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Public-Private Partnerships with Infrastructure Funds: an Optimal Incentive Device

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Abstract

We study the scheme of public-private partnerships (PPP) from an incomplete contracting perspective. We show that PPP can implement an efficient level of investment in a public project with externalities through a bargaining game played by the public sector and the delegated private agent, which functions as a device in internalizing the externalities. Also, we analyze the governance role of an infrastructure fund in PPP through its interaction with the financial market.

Keywords: PPP, Incomplete contracting, Externalities, Infrastructure fund
JEL classifications: D62, D86, G39

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1. Introduction

Public projects implementation by private entities has been recently promoted with an expectation that it improve efficiency by allowing the use of the private sector's expertise in the business as well as its funding ability. However, an obvious problem for the former is the private entities' lack of incentive to internalize externalities originating from public goods nature of the projects, which will adversely affect the quality of the projects. Also, for the latter, the use of external finance will cause typical moral hazard problems as been heavily discussed in the corporate finance literature.

The purpose of this paper is to analyze the public-private partnership (PPP) scheme as a contractual arrangement to address these problems. We view PPP from an incomplete contracting perspective that seems to fit well to explain distinctive features of PPP: long-term and complex nature of projects, specificity of investments, and frequently observed renegotiations of contracts between parties.

We consider a typical PPP project that generates social benefits as externalities which are not tradable in the market. The project consists of two stages, building and operating, which captures the long-term nature of the project. In the building stage a specific investment in the asset is made while in the operating stage the service from the asset is realized. We assume that the tasks of both stages are delegated to a special purpose vehicle (SPV), a private entity with limited liability set up for engaging specially in the project for expertise reasons. We also assume that the project is financed through an infrastructure fund (IFD) which raises money from the financial market to avoid tax spending for perhaps a political reason.

The assumption of one SPV engaging in both stages can be justified for several reasons including the claim that bundling can internalize externalities over the two stages (e.g., Hart (2003)). In this paper however we rather borrow the idea from the standard incomplete contracting modeling that the human capital developed in the building stage is indispensable in the operating stage. Thus we simply assume bundling over the stages since it is always superior in the efficiency sense.

The first feature of the model is an explicit use of bargaining games to resolve the externalities problem. SPV, unconcern about the social benefits as externalities, cannot commit to take the appropriate actions unspecified in the complete contracts. However, it can indirectly internalize at least part of them through bargaining games with the government which appreciates the fair value of the social benefits. Thus, renegotiation of initial contracts in PPP can improve social welfare because it works as a mechanism to incentivize investments. In fact, as Guasch (2004) reported in cases in Latin American countries, renegotiations occur quite often in concession contracts in PPP. Then the government should

design contract scheme allowing rooms for renegotiations, which will result in the efficient outcome. Note that for the renegotiation to occur the ownership of the project should be allocated to the government which does not make any investments decision. This contrasts to a result of the standard incomplete contract models showing that the ownership should be allocated to the party of making the most important investment decision (Hart (1995)).

The second feature of the model is the focus of IFD's governance role. Besides assumed expertise in specialized evaluation, IFD has an advantage of using the financial market for not only disciplining SVP's behavior but committing itself to monitoring SPV. Although the use of private finance has been considered an important feature of PPP, the governance aspect of the financial intermediary, a main research topic in corporate finance, has been somewhat ignored. Part of the reasons would be that public goods nature of PPP projects does not seem to fit well with profit-driven governance mechanisms, or that the financial intermediary itself may face moral hazard problems since it becomes informational monopoly. Both problems, however, can be overcome in the model of this paper.

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As the main results it is shown that renegotiation games between the government and SPV function as a device of internalizing the project's externalities and that the involvement of IFD which interacts with the financial market can play a disciplinary role.

Literature

This paper relates to two strands of literature: PPP as an incomplete contracting scheme and the governance role of financial intermediaries with costly monitoring.

Hart (2003) is seminal in analyzing PPP in an incomplete contracting perspective while Bennett and Iossa (2006) analyze bargaining games in PPP explicitly. These papers analyze efficiency in various ownership structures, particularly the efficiency in bundling of building and operating stages through ownership. This paper rather starts with bundling by assuming indispensability of the investing party in the both stages to focus on analyzing the effects of renegotiation games. The possibility of superiority of the government's ownership in public goods provision with bargaining was pointed out in Besley and Ghatak (2001), although their setting is very different from ours.

The use of private finance is considered important part of PPP as shown in the name of Private Finance Initiative, an influential type of PPP. Then, as corporate finance literature suggests, SPV is likely to face moral hazard problems in PPP with outside finance and financial intermediary would play governance roles. However, very few research has been studied on this issue in PPP. This paper studies an asset substitution moral hazard problem in the context of PPP in line with the idea of bank's

monitoring. A novelty of the model is focus on effects of fund's interaction with the financial market as monitoring incentives.

The organization of the paper is as follows. In section 2, we set an incomplete contracting model of PPP where there are externalities and moral hazard problems. In section 3, we analyze the model to obtain the results. In section 4, we conclude in discussing policy implications.

2. The Model

2-1 Project

The government has a project generating social benefits *B*, service non-tradable in the market as externalities, with an operating cost *C*. The project consists of two stages: the building stage and the operating stage. In the building stage, a fixed investment i which will affect *B* is made. We assume that the investment is relation-specific so that the investing party will be indispensable in the operating stage. In the operating stage, uncertainty θ occurs, which will affect *C*. Given θ, a level of the quality *q* is chosen, which will affect both B and *C*. At the end of the stage, B and *C* are realized. The variable i is the investing party's private information which is unobservable while θ and *B* are observable but unverifiable to the public. *B*, *C* is given as follows:

$$B(i,q);\ \ B_i(i,q)>0; B_{ii}(i,q)<0;\ \ B_q(i,q)>0;\ \ B_{qq}(i,q)<0$$
$$C(q,\theta);\ \ C_q(q,\theta)>0; C_{qq}(q,\theta)>0;\ \ C_\theta(q,\theta)>0;\ \ C_{\theta\theta}(q,\theta)>0$$

Notice that we assumes away externalities of the investment over the two stages since unlike previous researches our focus is not in the bundling problem. Rather, we start with the bundling by assuming indispensability of the investing party in the operating stage. Notice also the role of *q* affecting *B* and *C* in the opposite way: higher *q* will increase the value of *B* but incur higher *C*.

The first best choice of *i* and θ are following:

$$i^* = \underset{i}{\text{argmax}}\{\int_\theta [B(i,q(i,\theta),\theta) - C(i,q(i,\theta),\theta)]d\theta - i\}$$
$$q(i,\theta) = \underset{q}{\text{argmax}}\{B(i,q,\theta) - C(q,\theta)\}$$

2.2 Information structure

We assume that *i* is private information of the investing party so that it is non-contractible; otherwise

externalities can be resolved by directly controlling i through a contract. Also we assume that θ is observable but non-contractible: it is too complex to be specified in contracts. The outcome B and C are not contractible either since they depend on θ.

2.3 Delegation contract

The government delegates as a form of concession all the actions over the two stages to SPV which was chosen at an un-modeled previous date. At the beginning of the building stage they agree on a concession contract. Since it cannot be written on i, θ, nor B, the contract specifies a regulated price p_0 for the service delivered and the concession fee F of a concession right that entitles SPV an exclusive right to use the asset and to take the profit from it.

Notice that in the standard moral hazard problem SPV could be incentivized with a contract rewarding them according to the level of the outcome B or C. In this model, however, this type of contract is impossible because of their assumed non-verifiability. Notice also that the ownership of the asset remains in the government for renegotiations can occur: the government would no bargaining power without the ownership of the asset since it is dispensable for operating the asset. This setting is different from previous models which analyze incentive effects of the ownership allocation between the government and private entities. Also, the government issues a performance bond, a guarantee insuring the government the concession fee when the concession contract is not implemented.

2.4 Externalities Problem

SPV cannot be rewarded in providing B in the market since B is externalities. Thus SPV alone will choose:

$$i^{SPV} = 0$$

$$q^{SPV}(\theta) = \underset{q}{\operatorname{argmin}}\{C(q,\theta)\},$$

Besides it cannot be incentivized through standard incentive contracts since i, θ and B are non-contractible. Thus, through the market or the standard contracting, SPV does not make the sufficient level of investment. To address this problem we focus in this model on the use of bargaining games. SPV can internalize the social benefits indirectly through bargaining games with the government who appreciates the value of the social benefits. Thus, the use of bargaining games recovers SPV at least part of incentive to invest in the social benefit. Therefore, the goal here is designing the appropriate bargaining game to be played as renegotiation.

2.5 Financial Scheme

SPV without money needs outside finance for the investment. We assume that SPV raises money through a financial intermediary or the financial market of dispersed investors. But then SPV with outside finance faces moral hazard problems since SPV's actions are private information. To resolve this problem we focus on financing through IFD, raising money in the form of the short-term debt from the financial market, which is assumed to observe SPV's behavior by spending a fixed monitoring cost $m \in \{0, M\}$, which is observed only by IFD itself and SPV. Note that this scheme is similar in the spirit to the bank monitoring literature except that IFD does not raise money through deposits but the financial market that could discipline IFD effectively.

At the beginning of the building stage, SPV borrows a short-term debt with the face value D from IFD for its investment. Then IFD decides whether to spend m for monitoring. At the end of the building stage, IFD decides whether to renew the loan with the same as the initial conditions or terminate it. IFD's decision is assumed to be public information: both the government and the financial market observe the decision. If the loan is terminated, SPV must raise money for the repayment through the financial market. IFD may guarantee part g of the investors' losses.

2.6 Asset substitution problem

Because of limited liability, SPV may face a moral hazard problem of asset substitution. To incorporate this problem into the model, we assume that SPV has an alternative choice for each i in building the asset without any additional cost. The choice is observable only to SPV itself and IFD with spending M. The alternative choice faces another independent uncertainty: it is successful with probability r. Let R^A and C^A denote the revenue and the operating cost when it is successful while r^A and c^A when unsuccessful.

By the efficiency assumption:

$$\max_i\{\left[s\left(R^A(i) - C^A(i)\right) - (1-s)\left(r^A(i) - c^A(i)\right)\right] - i\}$$
$$< \max_i\{\int_\theta [B(i, q(i,\theta), \theta) - C(i, q(i,\theta), \theta)]d\theta - i\}$$

However, it is assumed with limited liability:

$$\max_i\{s\left[\left(R^A(i) - C^A(i)\right) - i\right]\} > \max_i\{\int_\theta [B(i, q(i,\theta), \theta) - C(i, q(i,\theta), \theta)]d\theta - i\}$$

Thus, SPV has an incentive to choose the alternative investment that is socially inefficient but more profitable to SPV. We denote SPV with the efficient choice as the efficient type while SPV with the alternative choice as the inefficient type.

All the parties are assumed to be risk neutral since this paper focuses on the incentive aspect of PPP rather than that of risk sharing.

Time Line

There are five dates. At date 0, the government and SPV agree with a concession contract. The government issues a performance bond.

The building stage includes the following two dates. At date 1, IFD decides to spend monitoring cost m. After observing m, SPV decides the level i and type t of an investment by a short-term debt from IFD, which raise money through the financial market. At date 2, IFD observes i and t if it spends $m=M$. Then, IFD decides to renew or terminate the loan. If the loan is terminated, SPV will finance the repayment money through the financial market. Observing IFD's decision to renew, the government forms a belief about SPV's type.

The operating stage includes the following two dates. At date 3, the government and SPV renegotiate the regulated price for service p_0. If no agreement is reached, the game ends; the project is stopped, the SPV earns zero, and the government is paid F through the performance bond. If the game continues the parties go on to date 4. At date 4, θ occurs. Then, the government and SPV renegotiate the level of quality q. If no agreement is reached, the game ends; the project is stopped, the SPV earns zero, and the government is paid F through the performance bond. If the game continues, the outcome B and C are realized and monetary rewards are distributed to the parties according to the contracts.

3. Analysis

3.1 Operating stage

We solve the game backwards. At date 4, SPV decides the level of quality. I analyze in assuming that the government has learned i in the operating stage as a result of games played among parties in the building stage.

Proposition 1. *Assume that the government learns i. Then at date 4 SPV alone will not implement the efficient quality. However, it will implement the efficient quality as a result of a renegotiation of the regulated price with the government.*

Proof. Suppose first renegotiation is impossible. Then, SPV with a concession right will maximize only its own profit. Thus, given the regulated price p_0, SPV will choose:

$$q^{SPV}(\theta) = \underset{q}{\operatorname{argmin}}\{C(q,\theta)\} \neq q(i,\theta).$$

Suppose now renegotiation of the regulated price is possible. Then, the parties bargain over:

$$[B(i,q,\theta) - C(i,q,\theta)] - p$$

Thus, regardless of any sharing rule, it is in the interest of the both parties to choose:

$$\underset{q}{\operatorname{argmax}}\{B(i,q,\theta) - C(q,\theta)\} = q(i,\theta)$$

So, for any given i and θ, they reach the efficient level of quality $q(i,\theta)$ ■

The proposition 1 says that a bargaining game allows parties to choose the efficient quality level that maximizes the size of the pie to be shared. Since PPP projects are generally too long-term and complex to specify in contracts ex ante, renegotiation would be useful. Note that the regulated price p that is set at the previous date works here as the status quo of the bargaining game.

Proposition 2. *Suppose SPV is the efficient type and the government learns i. Set the concession fee as follows:*

$$f = \frac{1}{2}\int_{\theta} [B(i^*, q(i^*,\theta)) - C(q(i^*,\theta))]d\theta.$$

Then at date 3 the bargaining game between the government and SPV results in the regulated price p being renegotiated to:

$$p(i) = \int_{\theta} B(i, q(i,\theta))d\theta - f.$$

Proof. Since the government believes SPC is the efficient type and it is a common knowledge, and in fact SPC is the efficient type, we can consider the situation as complete information. Because SPV is indispensable and the government is the owner of the asset, renegotiation on the concession fee will necessarily occur. Since the government appreciates the expected value of the social benefit, the parties bargain over:

$$\int_\theta [B(i,\theta) - C(i,\theta)]d\theta.$$

Then, since the government's outside option is F from the performance bond while SPV's outside option is zero, in following the standard non-cooperative bargaining game, the government's share will be:

$$\max \left\{\frac{1}{2}\int_\theta [B(i,q(\theta)) - C(q(\theta))]d\theta, f\right\} = f$$

since by the definition of i^*, for any i,

$$\int_\theta [B(i,q(i,\theta)) - C(q(i,\theta)]d\theta \leq \int_\theta [B(i^*,q(i^*,\theta) - C(q(i^*,\theta))]d\theta.$$

So, SPV's share will be:

$$\int_\theta [B(i,q(i,\theta)) - C(q(i,\theta))]d\theta - f$$

Thus, the renegotiated price of the service p will be:

$$p = \int_\theta B(i,q(i,\theta))d\theta - f \quad \blacksquare$$

3.2 Building stage

First, we prove the proposition showing that SPV's loan continuation decision correctly convey SPV's type.

Proposition 3 *At date 2, (1) SPV chooses the efficient type if m = M while it chooses the inefficient type if m = 0; (2) The government and the financial market believe that SPV's type is efficient if IFD renew the loan while they believe that the type is inefficient if IFD terminates the loan.*

Lemma 1 *Suppose IFD observes SPV's type and SPV knows it. Then, I the type is efficient then IFD will renew the loan; if the type is inefficient then IFD will terminate the loan.*

Proof. Suppose that IFD learns SPV's type is efficient. Then it is SPV's interest to renew the loan since it will be repaid D in earning the interest rate for one more period. Suppose instead that IFD learns SPV is inefficient. Then if it terminates the loan then the IFD will be repaid D; however, if it renew the loan then it will be repaid only $sD < D$. ■

Lemma 2 *Suppose IFD does not observe SPV's type and SPV knows it. Then, IFD will always terminate the loan since it is a dominant strategy for SPV to choose the inefficient type.*

Proof. Suppose SPV has a prior belief $b > 0$ in IFD choosing to renew the loan. Given a fixed b, it is in SPV's interest to choose the inefficient type because regardless of IFD's decision SPV will be better off in the inefficient type since SPV's actions which is unobservable will not affect IFD's continuation decision. But then IFD is always better off in choosing to terminate the loan. This contradicts with $b > 0$. Thus, SPV has $b < 0$ and choose always the inefficient type. ■

Proof of Proposition 3. (1) Suppose that the government and the financial market observe IFD's decision. Then the lemma 1 and 2 imply that SPV is an efficient type if IFD renews the loan while is an inefficient type I it terminates the loan. (2) Suppose $m = M$. Then, IFD learns SPV's type and SPV knows it. Suppose SPV chooses the inefficient type. Then from Lemma 1 IFD will terminate the loan. But then from (1) the financial market believe that SPV is the inefficient type so that it requires higher return for the new loan. Suppose SPV chooses the efficient type. Then from Lemma 1 IFD renew the loan. Thus SPV is better off in choosing the efficient type. Suppose instead $m = 0$. Then IFD will not learn SPV's type and SPV knows it. Then from Lemma 2 SPV will choose the inefficient type. ■

Thus the financial market which does not observe SPV's investment action directly can correctly infer SPV's type through IFD's loan continuation decision.

Proposition 4 *Suppose S spends $m = M$. Then SPV chooses (1) the efficient type as well as (2) the efficient level of investment i^*.*

Proof. (1) Suppose $m = M$. Then, IFD learns SPV's type and SPV knows it. Suppose SPV chooses the inefficient type. Then from Lemma 3 IFD will terminate the loan. But then form Proposition 5 the financial market believe that SPV is the inefficient type so that it requires higher return for the new loan. Suppose SPV chooses the efficient type. Then from Lemma 3 IFD renew the loan. Thus SPV is better off in choosing the efficient type. Suppose instead $m = 0$. Then IFD will not learn SPV's type and SPV knows it. Then from Lemma 4 SPV will choose the inefficient type. (2) From (1), SPV will choose the efficient type if $m = M$. Then IFD renew the loan and the government correctly infer that

SPV is the efficient type. Then from the Proposition 2, the SPV will be the residual claimant as a result of the bargaining game at date 3. Thus it chooses i^*. ■

Proposition 5 *IFD chooses $m = M$.*

Proof. From the previous propositions, IFD will be better off in choosing $m = M$ since then SPV will be induced to choose the efficient investment decisions and the information will be correctly conveyed to the government and the financial market; IFD will obtain appropriate return. ■

4. Conclusion and policy implications

We analyze in this paper effects of bargaining games and roles of infrastructure funds in PPP. First, we argue the importance of bargaining games as a device of internalizing externalities. We show that an appropriately designed bargaining game results in the first best level of internalization by relying on the fact that the government fairly appreciate the unmarketable value of the externalities.

Second, we argue the importance of infrastructure funds as a governance device through information production. By interacting with the financial market, an infrastructure fund disciplines SPV as well as committing itself to appropriately implement information production.

Several policy implications can be derived from the results of this paper. First, interim renegotiations of the concession contract can improve the efficiency of the project. Thus, just rather than trying to avoid renegotiations, the government can use them as opportunities to internalize externalities. In fact use of renegotiation for a better resource allocation is consistent with the spirit of incomplete contracting ideas.

Second, financial intermediaries can play important roles in PPP. Particularly, mechanism of funds can be useful since interaction with the financial market is useful for both discipline and commitment. Also, the government can delegate information production to a third party as in this model. Governmental funds are in a good position to implement it since they involves both expertise in social benefits and commitment devices.

Finally, we briefly discuss the possibility of corruption. Public related projects including PPP are often considered to be facing risk of corruption. In the model of the paper, one possibility is a collusion between SPV and IFD in the loan continuation decision. This problem however can be avoided by IFD's taking partial guarantee. For other corruptions are avoided in this model: all the social benefit

is internalized and the firm is the residual claimant. So there are no room to collude with any subcontractors.

References

Bennett, J. and E. Iossa (2006), "Building and managing facilities for public services," *Journal of Public Economics* 90; 2143-2160.

Besley, T. and M. Ghatak (2001), "Government versus Private Oownership of Public Goods," *Quarterly Journal of Economics,* 116: 1343-1372.

Guash, J.L. (2004), "Granting and Renegotiating Infrastructure Concessions: Doing it Right," *WBI Development studies*, the World Bank.

Hart, O. (1995), "Firms, Contracts, and Financial Structure," Clarendon Press, Oxford.

Hart, O. (2003), "Incomplete Contracts and Public Ownership: Remarks and an Application to Public-Private Partnerships," *Economic Journal*, 119: 69-76.