Imperfect Bundling in Public-Private Partnerships

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Abstract

The economic literature on PPPs has generally overlooked agency problems within private consortia. We provide a first contribution in this direction, relying on a simple incomplete contracts framework where a Builder and an Operator set up a Special Purpose Vehicle (SPV) to carry out a contract with the government. Because of incomplete contracts, the bundling of tasks is imperfect, and the SPV ownership structure is the main tool to regulate the power of private incentives. The scope for welfare-improving PPPs reduces with respect to the case of perfect bundling, and the private negotiation always allocates a suboptimal SPV-ownership share to the Builder. Thus, imposing ownership requirements in PPPs is a welfare-improving policy.

Keywords: Incomplete contracts; Nash Bargaining; Ownership; Special-Purpose Vehicle
JEL classification: D86, L33, H11, H57

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1 Introduction

The global financial and economic crisis has caused a temporary decline in the value of PPP transactions during the last years.[1] Nevertheless, the conventional wisdom is that the long-run trend in infrastructure financing and operation across countries features a steady growth of private sector involvement. A crucial role is played by complex contractual or institutional forms of public-private partnerships (PPPs) (Wagenvoort et al., 2010).

PPPs are characterized (and justified) by risk-transfer from the public to the private sector, aiming at improving the efficiency of public investments. A key feature of PPPs is the bundling of different tasks, in particular investment-related and operation-related ones. Bundling is motivated by the attempt to exploit within-project economies (e.g., externality of design-and-build on operation), and by the opportunity of securitization of future project revenues to back current debt (and equity) investments.

These stylized facts bring us to recognize that some forms of PPPs have been used to undertake investments in public infrastructures at least since the XIX century (e.g., the concession of construction and operation of bridges, railways, and so on). What distinguishes these *old* forms of PPPs from the new ones, that have been introduced in the last few decades in many developed and developing countries, is the degree of legal and financial complexity of the latter. Let us consider, for example, the most prominent form of PPP, relying on the project finance technique. In this case, a number of firms and financial institutions - e.g., builders, core service operators, facility managers, financiers, insurers, consultants - legally establish a

[1] The European PPP market performed a marked decline in 2009, followed by a new growing cycle in 2010 and 2011 (EPEC, 2011).

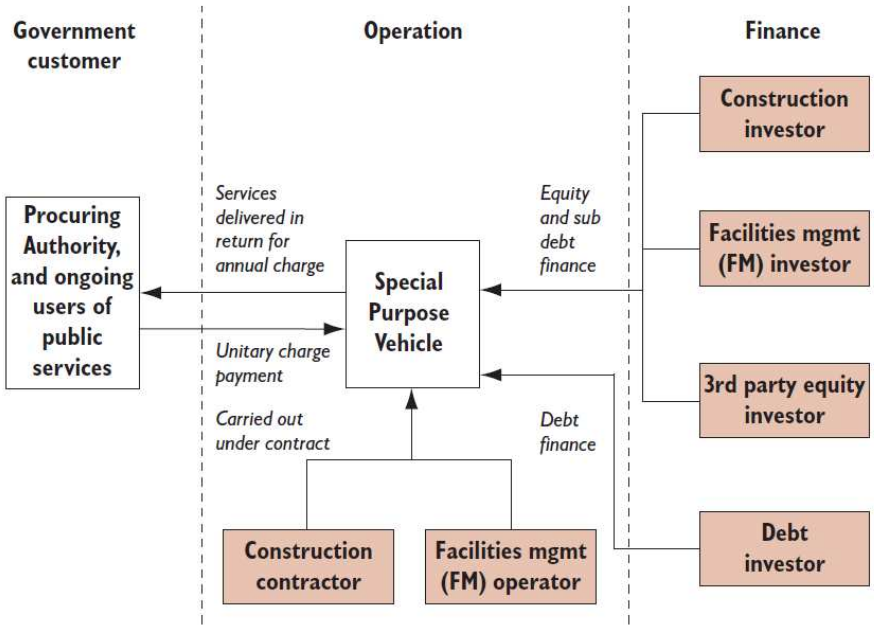

Figure 1: Bundling as Web of Contracts (HM Treasury, 2003, p. 43)

new company, or special-purpose vehicle (SPV), to carry out the project. All legal and financial obligations are backed by the future revenues of the project. The negotiation among involved firms and financial institutions hinges not only on the structure of the SPV but also on a *web of contracts* aiming at distributing risks and tasks among all (private) partners, as shown in Figure 1, (Engel et al., 2010).

This specific feature of PPPs has received little attention in the contract theory literature. Broadly speaking, the literature has contrasted Traditional Procurement (TP) procedures with PPP agreements in which subcontracting relationships are (at least implicitly) assumed unaffected by incompleteness of contracts or imperfect information problems, that on the contrary affect the relations between the government and the private consortium. Based on such a setting, the literature has clarified that the nature of efficiency gains afforded by PPP arrangements is basi-

cally related to enhanced incentives to improve infrastructure quality because of the internalization - within the private consortium of firms participating in the PPP - of the positive effects of investment effort on operation efficiency (Hart, 2003; Bennett and Iossa, 2006; Martimort and Pouyet, 2008; Iossa and Martimort, 2008).

Though many other issues have been addressed by the considered literature, encompassed by the broad theme of how incomplete contracts and imperfect information affect the capacity of government to regulate the behavior of the private consortium, the bulk of the literature has not yet considered the effects of incomplete contracting and asymmetric information within the consortium itself. Martimort and Pouyet (2008) clarified that the formation of a consortium as a single contractor of the government, which is an identifying character of PPPs, has two important implications: 1) private partners are able to share risks associated with the main contract; but 2) agency problems arise among private partners. The authors explicitly excluded the latter issue to focus on risk-sharing effects, but pointed out that *"the benefit of coordinated choice of efforts might be somewhat dissipated by internal agency problem"* (Martimort and Pouyet, 2008, p. 400). This intuition has been corroborated by Hoppe et al. (2011), who showed - through an experimental investigation on a procurement game - that contractual frictions among firms forming the consortium are likely to be relevant, and are responsible of a sensible divergence of empirical results with respect to the standard theoretical predictions.

In this paper we provide a first contribution in this perspective. We adapt a simple incomplete contracts model of PPPs *á la* Hart (2003)[2], to account for a preliminary bargaining phase among private partners aiming at determining the profit-

[2]Our setting is also quite similar to Bennett and Iossa (2006); Martimort and Pouyet (2008); Iossa and Martimort (2008).

sharing rules and property rights of the consortium[3] and the main sub-contracting agreements. We focus on the way imperfect bundling of tasks affects the performance of PPP with respect to TP, and the implications for optimal contracts between the government and the private consortium. We find that ownership structure is the main instrument to regulate the incentives of SPV partners. However, this fosters a fundamental trade off between improving the incentives of the Builder and those of the Operator. Because of this trade off, the scope for welfare improving PPPs is smaller than in the case of perfect PPPs. Also, the socially optimal ownership structure always involves a larger share to the Builder than the privately negotiated one. In turn, introducing minimum ownership constraints in PPP contracts improves the social welfare.

The paper is organized as follows: Section 2 introduces the theoretical setting; Section 3 analyzes our basic model involving imperfect bundling, contrasting it to the perfect bundling benchmark; Section 4 analyzes social welfare implication of imperfect bundling and considers possible welfare-improving policies; Section 5 discusses the relevance of imperfect bundling under incomplete contracts, as well as under richer informational settings. Section 6 draws some concluding remarks.

2 The Model

We consider a simple public procurement model. A public infrastructure, once build, has to be operated to provide a public service. The social welfare $S = S_0 + s \cdot (a - \alpha \cdot e)$ is assumed to be increasing in the public-infrastructure's quality, a ($s > 0$), and

[3] In this paper, there is a limited scope for the concept of ownership in the sense of residual control rights (Hart, 1995). We focus, instead, on the profit- and cost-sharing implications of negotiating alternative property rights over the SPV. The reason is that the SPV is explicitly set up to fulfill obligations deriving from the contract with the government. [COMPLETE HERE]

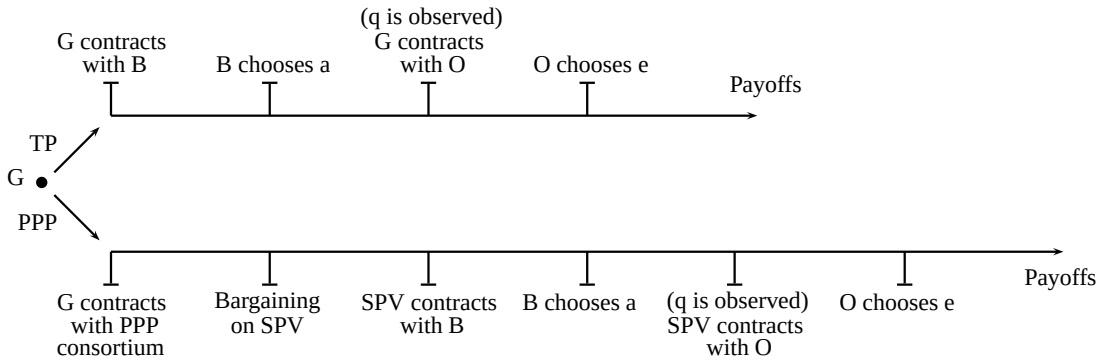

Figure 2: Sequential Game Structure

non-increasing in operation-phase productive efficiency, e ($\alpha \geq 0$). The investment (i.e., design and build) costs, $I = I_0 + a$, also increase in infrastructure's quality; moreover, improving the infrastructure's quality involves non-monetary management costs for the Builder (B) that, for the sake of analytical tractability, we assume equal to $i \cdot \frac{a^2}{2}$. The infrastructure's operation costs, $C = C_0 - (1 + \delta) \cdot a - e$, are reduced by productive efficiency, though pursuing it entails additional non-monerary management costs, $d \cdot \frac{e^2}{2}$, for the Operator (O); infrastructure's quality may increase ($1+\delta < 0$) or decrease ($1+\delta > 0$) them, depending on the specific technology under consideration.

It is worth remarking that in our setting we assume that the infrastructure quality has two economic dimensions: first, most important, and in line with the literature, an higher quality raises the social benefit provided by the infrastructure; second, we consider that more quality also raises (monetary) expenditures associated to design-and-building[4], besides the additional (non-monetary) managerial effort that is required to transform such expenditures in actual infrastructure quality. Though this more general setting brings to the same results of the standard models we find

[4]These are items that may appear in builder's accounts or in public procurement contracts.

in the literature in absence of any agency problem within the private consortium, it plays a relevant role when such agency problem is introduced. However, almost all results we find also apply to the conventional wisdom model, as we will discuss in Section 5.

We assume that the Government (G) maximizes the social welfare. As usual, G has to compare traditional procurement (TP) procedures, featuring sequential contracting with different firms carrying out investment (B) and operation (O), with public-private partnership (PPP) procurement. The sequential structure of the procurement game is represented in Figure 2. Under PPP procurement, G seals a single concession contract with a private consortium, typically gathering firms specialized in the different tasks, in our case building and operation, that are bundled in the PPP contract. To carry out the project, the private firms, B and O, establish a new company (i.e., the SPV).

The main focus of our analysis is on the bargaining process leading to the determination of private consortium structure, and its impact on the optimal structure and performance of PPP, and on the relationship between G and the private consortium itself. Therefore, before the design-and-construction phase we analyze a bargaining process specifying the property rights on the SPV, and the allocation of risks and tasks. We assume that the involved parties define the property structure of the consortium on the basis of the Nash Bargaining solution.[5] In particular, we assume that B's bargaining power is exogenously fixed to γ (hence, O's bargaining power is $1-\gamma$). Also, by individual rationality we assume that no firm would join a partnership determining negative profits, thus the disagreement point is equal to

[5]The Nash Bargaining solution can be seen as a reduced form of a negotiation game among parties featuring a risk of bargaining disruption, with (potentially) asymmetric costs of disruption driving the bargaining power (Osborne and Rubinstein, 2005).

zero.[6] Upon the bargaining phase, sub-contracts with B and O are implemented.

A key assumption of our analysis is that all contracts, i.e., contracts between government and private contractors, but also sub-contracts between the SPV and partner firms in the PPP case, are incomplete. In particular, both the infrastructure's quality, a, and the efficiency-enhancing effort, e, are unverifiable.

3 Incomplete Contracts

The first best benchmark is derived by the maximization of the net social welfare

$$\max_{\{a\geq 0, e\geq 0\}} S_0 + s\cdot(a-\alpha\cdot e) - I_0 - a - i\cdot\frac{a^2}{2} - C_0 + (1+\delta)\cdot a + e - d\cdot\frac{e^2}{2}.$$

Assuming that $s\cdot\alpha\leq 1$ corner solutions are excluded, the optimal investment in quality is $a^{FB}=\frac{s+\delta}{i}$ and the optimal effort to improve operational efficiency is $e^{FB}=\frac{1-s\cdot\alpha}{d}$.

Assuming that a sufficiently large number of B and O firms is available to undertake contracts with G, the procurement problem is easily analyzed. In the case of TP, G has to contract with B and then with O. Given that a cannot be verified, the optimal contract is fixed price, inducing zero investment in infrastructure quality, and such that the price is equal to the basic investment $T_B = I_0$ (Hart, 2003; Iossa and Martimort, 2008). In a similar way, by contract incompleteness about e, also the operation contract is a fixed price one. Because e is privately worthy, but O does not take into account the negative effect of it on the social welfare, the optimal

[6] In real world, firms starting PPPs procedures may incur in some sunk costs. In such a case, the profit associated to disagreement might be negative. However, such costs are never very relevant for involved firms, as compared to the value of the overall project.

effort in this case is excessive:

$$e^{TP} = \frac{1}{d} = argmax_{e \geq 0}\{T_O - C_0 + (1+\delta) \cdot 0 + e - d \cdot \frac{e^2}{2}\}$$

hence $e^{TP} > e^{FB}$.

Under PPP with perfect bundling, G offers a contract to a single company acting as B and O. Again by contract incompleteness the contract is a fixed price one, but the private contractor is able to internalize the (positive) externality of the investment phase on the operation phase. The private consortium in this case solves the problem

$$\max_{\{a,e\}} T_{PPP} - I_0 - a - i \cdot \frac{a^2}{2} - C_0 + (1+\delta) \cdot a + e - d \cdot \frac{e^2}{2}$$

hence, $e^{PPP} = e^{TP}$ and $a^{PPP} = \frac{\delta}{i} < a^{FB}$ when the investment in infrastructure's quality involves a sufficiently strong positive externality on the operation phase (i.e., $\delta > 0$). When the externality is not strong enough, i.e., $\delta < 0$, $a^{PPP} = 0 < a^{FB}$. Remark that this is equivalent to the case of negative externality elsewhere in the literature, e.g., Iossa and Martimort (2008). As argued above, we assume (differently from the considered literature) that quality involves additional design-and-build investments. If such investments do not reduce operating costs to a sufficient extent, i.e., the balance between higher investment in the building phase and positive externality in the operation phase is negative (or *negative net externality*), we have that the consortium chooses not to invest in quality. With this qualification, our results are comparable to the existing literature ones.

Thus, the PPP solution with perfect bundling is equivalent to the traditional

procurement one as regards production efficiency during the operation phase (which is excessive and reduces the value for money of the project), but may increase quality-enhancing investment. In particular, this is the case when infrastructure's quality involves a *positive net externality* between additional costs and benefits (i.e., $\delta > 0$), while in the case of *negative net externality* again zero investment in quality is reached.

3.1 PPP with Imperfect Bundling

The latter result is based on the strong assumption that bundling is perfect within the PPP private consortium. If we consider alternative settings where G deals with a general contractor who has to implement tasks through a sequence of subcontracts, these results do not hold any more. Under imperfect bundling (within PPP), we assume that private partners (and the SPV) face the same limitations as G in specifying contracts among them.

Given the incomplete contract setting, in the bargaining phase, B and O have to decide on the share of ownership of the SPV belonging to B (i.e., b) and to O (i.e., $1 - b$), but also on the subcontracting conditions. The sub-contracts cannot specify the level of effort (in terms of a or e), thus are fixed-price contracts, setting a payment for design-and-construction, P_B, and a payment for operation, P_O. Given these prices, the SPV has also to bear the operative costs, C. Therefore, the net profit of the SPV is

$$\Pi = T_{PPP} - P_B - P_O - C_0 + (1 + \delta) \cdot a + e \tag{1}$$

where T_{PPP} is the payment from G to the SPV, and the *consolidated* payoff (i.e.,

including the SPV's dividend) of B and O are

$$\Pi_B = b \cdot \Pi + P_B - I_0 - a - i \cdot \frac{a^2}{2} \tag{2}$$

$$\Pi_O = (1-b) \cdot \Pi + P_O - d \cdot \frac{e^2}{2} \tag{3}$$

respectively.

The level of subcontracts' payments, and the property rights are determined in the bargaining phase.[7] Once the bargaining process determines $\{b, P_B, P_O\}$, B and O carry out their tasks, choosing a and e, respectively. Solving the game (i.e., the branch PPP in Figure 2) by backward induction, O observes the level of a, and maximizes its profit (3): the optimal effort is found to be $e^{IB} = \frac{1-b}{d}$, that for any $b > 0$ implies an effort strictly lower than under the TP procedure (and the PPP when bundling is perfect). Given that the benefits from cost-cutting effort accrue only partially to the Operator, the incentive to bear such a cost shrinks.

In a similar way, B maximizes its profit (2), determining the optimal level of $a^{IB} = \frac{b \cdot (1+\delta) - 1}{i}$ (or $a^{IB} = 0$) if $b \cdot (1+\delta) \geq 1$ (or $b \cdot (1+\delta) < 1$). Thus, for a sufficiently strong positive externality, i.e., $\delta > \frac{1-b}{b}$ (where $\frac{1-b}{b} > 0$ whenever $b < 1$), $a^{IB} > a^{TP} = 0$. However, the optimal level of quality-enhancing investment is strictly lower than in the case of a perfect PPP.[8]

[7] This is what we observe in real world: the establishment of SPVs is characterized by a long and costly bargaining process aiming at determining all clauses that can actually be ex ante determined. Remark also that property rights regard only the value of the SPV, while the infrastructure, is assumed to be public. In the terms commonly used in the PPP literature, we focus on Build-Operate-Transfer schemes.

[8] Remark that the threshold in the level of δ under which no investment in quality is carried out is strictly larger than zero. This behavior depends on our assumption that higher quality requires more investments. In standard models, e.g., Iossa and Martimort (2008), Martimort and Pouyet (2008), where designing and building a higher quality infrastructure does not increases the monetary costs in the investment phase, the discontinuity in the privately optimal ownership structure b^{IB} takes place always at $\delta = 0$, independently of $\frac{i}{d}$ (Figure 4). We discuss this case in

Anticipating the optimal level of a and e that B and O will decide in the investment and operation phases, B and O negotiate over the property and sub-contracting structure of the private consortium. The bargaining solution $\{b^{IB}, P_B^{IB}, P_O^{IB}\}$ maximizes the Nash Product

$$\max_{\{b,P_B,P_O\}} \Pi_B^{\gamma} \cdot \Pi_O^{1-\gamma} \quad s.t.: \quad b \in [0,1]$$

where: by individual rationality, the disagreement profits are set to zero; γ is the bargaining power of B; and b is naturally constrained between zero and one.

The bargaining solution crucially depends on $a^{IB}(b)$ and $e^{IB}(b)$ functions. In particular, we observed that the derivative of $a^{IB}(b)$ is discontinuous. First, consider the case when $\delta \geq \frac{1-b}{b}$, hence $a^{IB}(b) \geq 0$. By the first order conditions of the Nash Product maximization, it is easy to check that corner solutions never arise. At the optimum, the payments P_B^{IB} and P_O^{IB} are such that

$$\frac{\Pi_O}{\Pi_B} = \frac{1}{\gamma} - 1 \tag{4}$$

Also, the optimal SPV ownership structure is $b^{IB} = b(\frac{i}{d}, \delta) \in (0,1)$, where

$$b\Big(\frac{i}{d}, \delta\Big) = \frac{1}{1 + \frac{i}{d \cdot (1+\delta)^2}} \tag{5}$$

Let us now turn to the case of $\delta < \frac{1-b}{b}$, hence $a^{IB}(b) = 0$. While the optimization condition featuring the optimal payments P_B^{IB} and P_O^{IB} remains (4), it is straightforward to see that now the optimal SPV ownership structure is $b^{IB} = 0$.

Summing up the previous results, we can characterize the optimal bargaining

Section 5.

solution among partners of the private consortium

Proposition 1 *Under imperfect bundling, the optimal PPP arrangements among private partners are such that:*

1. *the ratio between consolidated profits of partners depends just on their relative bargaining power, γ;*

2. *the ownership structure depends on the strength of the externality between investment and operation phases, δ, with a discontinuity at $\hat{\delta}(\frac{i}{d})$ (where $\hat{\delta}(\frac{i}{d}) \in (0, \frac{i}{d})$ and $\hat{\delta}' > 0$), in particular:*

$$b^{IB} = \begin{cases} b(\frac{i}{d}, \delta) & for \quad \delta \geq \hat{\delta}(\frac{i}{d}) \\ 0 & otherwise \end{cases}$$

Proof. The first statement derives by inspection of (4). As regards the second statement, remark that $b^{IB} > 0$ only if $a^{IB} \geq 0$, i.e., $b(\frac{i}{d}, \delta) \cdot (1 + \delta) \geq 1$. Let $\hat{\delta}(\frac{i}{d})$ be the value of δ such that $b(\frac{i}{d}, \delta) \cdot (1 + \delta) = 1$, or equivalently

$$\hat{\delta}\big(\frac{i}{d}\big) \equiv \Big\{\delta \mid \delta \cdot (1 + \delta)^2 = \frac{i}{d}\Big\};$$

therefore, $\hat{\delta}(\frac{i}{d}) \in (0, \frac{i}{d})$ and $\frac{\partial \hat{\delta}(\frac{i}{d})}{\partial \frac{i}{d}} > 0$. ■

It is worth highlighting the economic intuition of Proposition 1. As first, we see that the relative profits of partners are regulated by subcontract payments (P_B^{IB} and P_O^{IB}). Quite interestingly, the ownership structure is used by private partners to regulate their (future) incentives as subcontractors of the SPV. This nourishes a

fundamental trade-off between the strength of incentives of the Builder and of the Operator.

To understand this point, consider a comparative statics exercise on the ratio between the marginal costs of managerial efforts in the operation and investment phases, i.e., $\frac{i}{d}$. When $\frac{i}{d}$ increases two effects take place: given δ, if b^{IB} is positive then its optimal level drops; moreover, $\hat{\delta}(\frac{i}{d})$ grows, thus restricting the support of δ that is compatible with $b^{IB} > 0$. In other terms, when the marginal cost of managerial effort to raise infrastructure quality increases with respect to the marginal cost of managerial effort to curb operating costs (i.e., $\frac{i}{d}$ grows), it becomes less interesting for the consortium as a whole to invest in it. In turn, b^{IB} has to drop. In the same vein, a stronger (positive) externality between investment and operation phases (i.e., a higher private productivity of a) is required to make it interesting for the consortium to provide at least some incentives to the Builder to raise infrastructure quality.

4 Welfare Analysis

The analysis of the previous section underlined the implication of dropping the assumption that private consortia joining PPPs are unaffected by contract incompleteness. However, the introduction of internal agency problem in PPPs does not determine clear-cut welfare effects. As first, we remark that the effort to reduce operating costs drops as b increases. In particular, with $b^{IB} \in (0, s \cdot \alpha]$, the PPP under imperfect bundling is strictly welfare-improving with respect to TP (and to PPP under perfect bundling) as regards the level of e (given that $e^O \geq e^{FB}$). Indeed, an imperfect PPP involves weaker cost-cutting incentives. Conversely, if $b > s \cdot \alpha$

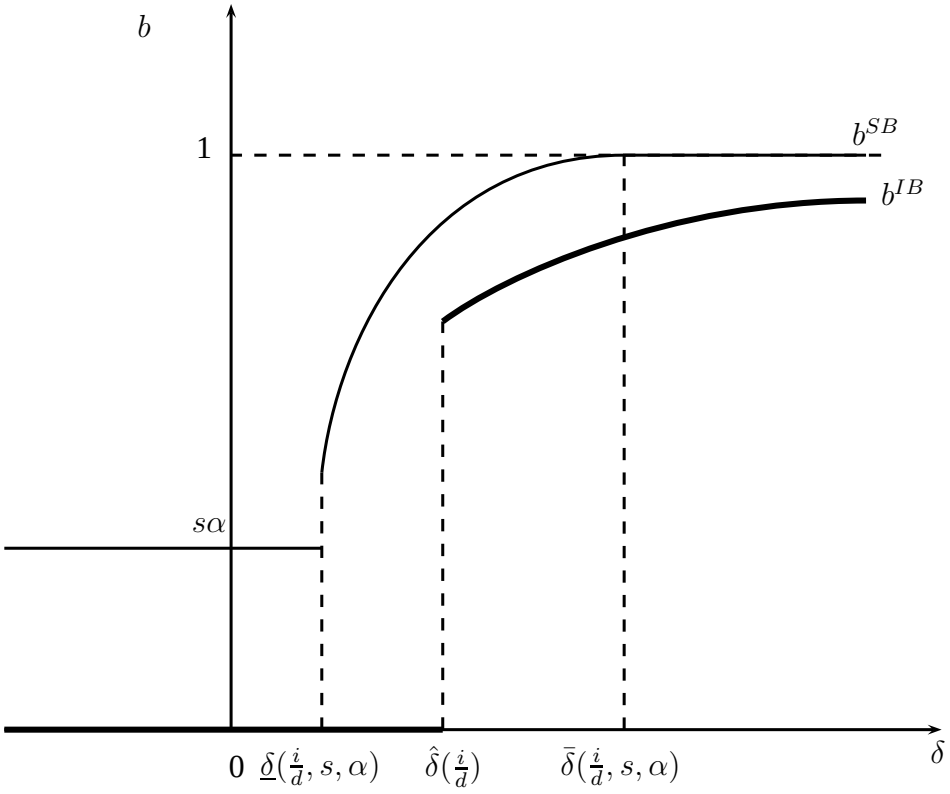

Figure 3: Optimal Ownership: Private vs Social

we may have that e is too low, and the social cost of this kind of (cost) inefficiency implies that PPP is worst than TP.

Potential welfare gains in the operation phase (with respect to perfect PPP) can come at the cost of welfare losses in the investment phase. In this case, if the balance between costs in the building phase and benefits (externality) in the operating phase is positive, the optimal effort to improve infrastructure's quality is strictly greater than under TP procedure, but lower than what one would expect in the case of perfect bundling - given $b^{IB} < 1$. In particular, under imperfect bundling a strictly stronger positive externality (i.e., $\delta > \hat{\delta}(\frac{i}{d}) > 0$), with respect to perfect bundling, is required to determine - at the bargaining equilibrium - sufficient incentives for B to improve infrastructure quality.

We now characterize the welfare effects of alternative ownership structures, i.e., $b \in [0, 1]$. It is easy to check that the social welfare function, depending on the ownership structures,

$$W^{IB}(b) = S_0 + s \cdot (a^{IB} - \alpha \cdot e^{IB}) - I_0 - a^{IB} - i \cdot \frac{a^{IB2}}{2} + \\ -C_0 + (1+\delta) \cdot a^{IB} + e^{IB} - d \cdot \frac{e^{IB2}}{2}$$

is concave in b; also, its first derivative is discontinuous at $b = \frac{1}{1+\delta}$, (because of discontinuity of the derivative of a^{IB} in b).[9] Such a discontinuity implies a first critical value of δ, that is relevant to determine socially optimal ownership structure:

$$\underline{\delta}(\frac{i}{d}, s, \alpha) = \{\delta \mid \frac{(1+\delta)^2 \cdot (s+\delta)}{1 - s \cdot \alpha \cdot (1+\delta)} = \frac{i}{d}\}$$

[9]Remark that for values of b below $\frac{1}{1+\delta}$, $a^{IB} = 0$.

(where $\frac{\partial \underline{\delta}(\frac{i}{d},s,\alpha)}{\partial \frac{i}{d}} > 0$, $\frac{\partial \underline{\delta}(\frac{i}{d},s,\alpha)}{\partial s} > 0$, and $\frac{\partial \underline{\delta}(\frac{i}{d},s,\alpha)}{\partial \alpha} > 0$).

A second critical value

$$\bar{\delta}(\frac{i}{d},s,\alpha) = \frac{i}{d} \cdot \frac{1 - s \cdot \alpha}{s} - 1$$

(where $\frac{\partial \bar{\delta}(\frac{i}{d},s,\alpha)}{\partial \frac{i}{d}} > 0$, $\frac{\partial \bar{\delta}(\frac{i}{d},s,\alpha)}{\partial s} < 0$, and $\frac{\partial \bar{\delta}(\frac{i}{d},s,\alpha)}{\partial \alpha} < 0$) is determined by the first order conditions of the social welfare maximization and features the level of δ above which the positive externality becomes so strong that the best ownership structure (in terms of social welfare) involves full property of the SPV to the Builder.[10] In such a case, the social value of infrastructure quality is so strong that, if no upper constraint existed on b, the social optimum implementation would require an extra marginal transfer from the Operator to the Builder proportional to the profit of the SPV (i.e., $b > 1$).

Lemma 2 *The socially optimal ownership structure is such that*

1. *if* $\delta \geq \bar{\delta}(\frac{i}{d},s,\alpha)$, $b^{SB} = 1$;
2. *if* $\delta \in (\underline{\delta}(\frac{i}{d},s,\alpha), \bar{\delta}(\frac{i}{d},s,\alpha))$, $b^{SB} = b(\frac{i}{d},\delta) \cdot (1 + \frac{s}{1+\delta}) + (1 - b(\frac{i}{d},\delta)) \cdot s \cdot \alpha$;
3. *if* $\delta < \underline{\delta}(\frac{i}{d},s,\alpha)$, $b^{SB} = s \cdot \alpha$.

The proof follows by manipulation of the first order conditions of the Kuhn-Tucker optimization problem incorporating the discontinuity at $b = \frac{1}{1+\delta}$ and upper and lower bounds on b (i.e., $b \in [0,1]$).

A first implication of Lemma 2 derives by comparison of the socially optimal ownership structure with the level of b that is privately negotiated by B and O.

[10] Remark that $\bar{\delta}(\frac{i}{d},s,\alpha) > \underline{\delta}(\frac{i}{d},s,\alpha) > 0$, whenever $\frac{i}{d} > \frac{s}{1-s\cdot\alpha}$.

Proposition 3 *Under imperfect bundling, the socially optimal ownership structure always involves a larger share for the Builder than the privately negotiated ownership structure.*

Proof. By $\alpha \geq 0$, $\hat{\delta}(\frac{i}{d}) > \underline{\delta}(\frac{i}{d}, s, \alpha))$, thus for any $\delta < \hat{\delta}(\frac{i}{d}))$ $b^{SB} \geq b^{IB} = 0$. For any $\delta \in [\hat{\delta}(\frac{i}{d}), \bar{\delta}(\frac{i}{d}, s, \alpha)]$, $b^{SB} = b(\frac{i}{d}, \delta) \cdot (1 + \frac{s}{1+\delta}) + (1 - b(\frac{i}{d}, \delta)) \cdot s \cdot \alpha > b^{IB}$. Finally, for any $\delta > \bar{\delta}(\frac{i}{d}, s, \alpha)$, $b^{SB} = 1 > b^{IB}$. ■

Figure 3 contrasts the social optimal ownership structure to the privately negotiated one. The intuition of Proposition 3 is similar to what is traditionally found in the PPP literature: given that the private consortium does not take into account the full benefits of investing in infrastructure quality (i.e., s), and does not consider the social burden of investing in operating cost cuts (i.e., $-\alpha s$), the privately negotiated ownership structure is conceived to provide excessive incentives to the Operator to cut operating costs and insufficient incentives to the Builder to improve infrastructure quality.

It is worth remarking that the social welfare associated to TP contracts is equivalent to the social welfare associated to PPP with imperfect bundling when b is fixed to zero, independently of the relevant parameters. By this reasoning, we can draw the following conclusion

Corollary 4 *Under imperfect bundling, the PPP contract weakly dominates the TP contract in terms of social welfare (strictly whenever $\delta > \hat{\delta}(\frac{i}{d})$).*

Proof. The proof follows by the consideration that $b^{SB} \geq b^{IB} \geq 0$ and that the social welfare function is concave in b. In particular, the social welfare function

takes strictly larger values when $b^{IB} > 0$ (hence for $\delta > \hat{\delta}(\frac{i}{d})$). ■

Thus, the PPP with imperfect bundling is still a solution (strictly) improving the social welfare for sufficiently large positive externality between the investment and the operation phases (i.e., $\hat{\delta}(\frac{i}{d}) > 0$). The Proposition 3 also implies that a further improvement of the social welfare can be determined if the government is able to impose a *minimum ownership share* to the Builder in SPV, letting the negotiation among private partners to take place on the other relevant variables such as subcontracting payments.

It is also worth remarking that the second best optimal solution that is obtained in the latter case (i.e., a PPP with imperfect bundling and minimum ownership requirements) is not dominated by the PPP under perfect bundling for all possible parameters. Quite intuitively, the PPP with imperfect bundling determines better results in social welfare terms when the the net balance of costs and benefits of investment in quality is negative for the consortium (i.e., $\delta < 0$). In such a case, under imperfect bundling, if the government can regulate the ownership structure of the private consortium, it can curb the power of the incentives of the Operator (i.e., by imposing a cap on b), thus mitigating the management effort to cut operating costs.

5 Imperfect Bundling: Discussion

How relevant is the imperfect bundling assumption? Though such an assumption is strongly motivated by real-world functioning of PPPs (Figure 1), we may wonder about the generality of results it delivers in incomplete contracts settings, and about

its added value in alternative informational environments.

In our simple framework characterized by incomplete contracts, imperfect bundling in private consortia joining PPPs implies two main results: first, the privately negotiated ownership structure of SPV is suboptimal from the social welfare point of view; second, in absence of policies affecting the governance of the SPV, imperfect bundling reduces the scope for welfare-improving PPPs (as compared to TP). The first result is quite general and derives by the fact that private firms' negotiation does not internalize the positive social effects of infrastructure quality, thus it holds also under alternative characterizations of the private costs and benefits of infrastructure quality (Figure 4). On the contrary, the latter result is somewhat specific to the assumed structure of costs in the investment and operation phases.

As argued in the previous sections, we assumed that increasing the infrastructure quality entails additional monetary costs in the investment phase (i.e., $I = I_0 + a$), as well as potential monetary benefits in the form of reduced operation costs if there is a positive externality (i.e., $1 + \delta > 0$); the net externality, i.e., the net balance of private costs and benefits of increased infrastructure quality, is measured by δ. Under perfect bundling, our results coincide with what is obtained in standard models of PPPs, e.g., Iossa and Martimort (2008), Martimort and Pouyet (2008), who assume that increasing the infrastructure quality does not involve any additional monetary cost, and may (or may not) determine a positive externality on operation costs (equal to δ). Under imperfect bundling the behavior of the two kinds of models diverge. Our modeling, that in some sense relies on gross accounting of costs and benefits of infrastructure quality, delivers the results that we analyzed in the previous sections. In particular, under our assumptions, there is a minimum positive level of net externality (i.e., $\hat{\delta}(\frac{i}{d}) > 0$) below which the privately negotiated ownership

structure would involve full property awarded to the Operator, hence the PPP would be equivalent to the TP, notwithstanding a positive externality of infrastructure quality on operation costs (Figure 3). Under a more standard modeling of costs and benefits of infrastructure quality, such a minimum threshold would collapse to zero. In other words, the privately negotiated ownership structure always involves, for $\delta > 0$, at least some share of SPV property awarded to the Builder (Figure 4).

The results obtained under the alternative specifications of private costs and benefits of infrastructure quality diverge because of the impossibility of summing costs and benefits of different firms under imperfect bundling. Indeed, the Builder's consolidated profit, which includes part of SPV profit, takes into account only a fraction b of the private benefit of investing in infrastructure quality, while fully internalizes the cost of it. In other terms, cost and benefit accounting becomes quite crucial when we introduce imperfect bundling in the analysis of PPPs.

A natural extension of our approach would be to consider the PPP internal agency problem in more rich environments, taking into account asymmetric information, complete contracts, and default risk. We expect our main results to be quite affected in such richer framework. In particular, as highlighted by Martimort and Pouyet (2008), the incomplete contracts framework is likely to overemphasize the role of property rights. To understand this point, we remark that in our model changing the SPV property share of the Builder (or the Operator) does not entail any trade off, as it would be with asymmetric information, complete contracts and risk-averse firms. Still, imperfect bundling is likely to play a crucial role also in the latter setting. In particular, the determination of the SPV ownership structure would be quite relevant to trade off risk-sharing and incentives (which would also be regulated by sub-contracts).

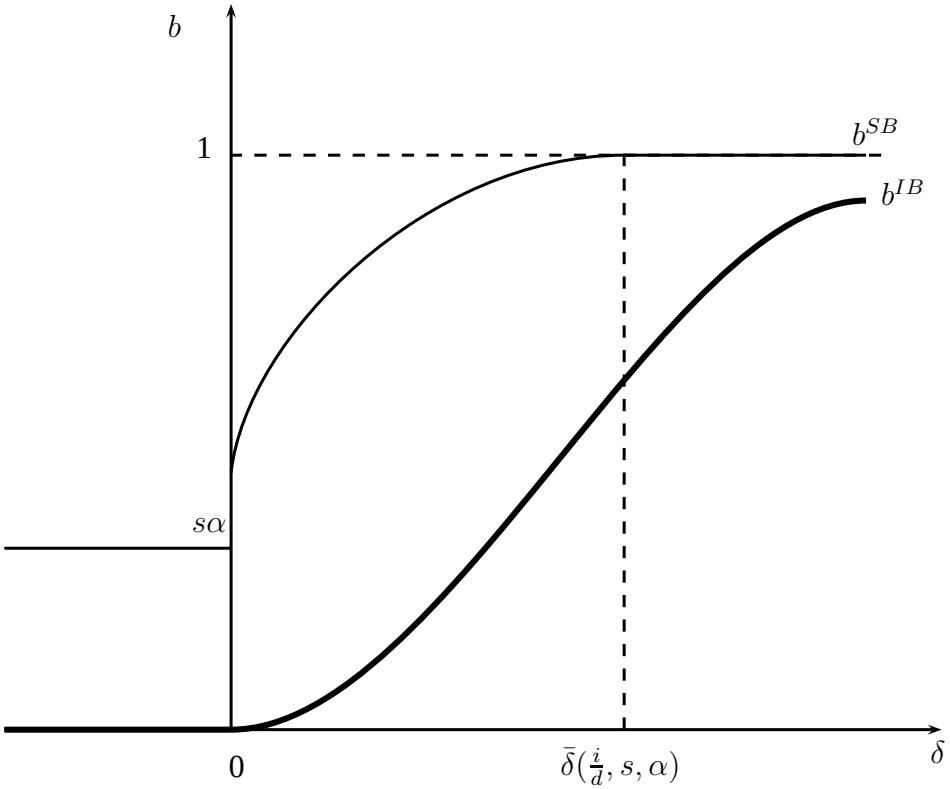

Figure 4: Optimal Ownership under Standard Modeling

Also, in the mentioned asymmetric information setting, the formation of coalitions among private partners of PPPs could be relevant to investigate the role of financial institutions and financial tools in PPPs. The contract theory literature on PPPs has mainly analyzed the role of financiers and financial tools along two perspectives. A first perspective is characterized by the idea that financiers are supervisors of builders and operators, relying on more effective monitoring technologies, thus potentially improving the performance of PPPs (Dewatripont and Legros, 2005; Iossa and Martimort, 2008, 2011). A different perspective considers private finance and financiers as a tool to solve a commitment problem that hinders the government to shut down bad projects (de Bettignies and Ross, 2009).

Another complementary perspective can be considered once we realize that PPPs rely on imperfect consortia of private firms, including financiers. In such a framework, financiers may play the role of *budget breakers* of private consortium they formed with builders and operators. In this perspective, the analysis of financial tools featuring private consortia joining PPPs may be employed to address the issue of the optimal financial structure of SPV warranting a better alignment of private and public interests in PPPs.

6 Conclusion

The contract theory literature on PPPs has often considered a fundamental asymmetry between public-private contracting, i.e., contracts between the private consortia (or SPV) and the government, and contracting among private partners belonging to the SPV. The public-private contracts have been typically (and rightly so) assumed to be affected by contract incompleteness and/or information imperfection. On the

other side, the effects of such imperfections have been overlooked as regards the second kind of contracts, among private partners.

In this paper, we showed that the agency problem among private partners determine several important effects in a framework of incomplete contracts. As first, the ownership structure of SPV plays a crucial role in determining the balance between incentives of the consortium to pursue more strongly improvements in infrastructure quality *or* in operation X-efficiency. In turn, this implies that stronger positive externality between investment and operation is required to warrant welfare-improving PPPs. Quite interestingly, the private negotiation always delivers suboptimal ownership structures (from the point of view of the social welfare), given that only the private balance between the costs and benefits of quality and efficiency are taken into consideration. Once additional social benefit of quality (or social costs of X-efficiency) enter the picture, we found that the socially optimal ownership structure should involve stronger incentives (i.e., ownership share) for the Builder.

An important policy implication of our work is that PPP contracts should introduce requirements on ownership structures, that are observable and contractible, while other features may not. This is partially in line with what we observe in real-world public procurement auctions, which often introduce similar requirements. An extension of such practices to PPP contracts should be taken into consideration.

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