Government Opportunism in Public-Private Partnerships*

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Abstract

This paper analyzes the contracting out of public services through Public-Private Partnerships (PPPs) subject to government opportunism. The government delegates the construction and management operations to a private sector consortium. The bundling of project stages induces, at the construction stage, the consortium to invest to achieve long-run cost savings. However, the consortium's incentive to invest is affected by the government's lack of commitment. We characterize the optimal PPP contract when the government is opportunistic, i.e., when it fails to commit not to revise the contract. We compare this result to the optimal concession contract, in which the construction and management activities are provided by two different firms. The purpose of this paper is two-fold. First, we show that an appropriate institutional framework is the key factor responsible for the success of PPP projects. Second, we specify the economic determinants of the government decision to prefer PPP contracts to conventional forms of procurement, when the government fails to honor its commitments.

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1 Introduction

The last three decades have witnessed a trend towards private sector involvement in public infrastructure and service provision. Governments are increasingly turning to the private

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sector to build and operate public assets such as roads, schools, prisons, hospitals and water. This State withdrawal from the provision of public services results in the use of partnerships between the public and the private sectors. These partnerships refer to contractual arrangements between a government and a private party for the provision of assets and the delivery of services traditionally provided by the public sector. They take place through a variety of contracts from the traditional form of public procurement to the modern form, Public-Private Partnership (PPP).

The aim of this paper is to compare the efficiency of PPP with respect to traditional procurement in different institutional frameworks. In the traditional procurement, the construction of infrastructure assets and the provision of related services are contracted separately. In PPPs, the public service delivery tasks are procured through one contract. The difference between these two procurement contracts reflects a belief that giving the private sector responsibility for building and operating public assets leads to increased efficiency in service delivery. More specifically, such bundling of tasks is believed to provide an incentive for the private sector to design and build assets with features that lower the costs of service provision over the long term (Hart, 2003). Most features of this new procurement method have been inspired by the English Private Finance Initiative (PFI), often presented as a success. In a study of 29 projects in the UK, Arthur and Entreprise LSE (2000) find that the average cost saving is 17% in PFI projects. In Australia, PPPs are 11% more cost efficient than traditional procurement (Allen Consulting Group, 2007). Although PPP programs have become increasingly widespread, experience is mitigated in emerging and developing economies. In Central and Eastern European (CEE) Countries, renegotiations have led to important additional transaction costs in the highway sector (Brenck et al., 2005). The problem of government-led renegotiations is not unique to the CEE. For instance, using data from concession contracts awarded in Latin America and the Caribbean countries from 1989 to 2000, Guasch, Laffont and Straub (2005) find that the social costs of such renegotiations are likely to be high, especially in the water and transport sectors. In countries with weak institutions, it appears that the PPP efficiency may be affected by the lack of strong government commitment.

The purpose of this paper is two-fold. First, we show that an appropriate institutional framework is the key factor responsible for success of the PPP projects. Second, we specify the economic determinants of the government decision to prefer PPP contracts to traditional forms of procurement, when the government fails to honor its commitments.

We start our analysis by developing a two-period model of procurement in which a government must procure a public service project. Each task of the project, the construction of a specific asset and its operation, is carried out by a private sector firm. An extra investment in the construction stage may reduce the operating costs in the operational stage[1]. As recent works has shown, the builder has an incentive to internalize externalities if he also has the right to operate the infrastructure (Hart, 2003; Bentz, Grout and Halonen, 2004; Martimort and Pouyet, 2006; Iossa and Martimort, 2008). So, the bundling of tasks in PPPs provides an incentive to realize an investment minimizing the cost of providing the public service. With two different firms, such externalities are not taken into account by the builder. In traditional procurement, the government has thus to subsidize the builder to provide incentives to invest in the quality of the infrastructure. First, we compare both contracts in a "strong" institutional framework. It will enable the private sector to enter into long-term contracts knowing that the government will honor its commitments. We show that PPP projects deliver better results in terms of cost efficiency in this case. Bundling the construction and operation of the public asset introduces stronger incentives in the procurement process than traditional separate contracts. Second, we consider a "weak" institutional framework where the government cannot commit to long-term contractual agreements. In this case, the long-term contractual nature of PPP leads the government to behave opportunistically. Observing construction costs, the government may update his beliefs about the firm's efficiency. He is tempted to take regulatory actions that expropriate firm rents[2]. The firm recognizes that the revealed information will be fully exploited. She takes this into account in her response to the policies established at the beginning of the relationship. Internalization of the externality will therefore be imperfect. Thus, under-investment arises. The previous efficiency cost of PPP projects are affected by government's lack of commitment. On the contrary, the traditional contract procurement does not suffer from government opportunism, the construction cost is not revealing information about the operator's efficiency. From their comparison, we can specify conditions under which PPP contracts are prefered to TP contracts. It results that PPPs should be only chosen when the firms are "sufficiently homogeneous" and the probability to face an efficient one is "low enough". In this specific case, the informational rent extraction from opportunistic government does not enough damaged the PPP cost efficiency to prefer TP contract.

We provide an extension of model to complete our analysis. It consists to add a moral hazard problem at the construction stage. In this framework, the consortium may exert an effort to reduce construction cost after contracting but before learning her type. Under no commitment, she chooses a level of effort taking into account both the effect on the first period reward and on the regulator's inference about her efficiency. She thus will be reluctant to convey favorable information early in the relationship. We show that this undereffort will undermine the efficiency of PPPs. Nevertheless, the benefit of the

[1]To illustrate such a positive externality, we can consider for example that a high-quality infrastructure may ease maintenance by lowering the likelihood of failure.

[2]A typical scenario is a government (or mayor in the case of water concessions, because they usually have exclusive jurisdiction) seeking to secure popular support during a reelection campaign and deciding to cut tariffs or not honor agreed-upon tariff increases, Guash (2004).

whole-life costing approach of the project by PPP is not nullified in some specific cases.

Debate about both types of contract for private provision of public services has been initiated by Hart (2003) and Bennett and Iossa (2004). Hart (2003) suggests that the choice between PPP (bundling construction and operation) and conventional provision (unbundling) depends on the ability to contract on service provision rather than building provision. Bennett and Iossa (2004) also study the desirability of bundling the contruction and operation tasks. They define PPP as an ownership structure rather than a simple "bundling" of these tasks. We abstract from the role of ownership in the provision of public services. We consider that the government can control every aspect of the relationship through the contract and achieve the efficient outcome regardless of ownership structure. Our paper addresses issues close to Martimort and Pouyet (2006). They show that the building of the facility and its operating should be managed together when an investment at the construction stage helps to save on operating costs. Even if they consider the effects of ownership, they also suggests that the role of ownership might have been overemphasized so far. Contrary to previous papers, we do not consider that bundling construction and operation would always be optimal if the investment is productive (i.e. reduce operation costs without deteriorates quality service). The unbundling approach (traditional procurement) may have an advantage even if there exist positive externalities between both tasks. We show that the decision to bundlle or not building and operation tasks depends essentially on the government's commitment. Guasch, Laffont and Straub (2006) account for the possibility of opportunistic behavior by government. We reach a similar conclusion in that the lack of government commitment discourages investment. However, their model does not allow to distinguish between procurement methods (bundling versus unbundling). Finally, our paper is close to Iossa and Martimort (2008, 2009). They conclude that the opportunistic behavior from government partially nullifies the benefits of bundling and suggest that PPPs should be preferred in "strong" institutional environments. In their papers, they focus on how the lack of commitment can lead to government opportunism which exploit the sunk nature of the firm's investment. We differ from their work not considering the hold up problem inherent to pure moral hazard models. Our model also includes adverse selection problem. Hence, government opportunism refers to situation where the government is tempted to exploit the revealed information by the firm to eliminate her information rent. In this context, we can specify new economic determinants of the government decision to prefer PPP contracts to TP contracts, when the government fails to honor its commitments.

The paper is organized as follows. Section 2 describes the models of PPP and traditional procurement. In section 3, we consider the government commitment case. After deriving both type of optimal contracts, we compare them. In section 4, we relax the commitment assumption. We characterize each type of contracts under government opportunism before to compare their cost efficiency . Section 5 provides an extension of these models. Section 6 concludes.

2 The Models of Procurement

We consider a two-period model of procurement in which the government must procure a public utility project which involves the construction of a specific asset and the operation of this asset. The value for the government of this production, which is common knowledge, is exogenously fixed at S. We assume that S is large enough so that the project is always desirable[3]. Each task of the project, infrastruture construction and service provision, is carried out by a risk neutral firm (respectively a builder and an operator). The firm can be either efficient ($\overline{\theta}$) or inefficient ($\underline{\theta}$) with respective probabilities υ and $1-\upsilon$[4]. We denote $\Delta\theta \equiv \overline{\theta} - \underline{\theta} > 0$. To be efficient (inefficient) increases the probability that the cost of the project is low C_l (high C_h). The efficiency parameter is unknown by the two parties at the beginning of the game and only observed by the firm after contracting[5].

Although the construction cost C^1 depends only on the builder's efficiency such that $Prob(C^1 = C_l^1/\theta) = \theta$, the operation cost C^2 depends on several other parameters. Indeed, in the second period, the operator can exert a positive and costly effort e where $e \in \left[0, e^{Max}\right]$. Exerting effort e increases the probability that the cost of the project is low but entails a disutility (in monetary units) of $\Psi(e)$ where $\Psi(e) = \frac{e^2}{2}$. This disutility increases with effort $\Psi' > 0$ for $e > 0$, at an increasing rate $\Psi'' > 0$, and satisfies $\Psi\left(0\right) = 0$. This action is supposed to be non-observable so that the government faces a moral hazard problem when delegating operation to the operator. Effort is extremely valuable for the government, who always wants to implement a high level of effort from both types of firm. In this dynamic procurement framework, after discovering her type, the builder can make a non verifiable investment I, which costs $g(I) = \frac{I^2}{2}$ at the first period. This investment increases the probability to have a low operation cost C_l^2 at the second period by βI. A better quality of infrastrusture may facilitate the operating task and reduces its cost. Since it refers to a positive externality, $\beta > 0$. To sum up, the project's cost in the second period depends on the operator's efficiency, on the cost-reducing effort and on the investment. So, the probability of having a low cost at the second period is $Prob(C^2 = C_l^2/\theta) = \theta + e + \beta I$.

The government designs a procurement contract on the only observable variable: the

[3] This assumption allows us to avoid problems of optimal shutdown.

[4] We could assume for example that a firm knows her efficiency but not on a specific project. We can reason in term of project complexity. The parameter $\overline{\theta}$ (resp. $\underline{\theta}$) can corresponds to the firm's efficiency on a basic project (resp. a complex project).

[5] The principal and the agent contract at the ex ante stage, i.e., before the agent learns her type for the construction stage.

realized cost. To accept working for him, the firm must be compensated by a net monetary transfer t in addition to the reimbursement of her cost. At the second period, this reward takes account the realized cost as well as the announcement about the firm's type. The government offers a long-term contract $\left\{(C_l^2, \overline{t}_l), (C_h^2, \overline{t}_h), (C_l^2, \underline{t}_l), (C_h^2, \underline{t}_h)\right\}$ to the firm which stipulates transfers at the end of the public service delivery project. His objective function, which corresponds to the consumer's welfare, is:

$$\begin{aligned} S \; - \; v \; \left[\overline{\theta} C_l^1 + \left(1-\overline{\theta}\right) C_h^1 - \delta[\left(\overline{\theta}+\overline{e}+\beta\overline{I}\right)\left(C_l^2+\overline{t}_l\right) + \left(1-\overline{\theta}-\overline{e}-\beta\overline{I}\right)\left(C_h^2+\overline{t}_h\right)]\right] \\ -(1-v)\left[\underline{\theta} C_l^1 + (1-\underline{\theta}) C_h^1 - \delta[(\underline{\theta}+\underline{e}+\beta\underline{I})\left(C_l^2+\underline{t}_l\right) + (1-\underline{\theta}-\underline{e}-\beta\underline{I})\left(C_h^2+\underline{t}_h\right)]\right] \end{aligned}$$

We let δ, be the common discount factor used by the government and the firm.

The firm's utilities on each phase of project are such that:

- for the efficient firm:

$$\begin{aligned} \overline{U}^1 &= -g(\overline{I}) \\ \overline{U}^2 &= \left(\overline{\theta}+\overline{e}+\beta\overline{I}\right)\overline{t}_l + \left(1-\overline{\theta}-\overline{e}-\beta\overline{I}\right)\overline{t}_h - \Psi(\overline{e}) \end{aligned}$$

- for the inefficient firm:

$$\begin{aligned} \underline{U}^1 &= -g(\underline{I}) \\ \underline{U}^2 &= (\underline{\theta}+\underline{e}+\beta\underline{I})\,\underline{t}_l + (1-\underline{\theta}-\underline{e}-\beta\underline{I})\,\underline{t}_h - \Psi(\underline{e}) \end{aligned}$$

At the first period, there are no tranfers[6]. At the second period, the transfers compensate the firm for investment and effort she made, and to reveal her type.

2.1 The PPP

In PPPs, the builder and the operator are integrated and represented by a single entity, the consortium. We assume that the consortium's efficiency is constant over time, i.e. the type θ is drawn once and remains fixed in both periods of the model[7].

The timing of the game is the following.

1. The government offers a contract to the consortium.

[6]The government has not to induce the firm either to reveal her type that she does not know at this stage or to realize an action influencing the construction cost. The firm will be incentivized to invest at the construction stage to reduce operation cost with the second period transfers.

[7]We implicitly assume that operation ability is one-to-one with construction ability. The best constructor may want to form the consortium with the best operator and the less efficient constructor can only be associated with an operator of the same type.

2. The consortium accepts or refuses the contract. If she refuses, she gets her reservation utility which is normalized to 0, and the game ends.

3. The consortium learns the value of her type θ.

4. The consortium chooses the investment I.

5. The first part of the contract is executed and transfers take place.

6. The consortium chooses the contract corresponding to her efficiency type and she chooses the effort e.

7. The second part of contract is executed and transfers take place.

To obtain the consortium's participation, the entire project must yield as least as much utility as the outside opportunity level.

$$v(\overline{U}^1 + \delta\overline{U}^2) + (1 - v)(\underline{U}^1 + \delta\underline{U}^2) \geq 0 \tag{1}$$

At this stage, the consortium knows her type $\overline{\theta}$ (resp. $\underline{\theta}$) and chooses her investment $\overline{I}^*$ (resp. $\underline{I}^*$) such that:

$$\overline{I}^* = \arg\max_{\overline{I}}\{\overline{U}^1 + \delta\overline{U}^2\} \tag{2}$$

$$\underline{I}^* = \arg\max_{\underline{I}}\{\underline{U}^1 + \delta\underline{U}^2\} \tag{3}$$

The consortium is given incentives to internalise possible externalities between the building and operating phase of the infrastructure.

Faced with an incentive contract $\left\{(\bar{t}_l, \bar{t}_h)\right\}$ *(resp.* $\{(\underline{t}_l, \underline{t}_h)\}$), the efficient firm $\overline{\theta}$ (resp. the inefficient firm $\underline{\theta}$) chooses an effort $\overline{e}$ *(resp.*$\underline{e}$) such that:

$$\overline{e}^* = \arg\max_{\overline{e}}\{\overline{U}^2\} \tag{4}$$

$$\underline{e}^* = \arg\max_{\underline{e}}\{\underline{U}^2\} \tag{5}$$

The value of the production for the government[8], S, is constant. So, the government[9]

[8] The government is also called the principal in this principal-agent model, and the firm is the agent.
[9] The government is assumed benevolent, seeking to minimize net social cost of the project.

wants to minimize the cost of the entire project. The program $(P1)$ writes as:

$$\min_{\substack{\{\overline{I},\overline{e},\overline{t}_l,\overline{t}_h\\ \underline{I},\underline{e},\underline{t}_l,\underline{t}_h\}}} \{v[(\overline{\theta}C_l^1+(1-\overline{\theta})C_h^1)+\delta\left((\overline{\theta}+\overline{e}+\beta\overline{I})(C_l^2+\overline{t}_l)+(1-\overline{\theta}-\overline{e}-\beta\overline{I})(C_h^2+\overline{t}_h)\right)]$$
$$+(1-v)[(\underline{\theta}C_l^1+(1-\underline{\theta})C_h^1)+\delta\left((\underline{\theta}+\underline{e}+\beta\underline{I})(C_l^2+\underline{t}_l)+(1-\underline{\theta}-\underline{e}-\beta\underline{I})(C_h^2+\underline{t}_h)\right)]\}$$

subject to $(1),(2),(3),(4) and (5)$.

Complete Information We suppose that there is no asymmetry of information between the government and the consortium. Then, both parties know the consortium's type and the government observes her investment and effort.

Under complete information, the government maintains all consortium's types at their zero status quo utility level.

$$U^1+\delta U^2=0.$$

As investment and effort are both verifiable, the principal can thus use forcing contracts to implement the first best (FB) optimal investment and effort pair where:

$$I^{FB}=\delta\beta e^{FB},$$

$$e^{FB}=C_h^2-C_l^2.$$

We denote $\overline{I}^{FB}$, $\overline{e}^{FB}$, $\overline{U}^1+\delta\overline{U}^2$ the solutions corresponding to $\overline{\theta}$ and $\underline{I}^{FB}$, $\underline{e}^{FB}$, $\underline{U}^1+\delta\underline{U}^2$ to $\underline{\theta}$.

These first best outcomes involve that the agent's actions depend on the difference between operation costs. The consortium's investment also depends on the degree of positive externality between design and operation (β) as well as her patience (δ). Investing increases building costs but, it improves the probability a lower service cost. The agent is incentivized by being rewarded for low cost levels and penalized for high cost levels. Since the agent is risk neutral, she is ready to accept such a transfer scheme as long as the expected payment she receives is greater or equal to zero.

2.2 The Traditional Procurement

In the case of traditional procurement, the construction and operation are contracted separately. The government contracts with a builder to build the facility and then later with an operator to run it. The government anticipates that the builder has no incentive to invest in the infrastructure in order to increase the probalities of a low operation cost, when this cost is incurred by another firm. So, he subsidizes the builder to exert some extra investment in the construction phase allowing to decrease costs in the operational phase.

The timing of the game is the following.

1. The government offers a contract to the builder.
2. The builder accepts the contract or refuses it (if she refuses, she gets her reservation utility).
3. The government subsidizes the builder to exert an investment I.
4. The firm realizes the investment I[10].
5. The contract is executed and transfers take place.
6. The government offers a contract to the operator who accepts or refuses.
7. The operator chooses the contract corresponding to her efficiency parameter θ and she exerts her effort e.
8. The second contract is executed and transfers take place.

The Construction Stage Infrastruture construction is carried out by a builder. To induce her to invest I, the government uses a transfer t^1. At this construction stage, the operator's type θ is unknown by both parties. So, the investment I is the same for both types of builders.

The builder's utilities are the same for the efficient and the inefficient builder, such that:

$$\begin{aligned} \overline{U}^1 &= t^1 - g(I), \\ \underline{U}^1 &= t^1 - g(I). \end{aligned}$$

To obtain the builder's participation, she must receive at least as much utility as outside opportunity level which is zero.

$$v\overline{U}^1 + (1-v)\underline{U}^1 \geq 0. \tag{6}$$

The government chooses the level of investment which minimizes the cost of investment on the entire project.

$$\begin{aligned} I^{TP} = \arg\min_I \{ & g(I) + \delta[v[(\overline{\theta} + \overline{e} + \beta I)(C_l^2 + \overline{t}_l) + (1 - \overline{\theta} - \overline{e} - \beta I)(C_h^2 + \overline{t}_h)] \\ & + (1-v)\left[(\underline{\theta} + \underline{e} + \beta I)\left(C_l^2 + \underline{t}_l\right) + (1 - \underline{\theta} - \underline{e} - \beta I)\left(C_h^2 + \underline{t}_h\right)\right]]\} \end{aligned} \tag{7}$$

[10] We assume that investment is ex post verifiable. The builder is then incentivized to invest by the threat of strong penalties once the infrastrure is completed and handed back to the government.

The Operating Stage The operator knows her type θ before contracting. The participation constraint of the operator is such that:

$$\overline{U}^2 \geq 0, \quad (8)$$
$$\underline{U}^2 \geq 0, \quad (9)$$

Faced with an incentive contract $\left\{(\bar{t}_l, \bar{t}_h)\right\}$ $(resp. \{(\underline{t}_l, \underline{t}_h)\})$, the efficient operator $\overline{\theta}$ (resp. the inefficient operator $\underline{\theta}$) chooses an effort $\overline{e}$ $(resp. \underline{e})$ such that:

$$\overline{e}^{TP} = \arg\max_{\overline{e}}\{\overline{U}^2\} \quad (10)$$
$$\underline{e}^{TP} = \arg\max_{\underline{e}}\{\underline{U}^2\} \quad (11)$$

The principal solves the following program $(P2)$:

$$\min_{\substack{\{\overline{e}, \bar{t}_l, \bar{t}_h \\ \underline{e}, \underline{t}_l, \underline{t}_h\}}} \{v[(\overline{\theta} + \overline{e} + \beta I)(C_l^2 + \bar{t}_l) + (1 - \overline{\theta} - \overline{e} - \beta I)(C_h^2 + \bar{t}_h)]$$
$$+(1-v)\left[(\underline{\theta} + \underline{e} + \beta I)\left(C_l^2 + \underline{t}_l\right) + (1 - \underline{\theta} - \underline{e} - \beta I)\left(C_h^2 + \underline{t}_h\right)\right]\}$$
subject to $(6), (7), (8), (9), (10) and (11)$.

Complete information We suppose that there is no asymmetry of information between the government and both private firms. The builder and the operator know their type as the government, which also observes their investment and effort. Whatever the firms' type θ, the contracts are defined as follows.

At the **construction stage**, the government maintains all builder's types at their zero status quo utility level.

$$U^1 = 0.$$

At the **operation stage**, the operator's utility is such that:

$$U^2 = 0.$$

The first best level of effort is equal to:

$$e^{FBB} = (1 - \delta\beta^2)(C_h^2 - C_l^2).$$

The first best level of investment depending of the level of effort:

$$I^{FBB} = \delta\beta[C_h^2 - C_l^2 - e^{FBB}].$$
$$I^{FBB} = \delta\beta[\delta\beta^2(C_h^2 - C_l^2)].$$

We denote $\overline{I}^{FBB}$, $\overline{e}^{FBB}$, $\overline{U}^1$, $\overline{U}^2$ the solutions corresponding to $\overline{\theta}$ and $\underline{I}^{FBB}$, $\underline{e}^{FBB}$, $\underline{U}^1$, $\underline{U}^2$ to $\underline{\theta}$.

When the government chooses the incentives to induce the operator to make efffort, he takes account for the fact that this effort also determines the investment at the construction stage[11]. There is a negetive relation between both actions. The more the effort are high, the more the investment is low.

3 The Procurement Contracts under Government Commitment

In this section, we assume that the institutional framework enables the private sector to enter into long-term contracts knowing that the government will honor its commitments.

3.1 The PPP

The government contracts at the beginning of the relationship with the private consortium for both periods. In this environment, the principal observes the agent's cost but not its efficiency parameter, its effort or its investment. The optimal contract in complete information is no longer implementable. Hereafter, he must incentive the agent $\overline{\theta}$ (resp.$\underline{\theta}$) to realize actions $\overline{I}$ and $\overline{e}$ (resp. $\underline{I}$ and $\underline{e}$), according to her type. Allocations must satisfy the following incentive constraints :

$$\begin{aligned}\overline{U}^1+\delta\overline{U}^2 &\geq \underset{e,I}{Max}\left\{-g(I)+\delta[\left(\overline{\theta}+e+\beta I\right)\underline{t}_l+\left(1-\overline{\theta}-e-\beta I\right)\underline{t}_h-\Psi(e)]\right\}, \\ \underline{U}^1+\delta\underline{U}^2 &\geq \underset{e,I}{Max}\{-g(I)+\delta[(\underline{\theta}+e+\beta I)\,\overline{t}_l+(1-\underline{\theta}-e-\beta I)\,\overline{t}_h-\Psi(e)]\}.\end{aligned}$$

In the second period, the contract $(\underline{t}_l, \underline{e})$ must be weakly preferred by agent $\underline{\theta}$ and $\left(\overline{t}_l, \overline{e}\right)$ by $\overline{\theta}$. We could rewrite these incentive constraints focusing on rents to highlight the distributive impact of asymmetric information:

$$-g(\overline{I})+\delta\overline{U}^2 \geq -g(\underline{I})+\delta(\underline{U}^2+\underline{e}\Delta\theta), \tag{12}$$

$$-g(\underline{I})+\delta\underline{U}^2 \geq -g(\overline{I})+\delta(\overline{U}^2-\overline{e}\Delta\theta). \tag{13}$$

The consortium is protected by limited liability. This limits the potential consequences of the ex ante contracting between the parties[12]. She is willing to participate in the

[11]From (7), the level of investment depends on the difference of the second period tranfers, equal to the level of effort (constraints (10) and (11)).

[12]The model thus incorporates an ex post participation constraint. It allows us to define the level of rents for each type of consortium.

regulatory process if and only if:

$$-g(\overline{I}) + \delta\overline{U}^2 \geq 0, \tag{14}$$
$$-g(\underline{I}) + \delta\underline{U}^2 \geq 0. \tag{15}$$

The principal will solve problem (P) subjet to (2), (3), (4), (5), (12), (13), (14) and (15). The standard simplification in the number of relevant constraints leaves us with only two relevant constraints, the efficient agent's incentive constraint (12) and the inefficient type's participation constraint (15)[13]. From the resolution of the optimization program, we obtain:

$$\begin{aligned} -g(\underline{I}) + \delta\underline{U}^2 &= 0, \\ -g(\overline{I}) + \delta\overline{U}^2 &= \delta\underline{e}\Delta\theta. \end{aligned} \tag{16}$$

The limited liability is costly for the principal. The restriction of penalties[14] from the principal obliges him to give up some ex ante rent to the efficient agent. It takes us back to a standard ex post contracting framework. So, the government faces to the same trade off between rent extraction and incentives than the adverse selection setting. Only the efficient type gets a positive rent.

Optimal regulation entails such level of investment:

$$\begin{aligned} \overline{I}^* &= \delta\beta\overline{e}^*, \\ \underline{I}^* &= \delta\beta\underline{e}^*. \end{aligned}$$

The constructor delivers an amount of investment depending directly on the efforts equal to:

$$\begin{aligned} \overline{e}^* &= e^{FB}, \\ \underline{e}^* &= (C_h^2 - C_l^2) - \frac{v}{(1-v)(1+\delta\beta^2)}\Delta\theta\ . \end{aligned}$$

The contract entails a downward distortion of inefficient consortium's effort from the first-best effort level. From (16), we see that the efficient consortium's rent depends on

[13] From the problem $(P1)$, we see that the principal's objective function is increasing in the agent's rent. So, since the rents are costly to the government, the contraints (12) and (15) are binding at the optimum. Furthermore, adding up (13) and (14), we obtain the *monotonicity constraint* that yields

$$\overline{e} \geq \underline{e},$$

in such a way that we check that is always the efficient type who has incentive to mimic the ineffcent one's effort and not the reverse. Note that the neglected constraints are satisfied by this solution.

[14] The principal is limited in the severity of the penalty imposed on the agent as in Armstrong and Sappington (1985) who discuss the effect of the limited liability constraint.

the inefficient consortium's action. The principal has an incentive to reduce the level of effort requested from the inefficient agent to lower the efficient agent's information rent. Furthermore, this distortion depends on the impact of investment on the second period. The more the parties are patient and the stronger the impact of investment on the probability to have a low cost, the less the distortion will be important and tend towards the first best level of effort. The introduction of a binding limited liability constraint reduces the incentive power of the optimal contract[15].

3.2 The Traditional Procurement

In a traditional procurement, the government contracts with the builder to build the infrastructure and then later with another firm to run it. The government anticipates that the builder has no incentive to invest in the infrastructure in order to enhance the probalities to have a low operation costs, since the infrastructure is run by another firm. So, he subsidizes the builder to invest at the construction stage.

The Construction Stage The constructor's rent, whatever her type, is nullified:

$$\begin{aligned}\overline{U}^1 &= 0,\\ \underline{U}^1 &= 0.\end{aligned}$$

The constructor is only compensated for the investment. As she does not her type before to contract, the government does not induce him to reveal her type with tranfers.

The Operating Stage At the second period, the contract $(\bar{t}_l, \overline{e})$ must be weakly preferred by the operator $\overline{\theta}$ and $(\underline{t}_l, \underline{e})$ by $\underline{\theta}$.

$$\begin{aligned}\overline{U}^2 &\geq \max_e \left\{(\overline{\theta}+e+\beta I)\underline{t}_l + (1-\overline{\theta}-e-\beta I)\underline{t}_h - \Psi(e)\right\}\\ \underline{U}^2 &\geq \max_e \left\{(\underline{\theta}+e+\beta I)\bar{t}_l + (1-\underline{\theta}-e-\beta I)\bar{t}_h - \Psi(e)\right\}\end{aligned}$$

$$\Leftrightarrow \ \overline{U}^2 \geq \underline{U}^2 + \underline{e}\Delta\theta \tag{17}$$

$$\Leftrightarrow \ \underline{U}^2 \geq \overline{U}^2 - \overline{e}\Delta\theta \tag{18}$$

The principal solves the program $(P2)$ subject to (7), (8), (9), (10), (11), (17) and (18).

[15] As underlined by Demski, Sappington and Spiller (1988), "bankruptcy considerations limit the penalties that can be imposed on the agents. In the face of such limitations, the principal cannot always attain the first-best solutions even when the agents are risk neutral".

The optimal commitment solution under incomplete information is characterized by:

$$\begin{aligned} \underline{U}^2 &= 0, \\ \overline{U}^2 &= \underline{e}\Delta\theta. \end{aligned}$$

As previously, the efficient operator's rent is positive. As usual, the inefficient agent obtains no rent and her effort is distorted downward below the first-best effort due to the fact that the principal has an incentive to lower the efficient agent's information rent. The respective level of effort are such that:

$$\begin{aligned} \overline{e}^{TP} &= (1-\delta\beta^2)(C_h^2 - C_l^2), \\ \underline{e}^{TP} &= (1-\delta\beta^2)(C_h^2 - C_l^2) - \frac{v}{(1-v)}\Delta\theta. \end{aligned}$$

The optimal incentive scheme for the operator trades off the two conflicting concerns of extracting the operator's informational rent and giving the latter appropriate incentives to reduce cost. The other part of distortion of efforts comes from the fact that the builder's investment, depends on the efforts:

$$\begin{aligned} I^{TP} &= \delta\beta[C_h^2 - C_l^2 - v\overline{e} - (1-v)\underline{e}] \\ I^{TP} &= \delta\beta[\delta\beta^2(C_h^2 - C_l^2) + v\Delta\theta]. \end{aligned}$$

The distortion of investment from the first best level comes from the fact that it depends on the level of effort required from both types of operator[16]. The negative relation between investment and effort implies that the distortion of investment is upward from the first best level.

3.3 Comparison of Procurement Contracts under Government Commitment

Combining the construction and the operation stage, the consortium will have better incentives to carry out the cost saving investment. This may involve spending more in construction to reduce operation costs later, an effect the consortium can internalize. PPP gives the private partner greater incentives to make investments and efforts.

$$\begin{aligned} \overline{e}^* &> \overline{e}^{TP}, \\ \underline{e}^* &> \underline{e}^{TP}. \end{aligned}$$

$$E(I^*) > E(I^{TP}) \text{ si } (C_h^2 - C_l^2) > \frac{(2+\delta\beta^2)}{[1-(\delta\beta^2)^2]}v\Delta\theta.$$

[16] At this stage, the governement does not the operator's type.

We evaluate the efficiency of both contracts comparing their total cost. The PPP contract is more efficient due to synergies between the different stages of production (construction and operation). The private partners have a long term approach of the project. Contrarily, in the TP contract, both private firms have a short term perspective (the constructor only builds the infrastructure and the operator run it).

Proposition 1 *With government commitment, PPP contracts are more cost efficient than traditional procurement.*

A strong institution framework secures the efficiency of PPP arrangements. We study their sustainability in environment suffering from a lack of government commitment.

4 The Procurement Contracts under Government Opportunism

We will now analyze the case with possibility of opportunistic behavior by government.

4.1 The PPP

When commitment is not available, the government can commit himself only to the current period. Observation of building costs, which provides useful information on the underlying state of nature, will be used by the government to update his beliefs about the consortium's efficiency. This revealed information is used by the principal as a signal to better design the second period optimal contract. These signals may take only two values which correspond to the first period costs C_l^1 and C_h^1. The process of beliefs revision takes place according to Bayes' rule. To simplify the writing of the program, we use σ such that:

$$\begin{aligned} \sigma &= P(\theta = \overline{\theta}/C^1) \text{ and } 1 - \sigma = P(\theta = \underline{\theta}/C^1) \\ \text{where } \sigma &= \sigma_L \text{ when } C^1 = C_l^1 \ , \\ \text{and } \sigma &= \sigma_H \text{ when } C^1 = C_h^1. \end{aligned}$$

In this no commitment framework, the PPP is run by short-term contracts. The government and the consortium are locked in their long term relationship, but government opportunism entails a government-led renegotiation.

Second period The government chooses the second-period incentive scheme optimally given his beliefs about the consortium's type at that date. To do this, he minimizes the cost of the project at the second period given the realization of the investment. We denote the anticipated level of investment I^A. This program $(P3)$ is such that:

$$\min_{\{e,t^2\}}\{\sigma[(\overline{\theta}+\overline{e}+\beta\overline{I}^A)(\overline{t}_l+C_l^2)+(1-\overline{\theta}-\overline{e}-\beta\overline{I}^A)(\overline{t}_h+C_h^2)]$$
$$+(1-\sigma)[(\underline{\theta}+\underline{e}+\beta\underline{I}^A)\left(\underline{t}_l+C_l^2\right)+(1-\underline{\theta}-\underline{e}-\beta\underline{I}^A)\left(\underline{t}_h+C_h^2\right)]\}$$

with respect to :

$$\overline{e}^O = \arg\max_{\overline{e}}\{(\overline{\theta}+\overline{e}+\beta\overline{I}^A)\overline{t}_l+(1-\overline{\theta}-\overline{e}-\beta\overline{I}^A)\overline{t}_h-\Psi(\overline{e})\}, \quad (19)$$
$$\underline{e}^O = \arg\max_{\underline{e}}\{(\underline{\theta}+\underline{e}+\beta\underline{I}^A)\underline{t}_l+(1-\underline{\theta}-\underline{e}-\beta\underline{I}^A)\underline{t}_h-\Psi(\underline{e})\}. \quad (20)$$

Hereafter, he must induce the agent $\overline{\theta}$ (resp.$\underline{\theta}$) to realize action $\overline{e}$ (resp $\underline{e}$), according to her type. Allocations must satisfy the following incentive constraints:

$$\overline{U}^2 \geq \max_e\{(\overline{\theta}+e+\beta\overline{I}^A)\underline{t}_l+(1-\overline{\theta}-e-\beta\overline{I}^A)\underline{t}_h-\Psi(e)\},$$
$$\underline{U}^2 \geq \max_e\{(\underline{\theta}+e+\beta\underline{I}^A)\overline{t}_l+(1-\underline{\theta}-e-\beta\underline{I}^A)\overline{t}_h-\Psi(e)\}.$$

To simplify notations, we note the difference of anticipated investment $\Delta I^A=\overline{I}^A-\underline{I}^A$. We rewrite these incentive constraints focusing on rents to highlight the distributive impact of asymmetric information:

$$\Leftrightarrow\ \overline{U}^2\geq\underline{U}^2+\underline{e}(\Delta\theta+\beta\Delta I^A), \quad (21)$$
$$\Leftrightarrow\ \underline{U}^2\geq\overline{U}^2-\overline{e}(\Delta\theta+\beta\Delta I^A). \quad (22)$$

We allow the consortium to leave the project if it is in her best interests to do so. Then, the participation constraints are such that:

$$\overline{U}^2 \geq 0, \quad (23)$$
$$\underline{U}^2 \geq 0. \quad (24)$$

The principal solves the problem $(P3)$ subject to $(19),(20),(21),(22),(23)$ and (24). The simplification of the number of relevant constraints leaves us with only two relevant constraints, the efficient agent's incentive constraint (21) and the inefficient type's participation constraint (24)[17]. This implies:

$$\underline{U}^2 = 0,$$
$$\overline{U}^2 = \underline{e}(\Delta\theta+\beta\Delta I^A). \quad (25)$$

[17]From the problem $(P3)$, we see that the principal's objective function is increasing in the agent's rents . So, since the rents are costly to the government, the contraints (21) and (24) are binding at the optimum. The incentive constraint of inefficient's type (22) seems irrelevant. Indeed, (21) and (24) immediately imply (23). Note that the neglected constraints (22) and (23) are satisfied by the solutions.

Only the efficient consortium gets a positive rent. This informational rent depends on the difference of the agent's type but also on the difference of the anticipated level of investment I^A[18].

At the second period, the government chooses an optimal static incentive scheme relative to his posterior beliefs updated using Bayes' rule. For the efficient consortium, the contract entails the first best level of effort:

$$\overline{e}^O = C_h^2 - C_l^2.$$

To simplify notations, the inefficient consortium's efforts are written as: $\underline{e}^O(C_l^1) = \underline{e}_L^O$ and $\underline{e}^O(C_h^1) = \underline{e}_H^O$. They depend on the observation of first period cost C^1.

$$\begin{aligned}\underline{e}_L^O &= C_h^2 - C_l^2 - \frac{\sigma_L}{(1-\sigma_L)}\left(\Delta\theta + \beta\Delta I^A\right),\\ \underline{e}_H^O &= C_h^2 - C_l^2 - \frac{\sigma_H}{(1-\sigma_H)}\left(\Delta\theta + \beta\Delta I^A\right).\end{aligned}$$

The efficient agent's rent is positive and her level of effort is the first best one. On the other hand, the inefficient agent obtains no rent. Furthermore, her suboptimal level of effort is due to the fact that the principal has an incentive to reduce her level of effort to lower the efficient agent's rent. Note that this downward distortion depends on the informativeness of the signal. If the principal observes C_l^1, he will think that is more likely that the agent is efficient. He thus has an incentive to reduce strongly $\underline{e}^O$ to lower the efficient agent's rent. On the contrary, if he observes C_h^1, he thinks he has a strong probability to face an inefficient consortium, then the distortion will be weaker. In this case, the consortium's compensation at the second period will depend on her performance in the current and the prior period.

First Period Bundling yields an investment that depends directly on the efforts:

$$\begin{aligned}\overline{I}^O &= \delta\beta\overline{e}^{FB},\\ \underline{I}^O &= \delta\beta(\underline{\theta}\underline{e}_L^O + (1-\underline{\theta})\underline{e}_H^O).\end{aligned}$$

The efficient consortium's investment, depending on her effort, corresponds to the first-best one. Only the inefficient consortium's investment is downwards distorted. As the construction cost is not realized when she invests, she envisages both efficiency issues. So, her investment decision is an expected value of the effort according to the cost C^1.

[18] The investment realized at the first period is considered as a private information for the consortium at the beginning of the second period.

At the equilibrium, the anticipated investment is equal to the realized one, $\overline{I}^A = \overline{I}^O$ and $\underline{I}^A = \underline{I}^O$, the level of consortium's investment are equal to:

$$\begin{aligned}\overline{I}^O &= \delta\beta(C_h^2 - C_l^2),\\ \underline{I}^O &= \delta\beta[C_h^2 - C_l^2 - \frac{v}{(1-v-v\delta\beta^2)}\Delta\theta].\end{aligned}$$

From the previous results, the levels of effort of the inefficient consortium will be defined as:

$$\begin{aligned}\underline{e}_L^O &= C_h^2 - C_l^2 - \frac{v\overline{\theta}}{(1-v)\underline{\theta}}[1+\delta\beta^2\frac{v}{(1-v-v\delta\beta^2)}]\Delta\theta,\\ \underline{e}_H^O &= C_h^2 - C_l^2 - \frac{v(1-\overline{\theta})}{(1-v)(1-\underline{\theta})}[1+\delta\beta^2\frac{v}{(1-v-v\delta\beta^2)}]\Delta\theta.\end{aligned}$$

When full commitment is not available, the principal succombs to the temptation to eliminate consortium's rent, i.e. he wants to expropriate the efficient consortium and to achieve more efficient level of effort for the inefficient one. But eliminating ex post inefficiencies enduces ex ante inefficiencies, which limits the inefficient consortium's investment.

Proposition 2 *In PPP contracts, government opportunism affects investment incentive negatively and induces a higher cost of the project.*

Due to the contractual setting, we notice that the consortium can not lead astray the government concerning her type. Indeed, she cannot influence principal's beliefs, the consortium's level of investment affecting only the second period costs. Sequential equilibrium eliminates ex post inefficiencies, but it encourages ex ante inefficiencies.

4.2 Comparison of Procurement Contracts under Government Opportunism

Traditional procurement contracts are the same as in the government commitment case. The reason is the following. As the infrastructure and the management of public utilities are being undertaken by two different firms, they do not suffer from lack of government commitment. The observation of the construction cost does not provide to the government useful information about the operator's efficiency.

As we have shown, the PPP induces greater incentives to invest and exert effort under the commitment assumption. However, this advantage is mitigated by relaxing this assumption which downwards distorts investments and efforts. PPP inefficiencies come from the temptation of the government to use revealed information to expropriate firm's rent.

Proposition 3 *PPP contracts may be more efficient than traditional contracts even when the government is tempted to behave opportunistically. However, it is the case only when the firm's competences are "sufficiently homogeneous" and/or if the probability of facing an efficient firm is "low enough".*

The intuition behind this proposition is the following.

Firm's competences are sufficiently homogeneous when the difference between firm's type $\Delta\theta$ is quite negligible. When it is the case and/or when the probability of facing an efficient consortium tends to zero, the information rent becomes insignificant. So, the rent expropriation from government is reduced, and the strategic consortium's response at the first period to this opportunism is less distorted. In other words, under these conditions, PPP contracts under government opportunism almost correspond to PPP contracts under commitment. In this case, we understand why they are more cost efficient than traditional procurement even if the government fails to honor his commitment. However, when consortiums become more heterogeneous and/or the probability of facing an efficient consortium is sufficiently high, the government opportunism leads to strong distortions affecting negatively the PPP cost efficiency. In this case, the traditional procurement contract is more efficient.

5 The extended model

An possible extension consists to add a moral hazard problem at the first period. The firm may exert an effort to reduce construction cost. We derive both contracts before to compare them.

5.1 The PPP

In this more sophisticated setting, the firm may exert an effort e^1 at the interim stage, i.e., after contracting but before learning her type. Therefore, the principal proposes a contract such that $\{(C_l^1, t_l^1), (C_h^1, t_h^1)\}$; $\left\{(C_l^2, \underline{t}_l^2), (C_h^2, \underline{t}_h^2), (C_l^2, \bar{t}_l^2), (C_h^2, \bar{t}_h^2)\right\}$. Note that the level of effort e^1 will be the same whatever her type in this model because at the moment of her choice, the firm don't know her type.

In this part, the second period incentive scheme will be chosen optimally given the beliefs'regulator about the firm's type at that date. These beliefs depend on the first period cost, and on the firm's equilibrium first period strategy (the firm's effort cannot be observed by the regulator). For any first period incentive scheme $t^1(C^1)$, the firm chooses a level of effort taking into account both effect on the first period reward and on the government's revision about her efficiency. The firm will be reluctant to exert effort which is supposed to entail low costs. Indeed, an agent with high performance today will tomorrow face a demanding incentive scheme. Lastly, the government chooses the first period incentive scheme knowing that the firm will take a dynamic perspective.

The principal is a bayesien expected utility maximizer. In designing the agent's payoff rule, he moves first as a Stackelberg leader anticipating the agent's behavior and optimizing accordingly within the set of available contracts.

Second period The results are the same than previously but now the probabilities σ take account of first period effort.

$$\begin{aligned} \underline{U}^2 &= 0 \\ \overline{U}^2 &= \overline{e}^2(\Delta\theta + \beta\Delta I^A). \end{aligned}$$

$$\begin{aligned} \overline{e}^{2*} &= C_h^2 - C_l^2 \\ \underline{e}^{2*} &= C_h^2 - C_l^2 - \frac{\sigma}{(1-\sigma)}\left(\Delta\theta + \beta\Delta I^A\right) \end{aligned}$$

First Period The firm chooses a level of effort taking into account both effect on the first period reward and on the regulator's inference about its efficiency. Note that the firm does not know her type at the moment of choosing e^1. The firm wants to affect the government beliefs but without using screening.

$$e^{1^*} = \arg\max_{e^1}\{E(U^1) + \delta[\sigma\underline{U}^{2*} + (1-\sigma)\overline{U}^{2*}]\} \tag{26}$$

$$\overline{I}^* = \arg\max_{\overline{I}}\{-g(\overline{I}) + \delta[E(\theta)\overline{U}^{2*}_{C_l^1} + (1-E(\theta))\overline{U}^{2*}_{C_h^1}\} \tag{27}$$

$$\underline{I}^* = \arg\max_{\underline{I}}\{-g(\underline{I}) + \delta[E(\theta)\underline{U}^{2*}_{C_l^1} + (1-E(\theta))\underline{U}^{2*}_{C_h^1}\} \tag{28}$$

$$E(U^1) = 0 \tag{29}$$

The solution is such that[19]:

$$e^{1*} < e^{1FB}$$

The first period effort is downward distorded from the first best as the investment level:

$$\begin{aligned} \underline{I}^* &= \delta\beta\frac{[C_h^2 - C_l^2 - 2\frac{\sigma}{(1-\sigma)}\Delta\theta]}{1 + 2\delta\beta^2\frac{\sigma}{(1-\sigma)}} \\ \overline{I}^* &= 0. \end{aligned}$$

[19] The effort is put in appendix due this unconfortable form.

The lack of institutional commitment reduces the efficiency of PPP downward distording the firm's effort and investment. At the first period, the firm's effort affect the building cost C^1. So, the firm is reluctant to convey favorable information (i.e. high effort) early in the relationship. Whatever her type, she has an incentive to convince the principal that she is inefficient.

From this explanations, we can formulate the following proposition.

Proposition 4 *No commitment entails a downward distortion from the first best level of investment and an undereffort affecting the probability that an efficient trade takes place in this extention case. It affects the efficiency of PPP.*

From now on, the agent may hold back on revealing information that could be used against her in later stages of the relation.

5.2 The Traditional Procurement

The government cannot use against the operator any cost information he infers from the observation of first period costs. So, the concession entails the first best outcomes as in the previous setting, but determines this additional level of effort at the first period such that:

$$e^{1FB} = C_h^1 - C_l^1.$$

This effort is supposed to be non-observable so that the principal faces a moral hazard problem when delegating production to the agent. This effort is extremely valuable for the principal, who always wants to implement a high level of effort from both types. Effort is still caracterized as a continuous variable. To solve this new problem under incomplete information entailed the same results about investment and second period effort than the previous setting. But it takes now into account the first period effort which is the first best.

5.3 The comparison of contracts

To be completed.

6 Conclusion

Recent years have witnessed the State withdrawal from the provision of public services. It resulted in a growing use of PPPs in many developed and developing countries. Public-Private Partnerships (PPPs) are presented as a way of resolving the lack of cost efficiency in traditional public procurement methods, by creating appropriate incentives among contracting partners. The consortium, having a long term perspective, will have greater incentives to realize investment, improving the infrastructure, in order to low the operating cost of the project. In contrast, with a traditional contract, the builder prefers to choose management strategies that maintain low construction costs. In this latter case, the builder and the operator do not have the same interests. It entails some cost inefficiencies. It results that PPPs are less expensive than the traditional contracts in a "strong" institutional environment, i.e. when the government honors its commitment. We have shown that the government commitment is one of the key factors responsible for the success of the PPP projects. When the government is opportunistic, the benefit of whole-life management for PPP contracts cannot be fully realized. We conclude that PPPs should be only chosen when the firms are "sufficiently homogeneous" and the probability to face an efficient one is "low enough".

Appendix

- **Proof of Proposition 2**: Decisons based on $P(\theta = \underline{\theta}/C^1)$ will be better than those based on $P(\theta = \underline{\theta})$ because they use the available information. This process of beliefs revision takes place according to the bayes' rule, and we obtain the following Bayesian Probabilities:

$$\begin{aligned}
P(\theta &= \overline{\theta}/C^1 = C_l^1) = \frac{v\overline{\theta}}{E(\theta)}, \\
P(\theta &= \underline{\theta}/C^1 = C_l^1) = \frac{(1-v)\underline{\theta}}{E(\theta)}, \\
P(\theta &= \overline{\theta}/C^1 = C_h^1) = \frac{v(1-\overline{\theta})}{1-E(\theta)}, \\
P(\theta &= \underline{\theta}/C^1 = C_h^1) = \frac{(1-v)(1-\underline{\theta})}{1-E(\theta)}.
\end{aligned}$$

To simplify the writing of the program, we used σ such that:

$$\begin{aligned}
\sigma &= P(\theta = \overline{\theta}/C^1) \text{ and } 1-\sigma = P(\theta = \underline{\theta}/C^1) \\
\text{where } \sigma &= \sigma_L \text{ when } C^1 = C_l^1 \\
\text{and } \sigma &= \sigma_H \text{ when } C^1 = C_h^1
\end{aligned}$$

At the second period, the efficient type's effort is the first best:

$$\overline{e}^* = C_h^2 - C_l^2,$$

and the inefficient type's effort are such that:

$$\begin{aligned}
if\ C^1 &= C_l^1\,, \quad \underline{e}_L^* = C_h^2 - C_l^2 - \frac{v\overline{\theta}}{(1-v)\underline{\theta}}\left(\Delta\theta + \beta\Delta I^A\right), \\
if\ C^1 &= C_h^1\,, \quad \underline{e}_H^* = C_h^2 - C_l^2 - \frac{v(1-\overline{\theta})}{(1-v)(1-\underline{\theta})}\left(\Delta\theta + \beta\Delta I^A\right).
\end{aligned}$$

We use a simplified notation of second period rents according to the observation of the contruction cost C^1. For the efficient firm, rents are written as:

$$\begin{aligned}
\overline{U}_l^2(C_l^1) &= \overline{U}_{lL}^2 \text{ and } \overline{U}_h^2(C_l^1) = \overline{U}_{hL}^2\ if\ C^1 = C_l^1\,, \\
\overline{U}_l^2(C_h^1) &= \overline{U}_{lH}^2 \text{ and } \overline{U}_h^2(C_h^1) = \overline{U}_{hH}^2\ if\ C^1 = C_h^1\,.
\end{aligned}$$

(resp. for the inefficient one with $\underline{U}$).

The efficient firm choose her level of investment such that:

$$\begin{aligned}
\overline{I}^* = \arg\max_{\overline{I}} \{ &-g(\overline{I}) + \delta[\ \overline{\theta}\ [(\overline{\theta} + \overline{e}^* + \beta\overline{I})\ \overline{U}_{lL}^2 + (1-\overline{\theta} - \overline{e}^* - \beta\overline{I})\ \overline{U}_{hL}^2] \\
&+(1-\overline{\theta})\ [(\overline{\theta} + \overline{e}^* + \beta\overline{I})\ \overline{U}_{lH}^2 + (1-\overline{\theta} - \overline{e}^* - \beta\overline{I})\ \overline{U}_{hH}^2]]\}
\end{aligned}$$

It entails:

$$\overline{I}^* = \delta\beta\overline{e}^*.$$

The inefficient firm choose her level of investment such that:

$$\begin{aligned}\underline{I}^* &= \arg\max_{\underline{I}}\{-g(\underline{I}) + \delta[\ \underline{\theta}\ [(\underline{\theta} +\ \underline{e}_L^* + \beta\underline{I})\ \underline{U}_{lL}^2 + (1-\underline{\theta} -\ \underline{e}_L^* - \beta\underline{I})\ \underline{U}_{hL}^2] \\ &\quad +(1-\underline{\theta})\ [(\underline{\theta} +\ \underline{e}_H^* + \beta\underline{I})\ \underline{U}_{lH}^2 + (1-\underline{\theta} -\ \underline{e}_H^* - \beta\underline{I})\ \underline{U}_{hH}^2]]\}\end{aligned}$$

It entails:

$$\underline{I}^* = \delta\beta(\underline{\theta}\underline{e}_L^* + (1-\underline{\theta})\underline{e}_H^*)$$

At the equilibrium, the anticipated investment is equal to the realized one,

$$\underline{I}^A = \underline{I}^*.$$

The level of inefficient firm's investment is such that:

$$\underline{I}^* = \delta\beta[C_h^2 - C_l^2 - \frac{v}{(1-v-v\delta\beta^2)}\Delta\theta]$$

It results that the level of effort will be defined as:

$$\begin{aligned}\underline{e}_L^* &= C_h^2 - C_l^2 - \frac{v\overline{\theta}}{(1-v)\underline{\theta}}[1+\delta\beta^2\frac{v}{(1-v-v\delta\beta^2)}]\Delta\theta \\ \underline{e}_H^* &= C_h^2 - C_l^2 - \frac{v(1-\overline{\theta})}{(1-v)(1-\underline{\theta})}[1+\delta\beta^2\frac{v}{(1-v-v\delta\beta^2)}]\Delta\theta\end{aligned}$$

- **Extended Model**: Bayesian Probabilities are such that:

$$\begin{aligned}P(\theta &= \overline{\theta}/C^1 = C_l^1) = \frac{(1-v)(\overline{\theta}+e^1)}{E(\theta)+e^1}, \\ P(\theta &= \underline{\theta}/C^1 = C_l^1) = \frac{v(\underline{\theta}+e^1)}{E(\theta)+e^1}, \\ P(\theta &= \overline{\theta}/C^1 = C_h^1) = \frac{(1-v)(1-\overline{\theta}-e^1)}{1-E(\theta)-e^1}, \\ P(\theta &= \underline{\theta}/C^1 = C_h^1) = \frac{v(1-\underline{\theta}-e^1)}{1-E(\theta)-e^1}.\end{aligned}$$

The probabilty that the agent is efficient is equal to $P(\theta = \underline{\theta})$. However, after the execution of the first contract, he observes the cost C^1 that he can use as a signal to better design of the contract. The probability distribution become then $P(\theta = \underline{\theta}/C^1)$. Clearly, decisons based on $P(\theta = \underline{\theta}/C^1)$ are better than those based on $P(\theta = \underline{\theta})$ because they use the available information.This process of beliefs revision takes place according to the bayes' rule as previously, but this Bayesian probabilities integrate e^1.

The optimal firm's effort at the first period is such that:

$$
\begin{aligned}
e^{1*} &= C_h^1 - C_l^1 + \delta\left(E(\theta) + e^1\right) \\
& \left\{ \begin{array}{c} (C_h^2 - C_l^2)\left[\beta \underline{I}^{*\prime}\sigma' + (\Delta\theta + \beta\underline{I}^*)\sigma''\right] \\ -2\beta\underline{I}^{*\prime}\tfrac{\sigma}{(1-\sigma)}(\Delta\theta + \beta\underline{I}^*)\left(2\sigma' - \tfrac{\sigma}{(1-\sigma)}(1-\sigma)'\right) + (\Delta\theta + \beta\underline{I}^*)\tfrac{\sigma}{(1-\sigma)}[(1-\sigma)' + (1-\sigma)'' - 2\sigma''] \end{array} \right. \\
& +\delta\left\{\frac{\sigma^2}{(1-\sigma)}\beta\underline{I}^{*\prime}(1 + \Delta\theta + \beta\underline{I}^*) - \frac{2\sigma\sigma'(1-\sigma) + \sigma^2(1-\sigma)'}{(1-\sigma)^2}(\Delta\theta + \beta\underline{I}^*)[1 - \frac{1}{2}(\Delta\theta + \beta\underline{I}^*)]\right\} \\
& -\sigma'\frac{(\underline{I}^*)^2}{2} - \sigma\underline{I}^*\underline{I}^{*\prime}
\end{aligned}
$$

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