating costs. This happens when, for instance, those infrastructures make operating tasks easier.[24]

- *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.[25]

The sign of this externality plays actually a major role in comparing organizational structures as we will see below.

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 efforts 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 costs of effort.

This first-best pair $\{e_1^*, e_2^*\}$ maximizes the government's expected social welfare, namely:

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

one immediately finds:

$$e_1^* = S + \delta \text{ and } e_2^* = 1.$$

We shall 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.

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

3 ORGANIZATIONAL FORMS WITH RESTRICTED SCHEMES

We follow Holmström and Milgrom (1987) in motivating the use of linear schemes in this environment.[26] The compensation of an agent depends thus linearly of the contracting observable variables.

Unbundling. Under *unbundling*, $\mathcal{B}$ and $\mathcal{O}$ are respectively given contracts of the form:

$$t(q) = b + aq \text{ and } z(c) = \beta - \alpha c.$$

The parameters b and β are fixed-fee payments whereas a and α are piece-rates. Note that each agent's reward is linked only to the realization of the performance related to his own task. In other words, more general contracts of the form $t(q, c) = b + aq + a'c$ for the builder and $z(q, c) = \beta - \alpha c + \alpha' q$ for the operator are for the time being ruled out.

To motivate these restrictions, first note that there is no value in making the compensation of the operator depends on the observable quality of the infrastructure. Doing so (i.e., $\alpha' \neq 0$) would only increase the risk borne by the risk-averse operator without any positive incentive effect on his effort supply. Second, the builder's payment takes place before costs realize so that such a general scheme $t(q, c)$ may not be feasible when payments cannot be delayed.[27] We will thus focus in this section on the case where $a' = 0$. The more complex contracting environments where delayed payments are available are analyzed in Section 4 below.

Given the above incentive scheme, 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 his incentive scheme:

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

whereas, under pure moral hazard, the fixed-fee b chosen by the government extracts all the builder's expected rent:

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

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 which extracts all the operator's expected profit is thus given by:

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

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 unbundling, the government wants to optimize expected social welfare defined as:

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

subject to constraints (2) to (5).

Rewriting this problem with efforts as the only variables, we get the following expression of social welfare optimization under unbundling:

$$(P^u): \max_{(e_1,e_2)\in\mathbb{R}_+^2} W^u(e_1,e_2,\delta) \equiv (S+\delta)e_1 + e_2 - \frac{e_1^2}{2}(1+r\sigma_\varepsilon^2) - \frac{e_2^2}{2}(1+r\sigma_\eta^2). \tag{6}$$

The optimal efforts $\{e_1^u, e_2^u\}$ are thus given by:[28]

$$e_1^u = \frac{S+\delta}{1+r\sigma_\varepsilon^2} < e_1^*, \text{ and } e_2^u = \frac{1}{1+r\sigma_\eta^2} < e_2^*. \tag{7}$$

Because of moral hazard, efforts are now below the first-best levels. 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 purposes.[29]

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

Bundling. The merger $\mathcal{B}-\mathcal{O}$ receives now a linear scheme which depends on both performances:

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

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 intertemporal transfer matters.[30]

The merged entity $\mathcal{B}-\mathcal{O}$ can 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:

$$a - \alpha\delta = e_1, \quad (8)$$

$$\alpha = e_2. \quad (9)$$

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-reducing 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.

The fixed-fee B is then used by the principal to extract $\mathcal{B}-\mathcal{O}$'s expected rent so that, under bundling, the government'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:[31]

$$e_1^b = \frac{(S+\delta)(1+r\sigma_\eta^2+\delta^2 r\sigma_\varepsilon^2)+\delta r\sigma_\varepsilon^2}{(1+r\sigma_\eta^2)(1+r\sigma_\varepsilon^2)+\delta^2 r\sigma_\varepsilon^2} \text{ and } e_2^b = \frac{1+r\sigma_\varepsilon^2+(S+\delta)\delta r\sigma_\varepsilon^2}{(1+r\sigma_\eta^2)(1+r\sigma_\varepsilon^2)+\delta^2 r\sigma_\varepsilon^2}. \tag{11}$$

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 $\delta < 0$ but small compared with S (the 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 comes out directly from the previous analysis.[32]

Proposition 1. *Assume that efforts are non-verifiable. Bundling is the optimal organizational structure if and only if $\delta > 0$ (positive externality). Efforts 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 providing incentives and providing insurance to the builder calls for moving towards lower powered incentives and reducing this quality-enhancing effort.[33]

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. A reverse argument applies when the externality is positive.

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

4 GENERAL SCHEMES

To test the robustness of our results, we now assume that more complex contracts can be implemented under unbundling. Under that organizational structure, the contract offered to any given agent is still linear but can now also depend on the other agent's realized action.

This possibility allows of course to achieve a weakly higher welfare under unbundling since the space of contracts is enlarged. Hence, under a negative externality, unbundling still dominates bundling. We thus only need to compare these organizational choices assuming instead a positive externality ($\delta > 0$).

Payments to the builder and the operator can now be written respectively as:

$$t(q,c) = b + aq + a'c \text{ and } z(q,c) = \beta - \alpha c + \alpha' q.$$

Since the externality is one-sided in our context, making the operator's payment dependent on the realized quality is useless for the government. Doing so would merely increase the risk faced by the operator thereby leading to increase the risk-premium needed to ensure his participation without any incentives benefits. In the following, $\alpha' = 0$ is thus optimal.

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

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

The builder's marginal incentives to enhance the infrastructure quality are now given by:

$$a = e_1 + a'\delta. \tag{12}$$

As is usual by now, the principal sets the fixed-fee so as to extract all the builder's expected rent, i.e.:

$$b = \frac{r}{2}[\sigma_\varepsilon^2(e_1 + a'\delta)^2 + \sigma_\eta^2 a'^2] - e_1\left(\frac{e_1}{2} + a'\delta\right) + a'\delta(\eta_0 - e_2 - \delta e_1). \quad (13)$$

Expected welfare under unbundling can thus be written as follows:

$$\max_{\{a',(e_1,e_2)\in\mathbb{R}_+^2\}} W^u(e_1, e_2, a', \delta) = (S + \delta)e_1 + e_2 - \frac{e_1^2}{2} - \frac{e_2^2}{2} - \frac{r\sigma_\eta^2}{2}e_2^2 - \frac{r}{2}\left[(e_1 + \delta a')^2\sigma_\varepsilon^2 + a'^2\sigma_\eta^2\right]. \quad (14)$$

To better understand the comparison between organizational forms, it may be useful to optimize first over the piece-rate parameter a' and, from there, get an indirect welfare function $\tilde{W}^u(e_1, e_2)$ which depends only on the effort variables (e_1, e_2). Doing so yields:

$$a' = -\frac{\delta e_1 \sigma_\varepsilon^2}{\sigma_\eta^2 + \delta^2\sigma_\varepsilon^2} < 0.$$

As expected, the builder's payment decreases when costs are higher since such cost realizations provide information on the fact that the builder's effort may have been too low.

Using the indirect welfare function $\tilde{W}^u(e_1, e_2, \delta)$, the principal's maximization problem can be written as:

$$\max_{(e_1,e_2)\in\mathbb{R}_+^2} \tilde{W}^u(e_1, e_2, \delta) = (S+\delta)e_1+e_2-\frac{e_1^2}{2}-\frac{e_2^2}{2}-\frac{r\sigma_\eta^2}{2}e_2^2-\frac{r\sigma_\varepsilon^2\sigma_\eta^2}{2(\sigma_\eta^2 + \delta^2\sigma_\varepsilon^2)}e_1^2. \quad (15)$$

This expression shows how cost observations can be used to diminish the risk-premium that must be paid to the builder to induce his participation. Indeed, the right-hand side of (15) differs from the expression obtained with restricted contracts in Section 3 only because the risk-premium $\frac{r\sigma_\varepsilon^2\sigma_\eta^2}{2(\sigma_\eta^2+\delta^2\sigma_\varepsilon^2)}e_1^2$ that must now be paid to ensure the builder's participation is lower than the risk-premium $\frac{r\sigma_\varepsilon^2}{2}e_1^2$ paid in the case of restricted contracts. The fact that $\frac{\sigma_\eta^2}{\sigma_\eta^2+\delta^2\sigma_\varepsilon^2} < 1$ captures therefore the informativeness gain from using cost observations to improve the builder's incentives.[34]

Importantly, this informativeness gain is *second-order* in the size of the externality δ. Hence, cost observation does not bring much in the limit of a weak positive externality.

Let us now turn on to the case of bundling. Remind that expected welfare under bundling is instead given by:

$$\max_{(e_1,e_2)\in\mathbb{R}_+^2} W^b(e_1,e_2,\delta) = (S+\delta)e_1+e_2-\frac{e_1^2}{2}-\frac{e_2^2}{2}-\frac{r\sigma_\eta^2}{2}e_2^2-\frac{r}{2}(e_1-\delta e_2)^2\sigma_\varepsilon^2. \tag{16}$$

The comparison between (15) and (16) is straightforward, at least in the limit of a small positive externality. The gain from bundling is of a first-order magnitude in δ since now a merged entity can better internalize the choice of quality-enhancing and cost-reducing efforts.

Although the use of a larger class of contracts improves unbundling, it is not enough to reverse our previous findings.

Proposition 2. *Assume that efforts are non-verifiable and that under unbundling the builder's payment can be made contingent on the operator's cost. Then, there exists $\delta_0 > 0$ such that for all $\delta \in [0, \delta_0]$, bundling is still preferred to unbundling.*

Proposition 2 offers thus a strong robustness check of our previous findings of Section 3. In practice, this result shows that the gains from unbundling with a negative externality can already be achieved with restricted schemes. Delayed payments to the builder do not bring much to the government.

5 CONSORTIUM

So far our modelling of a merger $\mathcal{B}-\mathcal{O}$ of the two firms has been rather crude. By assuming that both tasks were performed by a single agent, either the builder or the operator, we have alluded the question on how such a coalition between two entities might be formed in practice. In this section, we precisely investigate this issue.

When considering a detailed analysis of the formation of a consortium between the two otherwise identical risk-averse agents, two problems should be kept in mind. First, by merging, those two agents may be better able to share risk. A coalition improves risk-sharing compared with the case of a single firm.[35] Second, by merging, those two agents may be more or less able to observe each other's effort. The benefits of a coordinated choice of efforts might be somewhat dissipated by the internal agency problem that such a consortium may have to solve. To model a consortium of two otherwise identical risk-averse firms, we will put aside this internal agency problem (efforts are mutually observable and coordination is perfect) and focus on the risk-sharing issue.[36] To model this in a crude way, we assume that the two firms form a joint-venture denoted by $\mathcal{JV}$ which is supposed to be infinitely risk-averse. $\mathcal{JV}$'s reservation payoff is exogenously normalized at zero.

$\mathcal{JV}$ receives the aggregate net transfer $t(q,c) = B + aq - \alpha c$ from the government and then redistributes these transfers between the two individual firms $\mathcal{B}$ and $\mathcal{O}$. We denote by $t_i(q,c) = B_i + a_i q - \alpha_i c$ the share of the overall revenue which accrues to firm i ($i \in \{\mathcal{B}, \mathcal{O}\}$). Because $\mathcal{JV}$ is infinitely risk-averse, it will transfer all risk on the aggregate transfer $t(q,c)$ to the builder and the operator so that necessarily:

$$a_{\mathcal{B}} + a_{\mathcal{O}} = a \text{ and } \alpha_{\mathcal{B}} + \alpha_{\mathcal{O}} = \alpha. \tag{17}$$

Assuming that $\mathcal{JV}$ has all bargaining power in designing the individual compensations of the builder and the operator,[37] $\mathcal{JV}$ maximizes the certainty equivalent of the aggregate payoff of the firms subject to constraints (17) which captures the fact that the aggregate compensation risk is shared between these firms. $\mathcal{JV}$'s problem can thus be written as:

$$\begin{aligned}\max_{\{a_{\mathcal{B}},\alpha_{\mathcal{B}},(e_1,e_2)\in\mathbb{R}_+^2\}} \; & B + ae_1 - \alpha(\eta_0 - e_2 - \delta e_1) - \frac{e_1^2}{2} - \frac{e_2^2}{2} \\ & - \frac{r\sigma_\varepsilon^2}{2}\left[(a - a_{\mathcal{B}})^2 + a_{\mathcal{B}}^2\right] - \frac{r\sigma_\eta^2}{2}\left[(\alpha - \alpha_{\mathcal{B}})^2 + \alpha_{\mathcal{B}}^2\right].\end{aligned}$$

Because both firms have the same risk tolerance, they share equally the risk on the aggregate compensation:

$$a_{\mathcal{B}} = a_{\mathcal{O}} = \frac{a}{2} \text{ and } \alpha_{\mathcal{B}} = \alpha_{\mathcal{O}} = \frac{\alpha}{2}. \tag{18}$$

For a given incentive scheme offered by the government, optimal effort levels are thus the same as in Section 3:

$$a_1 = a + \delta\alpha \text{ and } e_2 = \alpha. \tag{19}$$

The consortium is efficient in the sense that it perfectly internalizes the effort externality just like a merger in Section 3. However, and because the two firms share equally risk, the aggregate risk-premium to be paid to induce participation of such consortium is half what was paid with the merger.

The government's problem becomes thus:

$$(P^c): \max_{(e_1,e_2)\in\mathbb{R}_+^2} W^c(e_1,e_2,\delta) = (S+\delta)e_1 + e_2 - \frac{e_1^2}{2} - \frac{r\sigma_\varepsilon^2}{4}(e_1-\delta e_2)^2 - \frac{e_2^2}{2}\left(1+\frac{r\sigma_\eta^2}{2}\right). \quad (20)$$

Using (11) but for a level of risk-aversion half as high, the optimal effort levels with an efficient consortium are now given by:

$$e_1^c = \frac{(S+\delta)\left(1+\frac{r\sigma_\eta^2}{2}+\frac{\delta^2 r\sigma_\varepsilon^2}{2}\right)+\frac{\delta r\sigma_\varepsilon^2}{2}}{\left(1+\frac{r\sigma_\eta^2}{2}\right)\left(1+\frac{r\sigma_\varepsilon^2}{2}\right)+\frac{\delta^2 r\sigma_\varepsilon^2}{2}} \text{ and } e_2^c = \frac{1+\frac{r\sigma_\varepsilon^2}{2}+(S+\delta)\frac{\delta r\sigma_\varepsilon^2}{2}}{\left(1+\frac{r\sigma_\eta^2}{2}\right)\left(1+\frac{r\sigma_\varepsilon^2}{2}\right)+\frac{\delta^2 r\sigma_\varepsilon^2}{2}}. \quad (21)$$

The comparison of (6) and (20) is now straightforward. Even when there is no externality, a consortium *strictly* dominates because it allows a better allocation of risk between two otherwise identical risk-averse firms. We obtain:

Proposition 3. *There exists $\delta_0' > 0$ such that an efficient consortium dominates unbundling for $\delta > -\delta_0'$.*

This result reinforces again our previous findings. Certainly, bundling must be observed for a positive externality. It also offers a justification for our earlier assumption that a merger keeps the same degree of risk-aversion than the agents. This assumption allows in fact to focus on the incentives benefits of bundling and to put aside the issue of risk-sharing, which is another advantage of a consortium already well-known from the literature.[38]

6 OWNERSHIP AND ORGANIZATIONAL FORMS

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. The only incentive scheme which is feasible 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 $P \times q$ (with $P \geq 0$) by disposing on the assets in case the ex post negotiation breaks down. This can be viewed as the resale value of these assets. Because assets may have a greater social value than their value for the sole owners, we certainly have $S = E + P \geq P$ where E 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, 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 worth to 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 modelled 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 should go.

Whatever the organizational structure chosen, the only feasible contracts with the builder consist now in allocating assets ownership.[39] 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[40] and the fact that costs instead are readily observable, verifiable and used in cost-sharing agreements.[41]

To understand the implications of ownership, it is useful to see it as a 'simple' contract fixing the marginal incentives to improve the infrastructure quality 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.[42]

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:

$$W_G^u(e_2) = e_2 - \frac{e_2^2}{2}(1 + r\sigma_\eta^2), \tag{22}$$

where e_2 is the operator's cost-reducing 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 (22).

We thus obtain immediately.

Proposition 4. *Assume that there is a negative externality between building and operating assets. Under government ownership, bundling and unbundling yield the same outcome.*

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:

$$W_G^b(e_2, \delta) = \left\{ \delta(S + \delta)e_2 - \frac{\delta^2 e_2^2}{2} \right\} + \left\{ e_2 - \frac{e_2^2}{2}(1 + r\sigma_\eta^2) \right\}. \qquad (23)$$

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 δ is small enough, this is a positive term when evaluated at the effort level $e_2^u = 1/(1 + r\sigma_\eta^2)$ which maximizes (22). The second bracketed term is nothing else than the expression for $W_G^u(e_2)$. Henceforth, we immediately get the following proposition.

Proposition 5. *Assume that there is a positive externality between building and operating assets. Then, for δ small enough and under government ownership, bundling strictly dominates unbundling.*

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 and 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 $\frac{r}{2}\sigma_\varepsilon^2 P^2$ 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:

$$W_B^u(e_2, \delta) = (S+\delta)P - \frac{P^2}{2}(1 + r\sigma_\varepsilon^2) + e_2 - \frac{e_2^2}{2}(1 + r\sigma_\eta^2). \tag{24}$$

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:[43]

$$P + \alpha\delta = e_1.$$

The operating-costs-reducing effort is still given by $e_2 = \alpha$.

Social welfare under bundling can finally be written as:

$$W_B^b(e_2, \delta) = (S+\delta)(P+\delta e_2) - \frac{1}{2}(P+\delta e_2)^2(1+r\sigma_\varepsilon^2) + e_2 - \frac{e_2^2}{2}(1+r\sigma_\eta^2). \tag{25}$$

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

The comparison of (24) and (25) immediately yields:

Proposition 6. *Assume that there exists a positive externality between building and operating assets. Under builder ownership and if* $P \leq \frac{S+\delta}{1+r\sigma_\varepsilon^2} - \delta e_2^u$*, bundling strictly dominates; if* $P \geq \frac{S+\delta}{1+r\sigma_\varepsilon^2} - \delta\frac{e_{2B}^b}{2}$*, 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 (23) and (25), we immediately get:

Proposition 7. *Assume that there is a positive externality between building and operating costs, 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 bundling, the latter should not only own the assets but also manage them. When quality is highly uncertain, the principal needs to pay a large 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 7 highlights conditions under which the most common form of public-private partnership emerges. Bundling of tasks 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 private ownership emerge as being optimal.

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 and government retains ownership. We already know from Proposition 4 that separation and integration are equivalent under government ownership and when the externality is negative: no incentives on quality-enhancing can be provided. The hope for unbundling to strictly dominate in this case thus vanishes. Nevertheless, we have:

Proposition 8. *Assume that there is 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.

7 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 benevolent social welfare maximizer. Opponents to public-private partnerships have often argued that this form of procurement increases 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.

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 socially optimal. 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 binding. 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 incentives for the operator to manipulate the decision-maker's decision so that he chooses more often bundling than what is socially optimal. Information 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 give some rent to the operator.

In our context, that piece of information from which the decision-maker gets discretion is the sign 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 bundling 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 6 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 piece of 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.

7.1 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 always 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,[44] 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:

$$U_{\mathcal{O}}(\underline{\eta}_0) \geq U_{\mathcal{O}}(\bar{\eta}_0) + \alpha(\bar{\eta}_0)\Delta\eta_0, \tag{26}$$

whereas the participation constraint of a high-cost operator is:

$$U_{\mathcal{O}}(\bar{\eta}_0) \geq 0. \tag{27}$$

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 $U_{\mathcal{O}}(\bar{\eta}_0) = 0$.[45] 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.

We have indeed:

$$a^u(\underline{\eta}_0, \delta) = a^u(\bar{\eta}_0, \delta) = e_1^u, \tag{28}$$

$$\alpha^u(\underline{\eta}_0, \delta) = e_2^u > \alpha^u(\bar{\eta}_0, \delta) = \frac{1 - \frac{p}{1-p}\Delta\eta_0}{1 + r\sigma_\eta^2}. \tag{29}$$

We shall assume that $1 > \frac{p}{1-p}\Delta\eta_0$ 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 which is worth:

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

Denoting the rent of the merged entity by $U_{\mathcal{B}-\mathcal{O}}(\eta_0)=\hat{U}_{\mathcal{B}-\mathcal{O}}(\eta_0,\hat{\eta}_0)$, incentive compatibility and participation constraints become respectively:

$$U_{\mathcal{B}-\mathcal{O}}(\underline{\eta}_0)\geq U_{\mathcal{B}-\mathcal{O}}(\bar{\eta}_0)+\alpha(\bar{\eta}_0)\Delta\eta_0, \tag{30}$$

and:

$$U_{\mathcal{B}-\mathcal{O}}(\bar{\eta}_0)\geq 0. \tag{31}$$

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:

$$a^b(\underline{\eta}_0,\delta)=e_1^b\gtrless a^b(\bar{\eta}_0,\delta)=\frac{(S+\delta)(1+r\sigma_\eta^2+\delta^2r\sigma_\varepsilon^2)+\delta r\sigma_\varepsilon^2(1-\frac{p}{1-p}\Delta\eta_0)}{(1+r\sigma_1^2)(1+r\sigma_\varepsilon^2)+\delta^2r\sigma_\varepsilon^2}, \tag{32}$$

$$\alpha^b(\underline{\eta}_0,\delta)=e_2^b>\alpha^b(\bar{\eta}_0,\delta)=\frac{(1+r\sigma_\varepsilon^2)\left(1-\frac{p}{1-p}\Delta\eta_0\right)+(S+\delta)\delta r\sigma_\varepsilon^2}{(1+r\sigma_\eta^2)(1+r\sigma_\varepsilon^2)+\delta^2r\sigma_\varepsilon^2}, \tag{33}$$

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-reducing 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 9. *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 benevolence of the decision-maker is assumed.

7.2 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 may be manipulated and publicly reported as being a positive one. Instead, the reverse manipulation is supposed not to be feasible.[46]

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:

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

This stake of capture is in fact positive when evaluated at the optimal incentive schemes of Section 7.1 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 where $k < 1$.[47]

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:

$$\begin{aligned}
&\nu\Big\{p\left(W^b(a^b(\underline{\eta}_0, \bar{\delta}), \alpha^b(\underline{\eta}_0, \bar{\delta}), \bar{\delta}) - \alpha^b(\bar{\eta}_0, \bar{\delta})\Delta\eta_0\right) + (1-p)W^b(a^b(\bar{\eta}_0, \bar{\delta}), \alpha^b(\bar{\eta}_0, \bar{\delta}), \bar{\delta})\Big\} \\
&\quad + (1-\nu)\Big\{p\left(W^u(a^u(\underline{\eta}_0, \bar{\delta}), \alpha^u(\underline{\eta}_0, -\bar{\delta}), -\bar{\delta}) - \alpha^u(\bar{\eta}_0, -\bar{\delta})\Delta\eta_0\right) \\
&\qquad + (1-p)W^u(a^u(\bar{\eta}_0, -\bar{\delta}), \alpha^u(\bar{\eta}_0, -\bar{\delta}), -\bar{\delta})\Big\} \\
&\qquad - k(1-\nu)p\Delta\eta_0 \max\{0; \alpha^b(\bar{\eta}_0, \bar{\delta}) - \alpha^u(\bar{\eta}_0, -\bar{\delta})\}. \qquad (34)
\end{aligned}$$

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. The next proposition summarizes some features of the optimization.

Proposition 10. *There exists $\bar{\delta}_0 > 0$ such that for $\bar{\delta} < \bar{\delta}_0$, capture is not a concern. More generally, $\alpha^b(\bar{\eta}_0, \bar{\delta})$ (resp. $\alpha^u(\bar{\eta}_0, -\bar{\delta})$) is reduced (resp. increased) under the threat of capture.*

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 whereas unbundling would have been optimal. This in turn might favor an efficient operator. The corresponding information rents are the stakes of capture of the decision-maker. The previous proposition shows that the threat of capture changes the provision of incentives to the builder. Under bundling (resp. unbundling) a builder is less (resp. more) incentivized in order to make the concealment of the externality less attractive. The collusive stake might even be null at equilibrium when the externality between tasks is not too large, leading to no incentive compensation for the decision-maker.

From a practical viewpoint, this result suggests that the threat of capture in a PPP context has certainly been overestimated. A simple modification of incentive schemes, of course reducing somewhat the gains from coordinating efforts, is enough to fight capture.

8 CONCLUSION

The presence of a production externality between building and operating assets raises the issue of the optimal organization of these tasks. Bundling allows to better internalize this externality and improves incentives when the externality is positive, thereby increasing welfare. By contrast, when the externality is negative, unbundling reduces agency costs and is socially preferable. Hence, a simple and technology-driven reason is at the heart of the decision to bundle or unbundle the various activities. We have generalized our results on the benefits of bundling in case of a positive externality by enlarging the contracts space, by considering a different form of arrangement between the builder and the operator and finally by introducing political economy considerations.

However, an incomplete contracts framework where contracts cannot depend on the quality of the infrastructure restores a role for the allocation of ownership. Giving ownership of the assets to the builder improves his incentives to enhance the quality of the infrastructure. If ownership does not confer the builder with enough incentives to improve this quality and the externality is positive, then bundling might be used. Depending on the private benefits that the builder withdraws from ownership and the risks associated to the different tasks, the public-private partnership –bundling and builder ownership– might outperform the more traditional form of public procurement –unbundling with government ownership.

Of course, all the extensions investigated in this paper could be possibly cast also in an incomplete contracts setting. We feel confident that the results we have found in more complete contracting environments would carry over but, certainly, some more formal analysis is required to qualify this assertion.

Three other extensions seem to us particularly attractive. First, it could be worth coming back on the maintained assumption that the firms' degree of risk-aversion was kept constant as ones changes organizational modes. Section 5 has gone some way towards endogenizing that degree but more could certainly be done. More specifically, one may be interested in tracing out the impact of organizational forms (whether firms are multi-tasks or not) on their access to the financial market and thus on the amount of risk they should keep as a result of frictions on these markets.

Second, we have assumed that consortia were efficient in coordinating efforts of the member firms. This assumption should be relaxed. Consortia may be inefficient when they suffer from internal agency problems. These problems may tilt the organizational choice towards unbundling. In an incomplete contracts perspective, this would make stronger the case for the more traditional form of procurement.

Finally, it could be worth investigating whether competition between potential builders and between operators may also change the incentives to form consortia and the decision to bundle or not activities.

These are extensions that we shall pursue in future research.

APPENDIX

A.1 Proof of Proposition 1

Simple manipulations show that:

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

The proposition follows.

A.2 Proof of Proposition 2

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), (12) and (13).

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 piece-rate parameters are equal to:

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

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 the optimum.

Finally, tedious but straightforward computations show that:

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

A.3 Proof of Proposition 3

Immediate.

A.4 Proof of Proposition 4

Immediate.

A.5 Proof of Proposition 5

Immediate.

A.6 Proof of Proposition 6

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.7 Proof of Proposition 7

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.8 Proof of Proposition 8

Immediate.

A.9 Proof of Proposition 9

Immediate.

A.10 Proof of Proposition 10

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 $\tilde{\alpha}^u(\bar{\eta}_0, -\bar{\delta})$ under the threat 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.

NOTES

[1]See the 1998 United Nations Development Programme.

[2]See Holmström and Milgrom (1991) (moral hazard) and Laffont and Tirole (1993, Chapter 3) (adverse selection) for analysis of the multi-task problem.

[3] 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]Otherwise, the first-best could be achieved with simple forcing contracts, thereby making the organizational issue of whether to bundle or not the two tasks by large irrelevant.

[6]The U.S. prison sector is an instance of the case of a positive externality, for the design of the prison may affect significantly the cost of implementing a given security level; see Schneider (2000).

[7]For instance, the report made by the French Cour des Comptes following the Roissy Airport Terminal E2 crash argues 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.

[8]Because assets are privately owned, the owner may not internalize the full social value of his investment in enhancing the quality of the infrastructure.

[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 et 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 6 below.

[14]The conflict between performing two opposite tasks at the same time is reminiscent of those found in Dewatripont and Tirole (1999) and Gromb and Martimort (2005) in an information gathering context. Both papers analyze why the same agent cannot gather two pieces of information which may conflict with each other and view these two tasks as being subject to moral hazard.

[15]More generally, the impact of production externalities on the kind of incentive schemes used in multi-agent contexts (most notably relative performance evaluations versus joint performance evaluations), keeping this separation between agents as given, has also been investigated in Choi (1993) and Che and Yoo (2001).

[16]This result is already well-known from Holmström and Milgrom (1990), Macho-Stadler and Perez-Castrillo (1993), Itoh (1994) and Ramakrishnan and Thakor (1991).

[17]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, getting outside financing, building the corresponding infrastructure and managing those assets.

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

[19]Section 5 will analyze the case where the two firms remain independent entities coordinating their efforts in a consortium.

[20]We will be silent about the origin of the firms' risk-aversion. The corporate finance literature (see Leland and Pyle (1977) for instance) suggests reasons (related most noticeably to asymmetric information and frictions in accessing to the capital markets) why firms may not be able to be fully diversified. In a full-fledged model, one might want to analyze how the decision to bundle or not activities affects these frictions on the capital market. The implicit assumption that we make here is that those frictions remain independent of the chosen organizational form. In other words, the decision to bundle or not activities has only a negligible impact on the difficulties that firms

may face when raising outside finance. This assumption is particularly justified in the case of large firms involved in a number of similar markets and for which the decision to bundle or not activities on a given market has little impact on the returns they get on others. This seems quite relevant for the large service providers found in some key sectors like water or transport.

[21]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, 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.

[22]The quality of the infrastructure may include the delay in building it.

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

[24]Prisons provide an interesting example along these lines. A better design certainly makes easier to maintain safety.

[25]Airports may be a case in order here. A good design in view of facilitating passengers access may be accompanied by an increase in the costs of providing all services required.

[26]We are not of course in a pure Holmström and Milgrom (1987) environment because there are two sequential tasks. 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 but we feel confident about that.

[27]This assumption on non-delayed payments is standard in the literature. See for instance Laffont and Tirole (1993, Chapter 8) for an analysis of repeated auctions of franchise contracts which also assumes that delayed payments are not feasible.

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

[29]See Holmström (1979) and Laffont and Martimort (2002, Chapter 4) for standard analysis of this trade-off between insurance and incentives.

[30]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.

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

[32]Remember that agents get no rent in every configurations. Moreover, looking at $W^u(e_1, e_2, \delta)$ and $W^b(e_1, e_2, \delta)$, the welfare comparison between the bundling and the unbundling scenarios only depends on the comparison of effort levels.

[33]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'.

[34]See Holmström (1979)'s 'informativeness principle'.

[35] This point is well-known from the collusion literature in multi-agents environments. See Varian (1989) and Itoh (1993).

[36]The consortium acts thus as a syndicate in the sense of Wilson (1968).

[37]This assumption somewhat simplifies the analysis but could easily be relaxed.

[38]See Holmström and Milgrom (1990), Macho-Stadler and Perez-Castrillo (1993), Itoh (1993, 1994) and Ramakrishnan and Thakor (1991).

[39]We will assume that only deterministic ownership structures are relevant. This is justified when ownership can be renegotiated.

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

[41]Water management, waste disposals, transports, etc. are examples in order there. This is contrary to what is assumed in Hart, Shleifer and Vishny (1997) for instance.

[42]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 $T - P + P$). 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.

[43]We assume again that δ is small enough to ensure a positive effort supply.

[44]See Laffont and Martimort (2002, Chapter 2).

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

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

[47]The parameter $1 - k$ represents the deadweight-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.

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