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The economics of infrastructure finance: Public-private partnerships versus public provision

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ABSTRACT

We examine the economics of infrastructure finance, focusing on public provision and Public-Private Partnerships (PPPs). *We show that project finance is appropriate for PPP projects, because there are few economies of scope and because assets are project specific. Furthermore, we suggest that the higher cost of finance of PPPs is not an argument in favour of public provision, since it appears to reflect the combination of deficient contract design and the cost-cutting incentives embedded in PPPs. Thus, in the case of a correctly designed PPP contract, the higher cost of capital may be the price to pay for the efficiency advantages of PPPs. We also examine the role of government activities in PPP financing (e.g. revenue guarantees, renegotiations) and their consequences. Finally, we discuss how to include PPPs, revenue guarantees and the results of PPP contract renegotiation in the government balance sheet.*

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The economics of infrastructure finance: Public-Private Partnerships *versus* public provision

1. Introduction

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The use of Public-Private Partnerships (PPPs) to replace and complement the public provision of infrastructure has become common in recent years.[1] Projects that require large upfront investments, such as highways, light rails, bridges, seaports and airports, water and sewage, hospitals and schools are now often provided via PPPs.

A PPP bundles investment and service provision of infrastructure into a single long-term contract. A group of private investors finances and manages the construction of the project, then maintains and operates the facilities for a long period of usually 20 to 30 years and, at the end of the contract, transfers the assets to the government. During the operation of the project, the private partner receives a stream of payments as compensation. These payments cover both the initial investment – the so-called capital expense (capex) – and operation and maintenance expenses (opex). Depending on the project and type of infrastructure, these revenues are obtained from user fees (as in a toll road), or from payments by the government's procuring authority (as in the case of jails).

As pointed out by Yescombe (2007), the growth and spread of PPPs around the world is closely linked to the development of project finance, a financial technique based on lending against the cash flow of a project that is legally and economically self-contained. Project finance arrangements are highly leveraged and lenders receive no guarantees beyond the right to be paid from the cash flows of the project. Moreover, as the assets of the project are specific, they are illiquid and have little value if the project is a failure.

In this article, we take a close look at the financing of infrastructure projects. We consider PPPs and public provision of infrastructure. We ignore two types of privately provided infrastructure, whose interest lies beyond the scope of this paper. The first type of private infrastructure is required as part of a larger private project, such as a railroad or road to a mining project, or the port required to export the ores to a refining plant. Then the finance of the infrastructure project is part of the financing arrangements for the main non-infrastructure- project. The other relevant type of infrastructure corresponds to privatized public utilities, such as electricity distribution, water and sanitation or general-use seaports. In these cases, finance does not differ from that of standard private projects.

We begin in Section 2 by describing the typical financial arrangement for a PPP, which has two characteristics. First, a so-called special purpose vehicle (SPV) – a new stand-alone firm – is created. This firm is managed by a *sponsor*, an equity investor responsible for bidding, developing and managing the project. In Section 2 we also argue that project finance meshes well with the basic economic characteristics of PPP projects, both for economic and financial reasons.

A second characteristic of PPP financing is that the sources of finance change over the project's life cycle. During construction, expenses are financed with sponsor equity (which may be complemented

1 There exist three broad alternative organizational forms to provide infrastructure: public provision, PPPs and privatization, perhaps under a regulated monopoly. Each of these forms includes a number of contractual arrangements. For example, Guasch (2004) lists the following 12 arrangements, ordered by increasing private participation: public supply and operation, outsourcing, corporatization and performance agreement, management contracts, leasing (also known as affermage), franchise, concession, build-operate-transfer (BOT), build-own-operate, divestiture by license, divestiture by sale, and private supply and operation. In what follows, our definition of PPP includes the four cases grouped by Guasch as concessions, namely leasing, franchise, concession, and BOT. We also use the terms PPP and concession interchangeably.

The source of finance changes over the life of a PPP project – from equity and bank loans during construction to a larger share of bonds during operation.

with bridge loans and subordinated or mezzanine debt) and bank loans. In some cases, it may receive government subsidies and/or minimum revenue guarantees from the government. Once the PPP project becomes operational, long-term bonds substitute for bank loans and the sponsor's equity may be bought out by a facilities operator, or even by third-party passive investors, usually institutional investors.

The changing sources of finance match the evolving pattern of risks and incentives over the life cycle of PPP projects. Most changes to the specifications of the project occur during construction. Yescombe (2007, p. 141) notes that banks exercise control over all changes of the PPP contract and tightly control the project company's behaviour. Thus, they are well suited for lending during construction. By contrast, bond holders only have control (through the bond covenants) over issues that may significantly affect the security of cash flows but cannot monitor the details of borrower behaviour because of transaction costs. Consequently, they are better suited to finance the project during its operational phase, when there are fewer unforeseen events such as project modifications.

Alternatively, in the case of contracts in the United States before the financial crisis of 2008-2009, projects were financed with bonds issued at the time of contract closure. In this case, the sponsors of the project bought cash flow insurance from a monoline (bond insurance companies). With this guarantee, credit rating agencies gave an investment grade classification to the project from the start. Thus, the monolines replaced the monitoring role of banks during the construction phase. Since monolines defaulted on their obligations during the 2008-09 crisis, this business model is unlikely to return in the foreseeable future.

Project finance may be appropriate for financing PPPs but it is often held that it is more expensive than public debt. Indeed, project finance rates are typically higher than rates paid by government debt. In Section 3, we analyze this argument by considering the various sources of risk.

We use a simple model to show that it is optimal to transfer demand risk to the government. Because PPPs involve large upfront investments, exogenous demand risk is an important concern of lenders when user fees are the main revenue source, so by assigning it to the government, the risk and therefore the rates charged to the project fall. However, even when projects are based on availability payments (and thus there is no demand risk), the finance rates charged PPPs are higher than the rates charged on government debt. In this case, the higher rate reflects in part the risk that the infrastructure will be unavailable at some point in the life of the contract, and no payments will be received to service the debt. In addition, the risk associated to construction costs of a PPP is similar to the risk under a price cap construction contract, which also provides strong incentives for cost reduction and thus may be efficient.

Hence, we suggest that the higher costs of project finance are partly due to faulty contract design, and partly due to the cost-cutting incentives embedded in PPPs. For a well designed PPP contract, the higher cost of capital may well be the flip side of the efficiency advantage of PPPs as compared to public provision.[2]

Section 4 discusses how investment in PPPs, as well as government guarantees and renegotiation of PPP contracts, are and should be accounted for in the government's balance sheet.

2 Of course, the alleged low cost of public financing may be a misconception in the first place. For an extensive analysis of the cost of public funds, see Riess (2008).

Our main proposal is that PPP investments receive the same treatment as government investment. This follows from noting that PPP contracts have similar – sometimes identical – implications for the *intertemporal* budget as public provision. For example, consider the case where the project can collect user fees both under public provision and under a PPP. We show that under a PPP, the income flows to the private sector, in the form of user fees during the concession, exactly offset the investment savings made by the government early on in the relationship, at the investment stage. PPPs change the timing of government revenues and disbursements, and the composition of financing, yet they have little impact on the intertemporal budget constraint. In effect, the government delegates to a firm the construction, operation and maintenance of the infrastructure project for the duration of the contract, with reversion of the infrastructure to public ownership at the end of the contract. In exchange, the firm receives a flow of revenue that the government could have used to the same purpose.

PPPs change the timing of government revenues and expenditures, yet they have little impact on the intertemporal budget constraint.

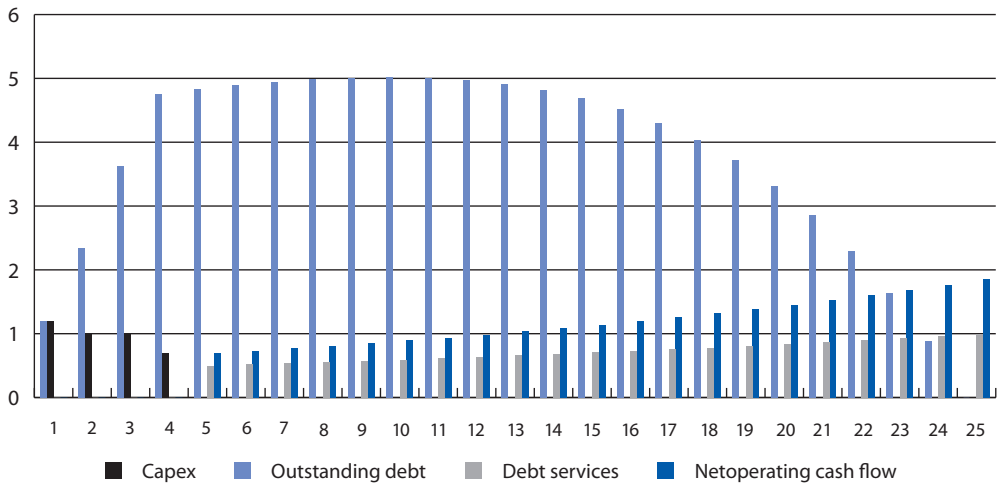
The contrast with privatization in this dimension is stark, since the link between the project and the government budget is permanently severed when an infrastructure project is privatized, as the project is sold for a one-time payment and all risk is transferred to the firm. In addition, in Section 4 we discuss how opportunistic renegotiation of PPP contracts can be used by governments to circumvent budgetary controls. Section 5 concludes.

2. Financial arrangements in PPPs

This section begins by describing the basic economics of PPP finance. It is followed by a discussion of the life cycle of PPP finance and the importance of project finance for PPPs.

The typical PPP infrastructure project involves a large initial upfront investment that is sunk, and operations and maintenance costs (O&M) paid over the life of the project. Maintenance and operation costs are a comparatively small fraction of total costs, and this fact determines several characteristics of PPP finance. Figure 1 shows the typical time profile of the financial flows of a PPP project. It assumes that the interest rate is 12 percent, that revenues grow at 5 percent each year and that debt payments grow 3.5 percent each year. Capital expenditures occur during the first four years. Revenues over the life of the project are used to pay off debt by year 25. After the initial capital expenditure, the main objective of the project is to collect revenues and disgorge them to pay for outstanding debt, and to generate dividends for the equity holders.

Figure 1. Time profile of financial flows



PPPs are characterized by independent management, bundling of construction and operation, and the subcontracting of most production processes.

Three additional economic characteristics of most PPP projects are important to understand the choice of financial arrangements. First, PPP projects are usually large enough to require independent management, especially during construction, and frequently even in the operational phase. Moreover, there are few synergies to be realized by building or operating two or more PPP projects together. For instance, the projects may be located far apart, at the place where the service is consumed, and efficient scale is site specific. This means that project assets are illiquid and have little value if the project fails.

Second, most production processes, both during construction and operation, are subcontracted. Hence any scale and scope economies are internalized by specialized service providers – *e.g.* construction companies, maintenance contractors or toll collectors.

Third, it is efficient to bundle construction and operation. Bundling forces investors to internalize operation and maintenance costs and generates incentives to design the project so that it minimizes life cycle costs. But perhaps even more importantly, when builders are responsible for enforceable service standards, they have an incentive to consider them when designing the project.

As we will see next, the specifics of project finance fit this basic economics of PPP projects.

2.1 The life cycle of PPP finance

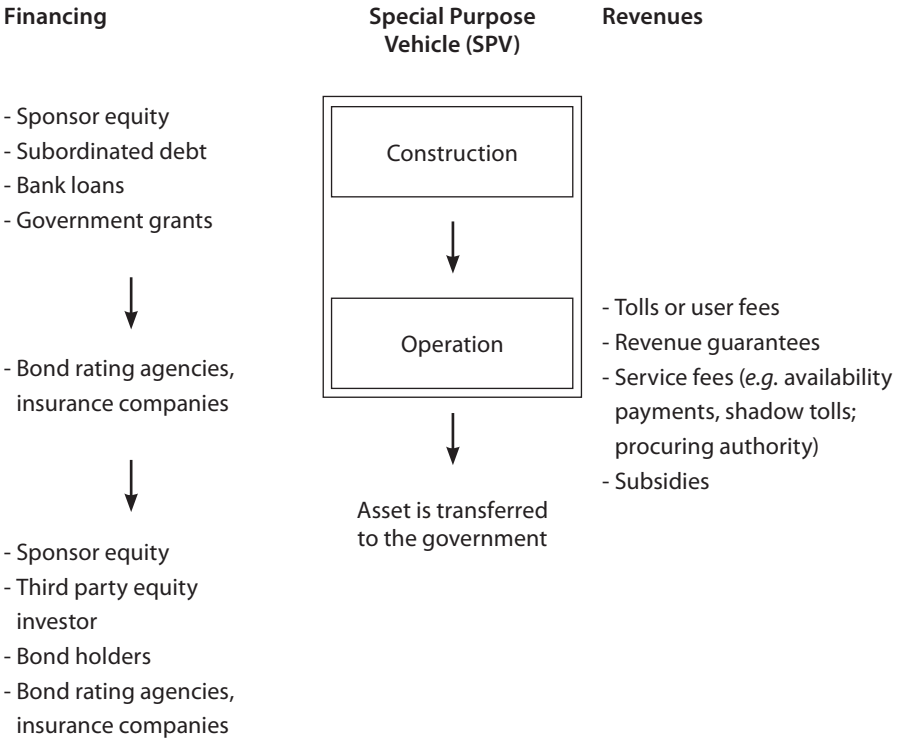
As pointed out by Yescombe (2007), the growth and spread of PPPs is closely linked to the development of project finance, a technique based on lending against the cash flow of a project that is legally and economically self-contained. As can be seen in Figure 2, this is ensured by creating a so-called Special Purpose Vehicle (SPV), which does not undertake any business other than building and operating the project (Yescombe 2002, p. 318).

Before the bidding for the project takes place, an SPV is set up by a *sponsor*. The *sponsor* is the equity investor responsible for bidding, developing and managing the project. They are the residual claimants and are essential to the success of the project. This means that lenders will carefully examine the characteristics of the sponsor before committing resources. Sponsors can be operational, in the sense that they belong to the industry, and will secure business for themselves as subcontractors; or financial sponsors, who are interested in the financial arrangements for the project.[3]

Initial sponsors supply the initial equity of the project, and in some cases are required to keep a fraction until the end of the PPP contract, without the possibility of transferring the asset. The aim is to create long-term incentives. This is expensive for the initial sponsor for two reasons: first, because the cost of capital of the sponsor is high; and second, because by tying up resources for a long time, they cannot be deployed to other uses. As the sponsor specializes in the early, building part of the project, this limits future business. This means that projects must be very profitable to compensate the sponsors for this cost. In most cases, however, after the project is operational, the initial sponsor transfers the SPV to a combination of a Facilities Management operator (in charge of operation and maintenance over the life of the PPP after construction) and to third-party passive investors.

3 The Queen Elizabeth II Bridge over the Dartford River in the UK is an example of the first type of sponsor: the construction division of Trafalgar House Plc organized local landowners plus an investment bank and presented an initial proposal to the government. The Department of Transport approved the proposal and, after seeking other bids, awarded the project to Trafalgar House (Levy 1996). The Dulles Greenway project in Virginia, which started operating in 1995, is an example in which the main sponsor was a family-owned investment company, with 57.04 percent of property of the sponsor (Toll Roads Investors Partnership II), see Levy (1996).

Figure 2. Financial lifecycle of a PPP



Even though the SPV remains active over the whole life of the project, there is a clear demarcation between financing during the construction phase and financing in the operational phase. This is shown in Figure 2. During construction, sponsor equity (perhaps including bridge loans and subordinated or mezzanine debt) is combined with bank loans and sometimes government grants in money or kind. In the case of projects that derive their revenues from user fees, the initial contribution to investment is sometimes supplemented with subsidies from the government.

As completion of the construction stage approaches, bondholders enter the picture and substitute for bank lending. Bond finance is associated to two additional entities: rating agencies and insurance companies (see Figure 2). When the PPP project becomes operational, but only then, the sponsor's equity may be bought out by a facilities operator, or by third-party passive investors, usually pension or mutual funds. Bond holders, of course, have priority over the cash flow of the project.

The change in financing sources between construction and operation is determined by the changing incentive problems and levels of risk.

The life cycle of PPP finance and the change in financing sources is determined by the different incentive problems faced in the two stages of the PPP, its construction and operational phases. Construction is subject to substantial uncertainty, major design changes and costs depend crucially on the diligence of the sponsor and the building contractor. Thus, there is ample scope for moral hazard at this stage. As is well known (Tirole 2006; Yescombe 2007), banks perform a monitoring role that is well suited to mitigate moral hazard by exercising tight control over changes to the project's contract and the behaviour of the SPV and her contractors. In order to control behaviour, banks disburse funds only gradually as project stages are completed. After completion and ramp-up of the project, risk falls abruptly and is limited to events that may affect cash flows. This is suitable for bond finance because bond holders care only about events that significantly affect the security of the cash flows, but are not

directly involved in management, or in control of the PPP. This is appropriate for institutional and other passive investors who by statutes can invest only small amounts of their funds in the initial stages of a PPP because of the high risk.

2.2 Contracts and project finance

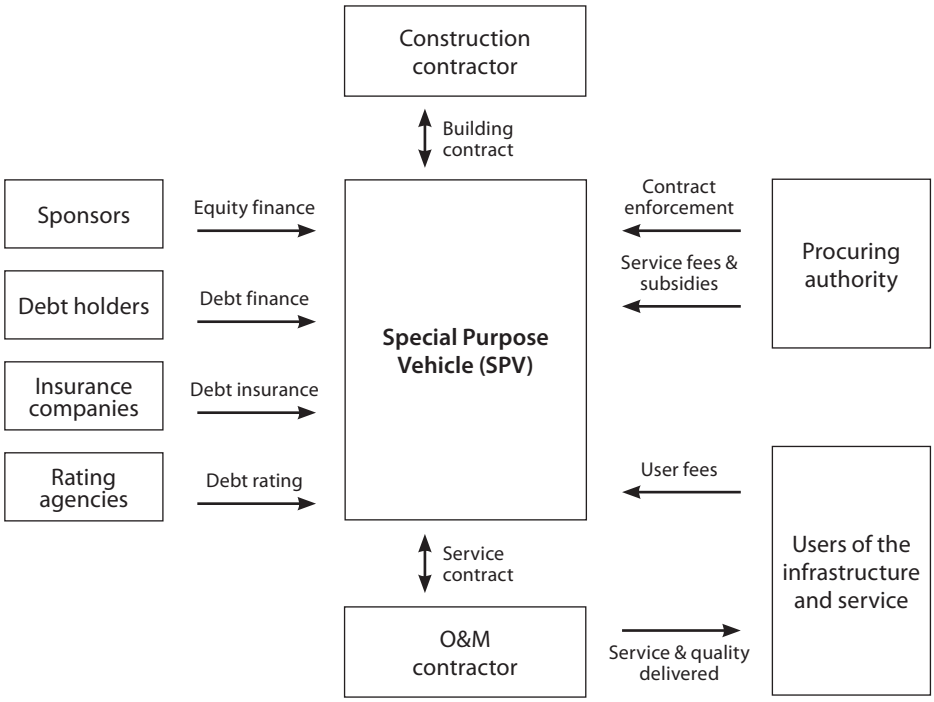
Financial contracts must deal with many incentive problems, which in the case of PPPs can be traced back to the contracts made by the SPV. In this section we examine these contracts and the role of various agents.

2.2.1 The web of contracts of an SPV

The Special Pupose Vehicle (SPV) lies at the heart of a web of contracts involving the procuring authority, financiers, builders, operators, and users.

As can be seen in Figure 3, the SPV lies at the centre of a web of contracts. These include contracts with the procuring authority (usually the local or central government), with users of the services provided by the PPP, with building and operations contractors as well as with the investors and financiers in the project. Each of these contracts is a potential source of conflict which may endanger debt holders. The success of the SPV in dealing with these conflicts depends on two factors. One is the quality of the legal institutions and laws on which the web of contracts rests. The second factor is that the particulars of each relationship and contract affect risk perceptions by debt holders.

Figure 3. Web of contracts of an SPV



The project is intended to provide a service to users, but the fundamental contracting parties are the SPV and the procuring authority, which enforces the PPP contract and represents the users of the project. As contracts give at least some discretion to the procuring authority, cash flows and even the continuation of the concession may depend on the authority's decisions. Thus, ambiguous service standards and defective conflict resolution mechanisms increase risk. In addition, user fees will be at risk if the political authority is tempted to buy support or votes by lowering service fees, either directly or by postponing inflation adjustments, in so called *regulatory takings*. Similarly, if a substantial fraction

of the SPV's revenues are derived from payments by the procuring authority, these payments depend on the ability or the willingness of the government to fulfil its obligations. It follows that the governance structure of the procuring authority, its degree of independence and the financial condition of the government affect the level of risk perceived by debt holders.

Next, consider the relationship of the SPV with construction and O&M contractors. Many PPP projects involve complex engineering. In complex projects, unexpected events are more likely and it becomes harder to replace the building contractor. In these cases, the experience and reputation of the contractor become an issue. Moreover, his financial strength is relevant because it determines the ability to credibly bear cost overruns without having to renegotiate the contract. Similarly, while the operational phase is less complex, revenue flows depend on the fulfilment of the contracted service and quality standards, which depend on the O&M contractor. Again, the experience and the financial strength of the contractor concern debt holders. Debt holders also care about the type of risk-sharing agreements between the SPV and the contractors. Cost-plus contracts, which shift cost shocks to the SPV, are riskier than fixed-price contracts.

Finally, debt holders care about the incentives of the sponsor, who provides around 30 percent of the funding in the typical PPP project. This large chunk of equity has the lowest priority in the cash flow cascade, and is theoretically committed for the length of the PPP contract in order to provide incentives to minimize the life cycle costs of the project. Providers of funds worry about the financial strength and experience of sponsors, particularly during the construction and the ramp-up phase of complex transportation projects. They value previous successful experience in the industry and technical prowess, and look for evidence that the sponsor is committed to the project, both financially and in terms of time and reputation.

2.2.2 Project revenues, demand risk and finance

SPV revenues depend on the project's availability, the level of user fees, demand volume and the term of the contract. The relevance of each factor varies over projects, but revenues can be classified along two dimensions, the source of payments and the extent to which the SPV is made to bear demand risk (on this issue, see Engel *et al.* 1997b and Engel *et al.* 2001).

Demand for most PPP projects is largely exogenous upon meeting minimum quality and availability standards – and yet, many PPPs are made to bear demand risk.

Provided that the SPV meets the minimum quality and availability standards, demand for most PPP projects is exogenous to a large extent. Despite the fact that they cannot affect demand, many PPPs are made to bear demand risk. When revenues are derived primarily from user fees, SPVs assume two types of project risks associated to demand. First, the risk that the project is a failure and will never be able to repay the creditors. This risk represents a market test of the quality of the project and is correctly assigned to creditors. The second risk appears because the term of the concession contract is fixed (say, at 20 years). This means that a profitable project may be unable to repay the debt over the contract term, due to adverse initial macroeconomic conditions, for instance. Even when the primary source of revenues is the procuring authority, the contract may tie payments to the use of the project over a fixed term, in so-called *shadow tolls* (or fees). In both cases, bondholders bear the uncertainty that demand may not generate enough revenues during the term of the contract to meet debt payments on schedule. Sponsors face even more risk, and expect large profits in compensation.

Contracts can be designed to make project revenues independent, or less dependent, of demand in a given time period. This reduces the second type of risk and therefore the expected rents to the sponsor as well as the return demanded by bondholders. When the source of revenues is the procuring authority, the contract that eliminates this risk has a fixed term, with payments contingent on the availability of the infrastructure – hence the term *availability payments*. When user fees are the main

Availability contracts and flexible-term contracts tend to receive higher ratings than contracts where the concession bears demand risk.

source of revenue, the appropriate contract is a present value of revenue (PVR) contract, which specifies a fixed present value of revenues, under a variable length contract. In either case, the contract eliminates demand risk to a large extent. Revenue risk is reduced to meeting (hopefully) clearly defined performance standards.

All things considered, financiers prefer predictable cash flows. Consequently, availability contracts and flexible-term contracts tend to receive higher ratings than contracts where the concession bears considerable demand risk (see Fitch Ratings 2010).

2.2.3 The role of credit rating agencies and insurance providers

While the relationship between bondholders and the SPV is kept at arm's length, management behaviour is still (somewhat loosely) monitored by credit rating agencies and insurance companies while there are bonds outstanding.[4] The role of credit rating agencies and credit insurance companies is essential to the issuance of bonds. The credit rating agency issues a so-called shadow rating of the SPV. With this rating, the SPV buys insurance that increases the rating of the bond to investment grade or higher (for instance from BBB to A$^-$). The bonds are then sold to institutional and other investors. In a market that operates correctly, the insurance premium should be the exact equivalent to the difference in effective risk premia between the insured and the shadow rating. In the example, this corresponds to the difference in risk premia between A$^-$ and BBB bonds. This premium varies over the life of the project, as risk perceptions and circumstances change. The bond covenants require that the SPV pay the premiums required to preserve the initial risk rating of the bond. This creates the correct incentives for the SPV, as its costs increase with the perceived riskiness of the bonds.

Credit rating companies worry most about the impact of the various risks facing the project on the ability of the project to make the scheduled debt payments. This requires the analysis of the expected value and the volatility of the project's net cash flow. In addition, credit rating agencies penalize poor information, ambiguities, complexity and discretion in laws or contracts. Thus, the rating of a bond depends on the quality and timeliness of the information revealed by the SPV; the opinions of experts (good news by independent experts increase ratings *ceteris paribus*); the quality of laws and institutions that have a bearing on the project; and the clarity and conflict potential of the web of contracts. In terms of contract theory, credit rating companies punish contract incompleteness.

In addition to the risks we have surveyed – construction, operation and revenue risks, *i.e.* those inherently related to the economics of the project – exchange rate, political and country risks are also considered in evaluations.

2.3 Leverage and SPVs

There are two possible forms of setting up the financial structure of a PPP infrastructure project: either as a project within the company, using corporate debt for financing; or as a stand-alone project, set up as an SPV. While the second form has large transaction costs, it provides advantages that compensate for the added cost of the complex structure of the SPV. Most PPP contracts use project finance because it is useful in raising long-term financing for major projects.

4 After the financial crisis of 2008-09, the various deficiencies of the dependency on rating agencies and monolines have come to light. The analysis assumes a reformed system of credit rating agencies and credit insurance companies that are not subject to the conflicts of interest that beset the industry up to 2008.

A characteristic of project finance is that sponsors provide no guarantees beyond the right to be paid from the project's cash flows. Nevertheless, sponsors need to attract large amounts of resources, which leave them highly leveraged, with 70 to 100 percent of the funds provided by lenders. Leverage depends on the volatility of revenues and when these are very volatile, the project may not be *bankable*. Governments sometimes provide revenue insurance to improve the bankability of a project. Better alternatives allowing for high levels of leverage are, for example, PVR and availability contracts. Conversely, technically complex projects require higher levels of sponsor equity.

There are various reasons for the choice of SPVs and project finance over corporate finance in PPPs. Since SPVs use high levels of leverage, the expected return on equity increases, even after adjusting for the higher financing costs. Moreover, it is more difficult to raise equity than to raise debt, especially in projects with no history, and this leads to higher leverage.

The stand-alone nature of the SPV helps to credibly pledge project cash flows to paying bondholders, enabling higher levels of leverage and return on equity.

In the construction phase, the stand-alone nature of an SPV precludes underinvestment in the project caused by competition for resources within a larger sponsoring corporation. Moreover, when setting up a PPP as a division within a corporation, the large free cash flows produced by the PPP in the operational phase are subject to costly agency problems, which may divert the revenues from repaying the debt contracted to fund the project. Since the infrastructure SPV does not have growth opportunities, the possibility of diverting resources from creditors is very limited, in contrast to the case of a division within a large corporation. Hence, the project's cash flow can be credibly pledged to pay bondholders and this allows for high leverage.

A final reason for isolating the project within an SPV is that it reduces the possibility of contaminating a healthy corporation with the problems of a large project. It must be recalled that even when the problems in a subsidiary of a large corporation do not threaten its financial stability, financial distress in the subsidiary affects the credit conditions facing the corporation.

Of course, these financial advantages of SPVs would be undone if stand-alone projects lost economies of scope. But, as argued at the start of this section, few, if any, productive efficiency gains can be realized by pooling multiple PPP projects whose demand is normally location based. Any gains that can be realized by being a sponsor of several separate PPP projects – previous experience, lobbying proficiency *etc.* – can be achieved by sponsoring several SPVs, which are legally independent from one another.

3. Is there a PPP premium?

A recurrent criticism of PPPs is that they cost more per dollar of financing than government debt – the so-called PPP premium. For example, consider this quote from the trade magazine Euromoney in 1995 taken from Klein (1997, p. 29):

> "The other solution [to highway finance] is to finance the project wholly in the public sector, either with government or multilateral funds. It is, after all, more expensive to raise debt on a project finance basis. When considered alongside the guarantees and commitments which have to be provided to attract commercial finance, the best approach would be to borrow on a sovereign basis."

The numbers that have been quoted for this difference in costs vary widely. According to Yescombe (2007, p. 18) the cost of capital for a PPP is usually 200-300 basis points higher than the cost of public funds. He also shows that the spread over the lender's cost of funds lies in the range of 75-150 basis points, with highway projects being at the upper limit (Yescombe 2007, p. 150). Hence, it would seem

The literature is divided on whether PPPs are more expensive than public provision from an economic point of view.

that when governments decide between public provision and PPPs, they trade off a lower cost of funds under public provision against the supposedly higher efficiency of a PPP.

Nevertheless, other authors disagree and argue that it is likely that there is no PPP premium. One line of argument claims that the alleged advantage of public funding rests on the government's ability to tax:

> "The view that "private sector capital costs more" is naïve because the cost of debt both to governments and to private firms is influenced predominantly by the perceived risk of default rather than an assessment of the quality of returns from the specific investment. We would lend to government even if we thought it would burn the money or fire it off into space, and we do lend it for both these purposes." (Kay 1993, cited in Klein 1997, p. 29)

In other words, while many failed projects go unaccounted under public provision because taxpayers assume the costs of this risk, under a PPP these risks are made explicit and priced, increasing the measured financing cost of a PPP project *ceteris paribus*. So the higher financing cost merely reflects a just reward for carrying those risks.

This section examines four possible explanations for the PPP premium. Sub-section 3.1 compares the opportunities of diversifying exogenous risk under PPPs and public provision. Sub-section 3.2 examines the relation between endogenous risk and incentives in PPPs. Sub-section 3.3 explains why PPPs may imply higher financial transaction costs than public provision. Last, in Sub-section 3.4 we examine several transaction costs which may make PPP finance more expensive.

3.1 Diversification and contracting

Ignore for a moment the alleged efficiency advantages of a PPP. Is there a *prima facie* reason to think that the public sector can be better at diversifying exogenous risks than PPP financiers? It is well known that with frictionless, perfect capital markets, the diversification that can be achieved through the tax system is also achievable through the capital market, so no PPP premium would exist. As Hirshleifer (1966, p. 276) pointed out:

> "The efficient discount rate, assuming perfect markets, is the market rate implicit in the valuation of private assets whose returns are comparable to the public investment in question – where "comparable" means having the same proportionate time-state distribution of returns."

Hence, the PPP premium and the alleged financial advantage of public provision would seem to rest on capital market imperfections that give an edge to diversification through the tax system.[5] In the real world, there are costs of conducting transactions which make complete markets uneconomic. On the other hand, it is hard to believe that diversification through the tax system is frictionless, given that it is administered by a governmental bureaucracy.

Independently of whether transaction costs involved in diversification are larger under public or under PPP provision, it is important to note that any diversification advantage that the public sector may have is *not* incompatible with PPPs. As we show next, there are risk sharing PPP contracts where the public sector bears most, if not all, exogenous risks.

5 This does not require that project returns be independent of the economy (the assumption of the Arrow-Lind theorem), only that some options of risk spreading available through the tax system are unavailable through the capital market, see Brainard and Dolbear (1971).

To see this, assume that demand for the infrastructure is uncertain, so that the consumer surplus at time t, CS_t, and user fee revenues, R_t, are random variables determined by the state of demand, v, that is, by one possible trajectory of demand realizations. Further, assume for simplicity that the upfront investment, I, is the same in all demand states, and that operation and maintenance costs are zero. Finally, assume that the PPP firm is selected in a competitive auction that dissipates all rents.

The upper half of Table 1 depicts the distribution of the present value of cash flows and surpluses in one demand state v for alternative sources of funds and procurement mechanisms. Rows distinguish between the sources of revenues: user fees or taxes. Columns distinguish between governance structures: public provision and PPP. Within PPP, alternative contractual forms are possible, depending on the source of revenues.

It can be seen that columns (1) and (2), *i.e.* public provision, PVR contract and availability payment are identical. This is our main claim: independently of the source of funds, there exist PPP contracts that replicate in all demand states the surplus and cash flow distribution of public provision and have the same impact on the intertemporal government budget.

PPP contracts can replicate the surplus and cash flow distribution of public provision, so any diversification advantage of the public sector is not incompatible with PPPs.

Table 1. Risk allocation, the source of funds and contractual form

Procurement form → / Source of funds ↓	**Public provision**	**PPP**	
User fee finance		PVR contract	Fixed term
A. Users	$CS_0^{\infty}(v) - R_0^{\infty}(v)$	$CS_0^{\infty}(v) - R_0^{\infty}(v)$	$CS_0^{\infty}(v) - R_0^{\infty}(v)$
B. Tax payers	$R_0^{\infty}(v) - I$	$R_0^{\infty}(v) - I$	$R_0^{\infty}(v) - R_0^{T}(v)$
C. Firm	$I - I$	$I - I$	$R_0^{T}(v) - I$
Tax finance		Availability payment	Fixed term, shadow toll
A. Users	$CS_0^{\infty}(v)$	$CS_0^{\infty}(v)$	$CS_0^{\infty}(v)$
B. Tax payers	$-I$	$-I$	$-R_0^{T}(v)$
C. Firm	$I - I$	$I - I$	$R_0^{T}(v) - I$

Notes: v = state of demand; CS = consumer surplus; R = user fee or shadow toll revenue; I = upfront investment; $X_{t_1}^{t_2}$ = present discounted value of X between t_1 and t_2; T = length of fixed-term contract.

To see this, consider first the case where financing comes from user fees. Under public provision, the project is built at cost I and the firm receives I before the infrastructure becomes operational. Hence, taxpayers pay I upfront, collect $R_0^{\infty}(v)$ in state v and receive $R_0^{\infty}(v) - I$ in present value, where $X_{t_1}^{t_2}$ denotes the present value of X_t between $t = t_1$ and $t = t_2$, as of time $t = 0$. Users, on the other hand, receive a net surplus equal to $CS_0^{\infty}(v) - R_0^{\infty}(v)$. Under a PVR contract, taxpayers save I upfront, but relinquish user fee revenue during the length of the concession, which is equal to I in present value (given that the competitive assumption means that the winning bid will ask for I in present value of revenues). Since

the state collects user fees after the concession ends, taxpayers receive $R_0^{\infty}(v) - I$. Users' net surplus in state v is $CS_0^{\infty}(v) - R_0^{\infty}(v)$, as with public provision. It follows that any risk diversification advantage of the government can be realized with a PVR-type PPP contract.

A fixed-term contract shifts risk from taxpayers to the concessionaire.

Now consider the fixed-term PPP in column (3), which lasts T years. The concessionaire collects $R_0^T(v)$ and its surplus is $R_0^T(v) - I$, a random quantity, in contrast to the situation under a PVR contract, where it faces no risk. Taxpayers receive $R_0^{\infty}(v) - R_0^T(v) = R_T^{\infty}(v)$ and, in general, their risk falls.[6] Hence, a fixed-term contract shifts risk from taxpayers to the concessionaire because it is uncertain how many users will use the project during the fixed term T.

Next, consider projects that are fully financed by taxpayers. Again, with public provision, the project is built at cost I, which the firm receives before the infrastructure becomes operational – taxpayers pay I upfront. With a PPP financed by availability payments, the timing of disbursements differs, but the present value of payments is the same (I). Hence, neither taxpayers nor the concessionaire bear risk, and the impact of the project on the intertemporal government budget is the same in both cases.

PPPs financed via taxes have sometimes resorted to shadow fees – during a fixed number of years *(T)*, that is, the state pays a fee to the concessionaire for every user of the infrastructure. Compared with public provision, this type of PPP contract not only shifts risks to the concessionaire, but also creates risk. As can be seen in the lower right corner of Table 1, now both the concessionaire and taxpayers bear risk, and a PPP premium should be observed. Viewed from this perspective, a shadow toll contract consists in adding a lottery to an availability contract. The firm and taxpayers are forced to participate in the lottery and whatever one of them wins is lost by the other participant.

Thus, part of the observed PPP premium may be a reflection of faulty contract design, and is not an inherent disadvantage of PPPs. The following example, based on Engel *et al.* (1997a), further illustrates this point.

An example. To see the effect of contracting on the PPP premium, we consider an example, summarized in Figure 4. Assume a project which requires an upfront investment of I=100 (the horizontal line). The upper and lower continuous lines show discounted user fee revenues over time in the high and low demand states, which are assumed equally likely.[7] The line in between is the average and shows expected discounted revenue as a function of time.

The PVR contract lasts until the firm collects 100, that is, 10 years if demand is high (left-most dotted vertical line) and 20 years if demand is low (right-most dotted vertical line). The firm bears no risk and therefore charges no risk premium. The implicit interest therefore equals the risk-free discount rate of 5 percent and there is no PPP premium. Finally, we assume that firms cannot fully diversify risk (for example, to provide incentives to owners or managers) and have a concave utility function.

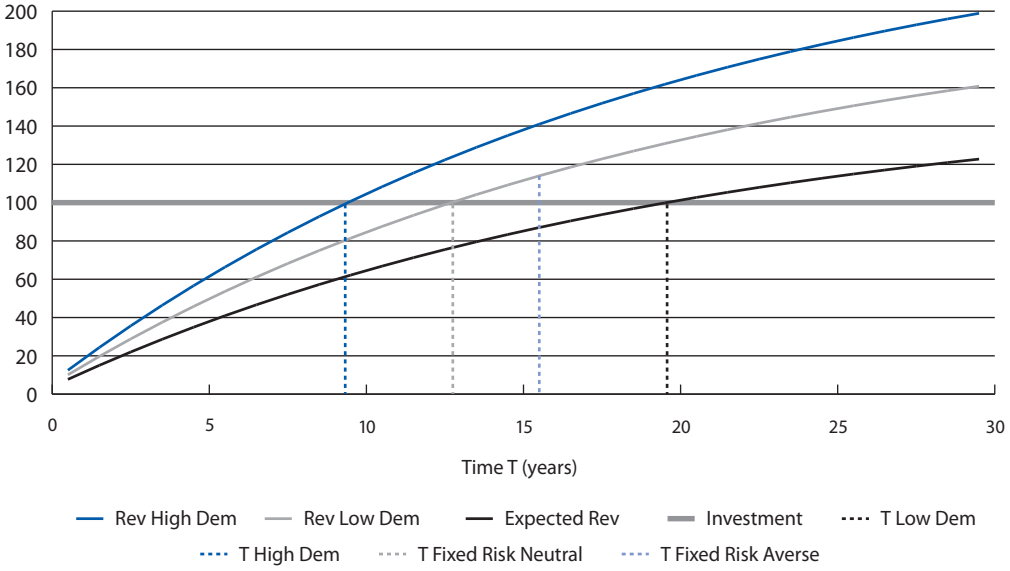
Consider next a fixed-term contract and assume that firms bid on the shortest contract term T. If firms are risk neutral, the winner will bid a contract length that ensures, on average, discounted revenue of 100. The contract length in this case is 13.2 years (second vertical line from the left). If the firm cannot

6 For any process with independent increments, as well as any stationary non-deterministic process, the standard deviation of R_T^{∞}, as of time zero, is decreasing in T. It follows that with public provision the standard deviation of taxpayer's discounted revenue will be higher than under a fixed-term PPP.

7 User fee revenue is assumed constant over time, equal to 7.9 and 12.8 in the low and high demand states, respectively.

fully diversify risk, it will demand a risk premium. The third vertical line from the left depicts the contract length, in this case: 16 years.[8] The firm's expected revenue is larger than 100: in our example, the expected-revenue curve at time *t=16* years has a reading of 114. Hence, with a fixed-term contract and risk-averse firms, there is a PPP premium: the firm invests 100 and expects discounted revenue of 114.

Figure 4. Comparing fixed and flexible term contracts



It follows that a PVR contract can attract investors at lower interest rates than the usual fixed-term PPP contract. The realized sample path of user fee revenues are the same under both contractual forms but the franchise term is demand contingent only under a PVR contract. If demand is low, the franchise holder of a fixed-term contract may default. In contrast, a PVR concession is extended until toll revenue equals the bid, which rules out default. The downside under PVR is that bondholders do not know when they will be repaid, but this risk has a lower cost than the risk of default.

A present value of revenues contract can attract investors at lower interest rates than a fixed-term PPP contract.

Further issues. Of course, under a PPP some risks remain with the SPV and its creditors. The weighted average cost of capital (WACC) of an SPV averages the own cost of capital of the sponsor of the project (who holds equity) and the cost of outside funds – bank loans initially, long-term bonds later on. The sponsor's cost of capital is usually higher than the cost of outside funds for two reasons: first, to moderate the sponsor's moral hazard and second, to satisfy the order of priority of debt (the cash flow cascade), where the equity is the residual claim. For projects in the 1990s, Fishbein and Babbar (1996) cite expected nominal annual returns of 15-30 percent on sponsor equity for PPP road projects, though these high values must be qualified because they include a large number of projects in developing countries and because it was an early stage in the current wave of PPPs.[9]

3.2 Endogenous risk and efficiency with PPPs

An essential aspect of our analysis is that the government foregoes user fee revenue under a PPP arrangement. Thus, in the absence of efficiency gains under a PPP, it is not obvious that PPPs should

8 For example, with the approximation for the risk premium in Proposition 9 in Engel *et al.* (2001), this corresponds to a utility function with coefficient of relative risk aversion equal to 2.15.

9 Higher leverage is usually associated to higher returns (on a smaller amount of equity) to compensate for the higher risk borne by the residual claimant.

The main argument in favour of PPPs is efficiency gains, not lowering the cost of public funds (which PPPs do not do).

be preferred to public provision. For example, it is sometimes argued that the use of PPPs avoids having to finance the infrastructure project with distortionary taxes and therefore should be preferred to public provision. This "lower cost of public funds" argument in favour of PPPs turns out to be wrong. It is true that under public provision the government must collect taxes to finance the infrastructure investment upfront while no government resources are needed at the construction stage under a PPP.

On the other hand, the government foregoes user fee revenue under a PPP arrangement, and these revenues could have been used to substitute for distortionary taxes. Hence, a one-dollar increase in user fees paid to the private party saves the government the dollar, plus the per-dollar distortion due to tax collection. However, it also reduces the resources the government receives and could have used to reduce distortions elsewhere in the economy by exactly the same amount in discounted terms. We have formalized this Irrelevance result in Engel *et al.* (2007), and present a simplified version here (Box 1). The argument underlying the Irrelevance Result is closely related to the discussion in Section 3.1 showing that there is no fundamental difference in the risk allocations that can be achieved under public provision and (optimal) PPP contracts.

Box 1. Basic Model and the Irrelevance Result[1]

A risk-neutral, benevolent social planner wants to select firms that build, operate and maintain an infrastructure project. The planner must choose between public provision, where one firm builds the project and another maintains and operates it, and a PPP, where the same firm is in charge of construction, maintenance and operations. The firm controls the infrastructure assets during the operational phase under a PPP, but not under public provision.

All firms are identical, risk-averse expected-utility maximizers, with preferences represented by the strictly concave utility function u.[2] The technical characteristics of the project are exogenous and there are many firms that can build it at a cost $I > 0$.

Demand for the project is constant and completely inelastic. It may be high (Q_H), with probability π_H, or low (Q_L), with probability π_L, where $Q_H > Q_L > 0$ and $\pi_L + \pi_H = 1$. This probability distribution is common knowledge to firms and the planner. There is a fixed price per unit of service equal to 1 and constant across demand states.

The upfront investment does not depreciate and service standards are contractible. Maintenance costs are proportional to usage with constant of proportionality m which, without loss of generality, we assume equal to zero.

Planner's problem. Let PS_i denote producer surplus in state i, CS_i consumer surplus in state i and $\alpha \in [0,1]$ the weight that the planner gives to producer surplus in the social welfare function.[3] The planner's objective is to maximize:[4]

1 Based on Engel *et al.* (2007 and 2010).

2 This should be interpreted as a reduced form for an agency problem that prevents the firm from diversifying risk. See Appendix D in the working paper version of Engel *et al.* (2001) for a model along these lines. Martimort and Pouyet (2008) also assume a risk-averse concessionaire; see also Dewatripont and Legros (2005) and Hart (2003). Others are skeptical and point out that private firms can use the capital market to diversify risks at least as well as the government (Hemming 2006; Klein 1997). For a discussion of the controversy in economics see Brealey *et al.* (1997).

3 In many countries foreign firms are important investors in PPPs, which implies $\alpha < 1$.

4 This objective function assumes that the income of users is uncorrelated with the benefit of using the project, so that if users spend a small fraction of their incomes on the services of the project, they will value the benefits produced by the project as if they were risk neutral. See Arrow and Lind (1970).

$$\sum_{i=H,L} \pi_i [CS_i + \alpha PS_i] \quad \text{(B1)}$$

subject to the firm's participation constraint

$$\sum_{i=H,L} \pi_i u(PS_i) \geq u(0) \quad \text{(B2)}$$

where $u(0)$ is the value assigned by the firm to its outside option. To maximize (B1), the planner chooses the contract length and subsidy in each demand state. Denoting contract length by T_i and the value of subsidies the firm receives in state i by S_i, we have:

$$PS_i = PVR_i(T_i) + S_i - I \quad \text{(B3)}$$

$$\text{with } PVR_i(T_i) \equiv \int_0^{T_i} Q_i e^{-rt}\, dt = \frac{Q_i(1 - e^{-rT_i})}{r},\ i = H, L \quad \text{(B4)}$$

where r is the risk free interest rate, common across firms and the planner. Note that by "subsidy" we mean any cash transfer from the government to the private concessionaire. It may be the upfront payment made by the government under public provision (in which case S_i is the same for all i), but it could also be a cash transfer made over time, contingent on demand, to supplement revenue from the project under a PPP contract (a so-called "minimum-revenue" or "minimum-income" guarantee).

If the term of the concession is finite in state i, the government collects user fee revenue after the concession ends and uses these revenues to reduce distortionary taxation elsewhere in the economy. Letting $1+\lambda>1$ denote the cost of public funds, we then have:

$$CS_i = [PVR_i^{\infty} - PVR_i(T_i) - (1+\lambda)S_i] + \lambda[PVR_i^{\infty} - PVR_i(T_i)] = (1+\lambda)[PVR_i^{\infty} - PVR_i(T_i) - S_i] \quad \text{(B5)}$$

where the present value of user fee revenue when the contract lasts indefinitely, $PVR_i(\infty)$, is denoted by PVR_i^{∞} – this represents the largest amount of user fees that can be collected, in present value, in demand state i. The first term in the expression between both equal signs in (B5), $PVR_i^{\infty} - PVR_i(T_i) - (1+\lambda)S_i$, is the difference between users' willingness to pay in state i and the total amount transferred to the firm, where the cost of the subsidy is increased by the tax distortion required to finance it. The term $PVR_i^{\infty} - PVR_i(T_i)$ is the total user fee revenue collected by the government after the end of the concession, so the second term in the expression between both equal signs in (B5) corresponds to the reduction in distortionary taxes due to this revenue.

Substituting (B3) and (B5) into (B1) and (B2) allows rewriting the planner's problem as:

$$\min_{\{T_H \geq 0, T_L \geq 0, S_H \geq 0, S_L \geq 0\}} \sum_{i=H,L} \pi_i [PVR_i(T_i) + S_i] \quad \text{(B6)}$$

$$s.t. \quad \sum_{i=H,L} \pi_i u[PVR_i(T_i) + S_i - I] \geq u(0) \quad \text{(B7)}$$

where we used that, since $1+\lambda-\alpha>0$, maximizing the planner's objective function is equivalent – in the sense that the optimal choices of the T_i and S_i are the same – to minimizing $-1/(1+\lambda-\alpha)$ times this function. Thus, the term $-1/(1+\lambda-\alpha)$ was dropped from the objective function. The terms αI and $(1+\lambda)\ PVR_i^{\infty}$ were dropped too, because they do not depend on the problem's choice variables. That is, subject to the firm's participation constraint, the planner minimizes the expected transfer of resources to the firm.

Irrelevance Result. From the planner's problem specified in (B6) and (B7), it can be seen that the per-dollar cost of paying for the project with sales revenues or subsidies is the same. Thus, social welfare only depends on total transfers to the firm, not on how these transfers are split between subsidies and user fee revenue. This is the fundamental insight behind the following result.

Result 1 (Irrelevance of the public cost of funds argument). Any combination T_H, T_L, S_H, S_L such that $PVR_i(T_i)+S_i = I$ for all i solves the planner's problem specified by (B6) and (B7).

Proof. Any of these combinations satisfies the firm's participation constraint, so they are feasible. They also eliminate risk for the firm. They are optimal because they minimize total expected transfers to the firm and because the firm is risk averse.

Result 1 shows that there exists a multiplicity of optimal subsidy-sales revenue combinations that implement the optimal contract, indicating that distortionary taxation ($\lambda > 0$) is not sufficient to make PPP provision preferable, for one possible solution is that $T_L = T_H = 0$ and $S_L = S_H = I$. This is public provision – the government pays for the project upfront. At the other extreme is a PPP contract financed entirely with user fees, where the firm invests I, collects user fee revenues equal to I in present value, and no subsidies are paid. In addition, there is a continuum of intermediate solutions, where the government provides partial financing.

We show next that the optimal contract described in Result 1 can be implemented both using public provision and using a PPP. Consider first public provision. The firm that builds the project is selected *via* a competitive auction, and the firm that maintains the project *via* another auction. There is no relation between the two firms. Assume that the firm that asks for the lowest compensation to build the project wins the first auction. The winning bid in a Nash equilibrium will equal I, for if it is less than I, the winner will have a guaranteed loss and if it is above I, the losers will regret not having bid slightly below the winning bid. An analogous argument shows that the second auction selecting the firm that will maintain the project will go to a firm that offers to charge zero.

The optimal contract can also be implemented using a PPP. Furthermore, if $PVR_L^{\infty} \geq I$, the implementation requires no transfers from the government to the concessionaire. Assume that firms bid on the present value of user fee revenue they require to finance, build, maintain and operate the project. The winner is the firm that bids the least PVR, where the discount rate is the risk free rate r. The contract lasts until the firm has collected I. When this happens, the project returns to the government.[5] Both implementations described above do not require that the planner knows I. The competitive auctions reveal the value of I to the planner.

Result 2 (Implementation). Public provision and PPPs can be used to implement a contract that achieves the optimum described in Result 1. When the project is self-financing in all demand states, it can be implemented *via* a PVR auction. In this case the contract lasts longer when demand is low.

5 As mentioned, the winning bid equals I. Furthermore, the contract term is longer in low demand states: $T_i = \frac{1}{r} \log \frac{Q_i}{Q_i - rI}, i = H, L$.

The literature on private provision of infrastructure has identified three reasons why social welfare under public provision and PPPs may be different. First, since the same firm builds and operates the project under a PPP, it has incentives to internalize life cycle cost considerations during the construction phase. These incentives are not present under public provision. When service quality is contractible, bundling of construction and operations provides an argument in favour of PPPs (Engel *et al.* 2008). The reason is that the firm has an incentive to internalize life cycle costs and, at the same time, cannot skimp on the quality of service.

A second argument in favour of PPPs notes that firms own the infrastructure assets during the life of the contract under a PPP, in contrast to public provision, where any innovation conducive to using the assets more efficiently requires a negotiation with the regulator. For the same reason, there are more incentives for effective risk management under a PPP than under public provision. This suggests that there will be more innovations and better risk management under PPPs than under public provision.[10] Box 2 extends the basic model from Box 1 to formalize this idea.

A third argument in favour of PPPs focuses on the wedge between the costs of compensating the private partner *via* government transfers *versus* the cost of user fees, due to agency costs associated with disbursing government funds. The planner prefers contracts that rely more on user fees and less on subsidies if government transfers are more costly to society, even if this results in having the firm bear some risk (see Engel *et al.* 2007).

In all these cases, the financial arrangements impose risk on the firm, and this translates into a PPP premium. The higher financing costs that result should not necessarily be held against PPPs when comparing them with public provision. In exchange for the high cost of sponsor funds, the procuring authority obtains the services of a company that is focused on reducing life cycle costs. The endogenous risks provide incentives and it is a mistake to consider a PPP premium while omitting the improved performance (see Box 2) which compensates for the lower risk premium required under public provision. There is no *prima facie* reason to believe that achieving equivalent incentives with public provision would be cheaper. Following Klein (1997, p. 37):

In exchange for the higher cost of sponsor funds, society gets the services of a company focused on reducing life cycle costs.

"[...] the cost of funds cannot be considered independently of the incentive system under which intermediaries collect them."

10 For references that consider one or both elements described above as possible arguments in favour of PPPs, see Grout (1997); Hart (2003); Bennett and Iossa (2006); Bentz *et al.* (2005); Martimort and Pouyet (2008); Iossa and Martimort (2008).

Box 2. Efficiency gains from PPPs: Non-contractible innovations[1]

Our starting point is the model described in Box 1. The only addition is that during the construction and operational phases, the firm can exert effort $e \geq 0$, at a monetary cost of ke, with $k > 0$. This effort may result in an innovation that saves θ during the life of the contract with probability $p(e)$, while no savings occur with probability χ 1-p(e). The innovation has no effect on the quality of service.[2] The "probability-of-success" function $p(e)$ satisfies $p(0)=0$, $p'>0$, $p''<0$ and $p(e)<1$ for all $e\geq 0$. Neither effort nor the innovation is verifiable.[3]

Under public provision, the firm that builds the project is selected with a competitive auction where firms bid on the lowest price to build the project. Since the benefits from innovation occur after the construction phase, the firm does not have incentives to invest in effort. It follows that the planner's problem is the one considered in Box 1 with the additional constraint that the firm can only be remunerated with government transfers.

Result 3 (Non-contractible innovations and public provision). Under public provision the winning firm bids *I* for the contract, exerts no effort, and builds the project at a cost *I*.

Under a PPP, the firm may find it convenient to invest additional resources to lower life cycle costs. Even if the planner designs a contract where discounted revenues are the same in all demand states, so that the firm only bears risk if it decides to exert effort, the concessionaire may nonetheless decide to do so if the expected benefits exceed the cost of the additional risk premium. Not surprisingly, this will be the case when the probability of a successful innovation responds strongly to effort (large p'(0)), when the benefits of innovation θ are large, and when the cost of effort k is low. The following result formalizes this intuition (for proof, see Annex).

Result 4 (Non-contractible Innovations and PPPs). Assume

$$\theta p'(0) > k\frac{u'(0)}{u'(\theta)}. \qquad \text{(B8)}$$

Then social welfare is higher under a PPP than under public provision. In particular, the planner can achieve higher welfare than under public provision by setting discounted user fee revenues equal to *I* in all demand states. If the firm finds it optimal not to exert effort, welfare is the same under both contractual forms.

Under public provision, the concessionaire bears no risk, so the interest rate implicit in the firm's participation constraint equals the risk free discount rate *r*. Under a PPP the implicit cost of capital is larger than *r* since the firm bears risk. This does not mean a PPP is more expensive to society than public provision because the additional risk induces the firm to exert welfare-improving effort. The total cost of the infrastructure to society is lower under a PPP than under public provision even though the financing cost per dollar (or euro) is higher under a PPP. This is summarized as follows:

Result 5 (A PPP premium may reflect a socially desirable high-powered contract). Under the assumptions of Result 4, the optimal PPP contract leads to higher social welfare than public provision – despite higher cost of capital under a PPP – because the overall cost is lower.

Summing up, a contractual form that minimizes the cost of capital or protects the concessionaire from bearing desirable risk can be misguided. Risk bearing and the resulting higher cost of capital induce the firm to exert effort that leads to an outcome with higher welfare.

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1 Based on Engel *et al.* (2010).

2 For example, θ could include any change in costs needed to meet contractual quality standards after an innovation.

3 It is usually difficult for the regulator to monitor the firm's innovation efforts and to write contracts that anticipate the many forms in which the firm's undertakings may succeed in reducing operating and maintenance costs.

3.3 Transaction costs

Higher transaction costs under a PPP partly reflect more careful project planning, which lowers the probability of costly ex post renegotiations.

The complexity of the relationship between the sponsor, who owns the SPV, and the procurement agency, which oversees the contract and certifies compliance, creates transaction costs. These could potentially be so high that they negate the other advantages of PPPs.

Complexity. It is sometimes argued that PPPs are financially more expensive because they require legal, technical and financial advisors as well as an estimation of demand risk. These costs can reach 10 percent of the total cost of the project (Dos Santos Senna and Dutra Michel 2008; Yescombe 2007, p. 26). These costs do not scale with the size of the project, so for small projects a PPP is impracticable unless several projects can be "packaged" as copies of a single project (Yescombe 2007). It is not clear that this expense, which duplicates the studies of the procuring authority, is wasted as it provides a check on the potentially over-optimistic numbers provided by the government and the sponsor of the project.

In addition, the more detailed nature of the contract, as compared to the contract under public provision, is useful because it limits the possibilities of *ex post* renegotiations of the original contract. Hence, when these factors are considered, the additional expense might be partly justified by reducing the life cycle costs of the project.

Lead time. PPPs require a lead time which is usually longer than the lead time for public provision. The complexities inherent to the SPV form, plus the many eventualities that have to be considered in a contractual relationship that lasts for a very long time, explain the longer preparation periods. This can be seen in Table 2, which shows the time to financial closure (before beginning construction), in the UK. As financiers usually recover these costs through the rate they charge, this tends to increase the PPP premium.

Table 2. PFI lead times by sector

Sector	Procurement dates	Financial close	Lower – upper bounds
	months	months	
Health	12/94-12/98	40	22 – 60
Schools	03/97-12/99	23	15 – 25
Defence	11/94-09/99	23	18 – 32
Custodial/Prisons	03/97-11/99	21.4	14 – 25
Roads	03/86-11/95	18	15 – 20
Tram/Light rail	03/86-11/95	22.3	13 – 30

Source: HM Treasury (2003)

Against this longer lead time, it is slightly more likely that a project will be completed on time and on budget under a PPP than under public provision, as can be seen in Table 3. Even though the more careful study by the UK National Audit Office (NAO 2009) finds a smaller advantage for Private Finance Initiatives (PFI), it is not altogether clear that the additional lead times translate into higher life cycle costs of the project.

Table 3. Percentage of on-time and on-budget projects

	2003 HM Report		NAO 2009 Report	
	PFI	Non PFI	PFI	Non PFI
On time	88	30	69	65
On budget	79	28	65	54

Sources: HM Treasury (2003) and NAO (2009)

Agency costs. As we have already mentioned, PPPs introduce a second relationship, the one between the sponsor, who owns the SPV, and the procurement agency, which oversees the contract and judges compliance. This relationship, absent under public provision, introduces the potential for conflicts which may affect the flow of revenues to the concessionaire and to debt holders. For this reason, various additional contractual aspects affect the rating and default premium demanded by bondholders, and raise it above the premium demanded by the same bondholders when they buy sovereign debt. These aspects include the reasonableness of performance tests, the penalty mechanisms in the concession contract, the experience of the sponsor and operator in the industry or the country, the transparency of the tender agreements, the strength of legal precedent, the strength of the conflict resolution framework, and the political support for PPPs.

3.4 Credit constraints

The claim that PPPs allow credit-rationed governments to invest in additional projects is questionable.

It is a commonly-held view that PPPs allow credit-rationed governments to invest in additional socially, or even privately, profitable projects, which may be impossible under public provision due to the credit constraints. We show that this argument has only limited applicability.

First, if the project does not generate user fee revenue, a credit-rationed government will be unable to find private investors since repayment requires a flow of funds which, by definition, a credit-constrained agent cannot commit. This leaves the case of projects that generate enough user fee revenue to pay for themselves (or for whatever fraction is not subsidized by donor aid). Public provision is difficult since there would have to be a clear separation of the project cash flow from the remaining government fiscal accounts. Otherwise the revenues of the project could be appropriated to other purposes. As it is almost impossible to provide guarantees preventing this possibility, an SPV is the appropriate mechanism to protect the investors in the project. However, the flow of cash derived from the sunk investment in profitable projects is an attractive target for expropriation by credit-constrained governments.

To reduce this possibility, these projects are often protected by receiving partial funding from multilateral banks. Multilateral banks protect the project from being expropriated by the clauses associated to their lending. It is important to note that the loans and equity participation of Multilateral Banks are privileged (Buiter and Fries 2002). This is, first, because of the repeated interactions between borrowing countries and multilaterals, which promise future lending only if the country complies with the terms of current loans; though there are exceptions to this policy (see Buiter and Fries 2002). Second, it is because the claims of multilaterals have priority over the international reserves of the country and are senior to those of bilateral and commercial creditors in case of financial distress. Third, the multilateral banks are active in protecting their equity investments in national and international courts of law, and the reputation for this policy increases the cost of non-compliance. This explains the value of the

participation of the private investment arm of the multilateral banks in PPP projects in developing countries. By their normally careful lending procedures, multilateral banks can also promote funding by providing information about the quality of the projects in which they invest.

4. Public finance and PPP finance

One of the reasons for PPPs has been the desire of governments to indulge in public works even when restricted by budgetary constraints (see Engel *et al.* 2009 and also House of Lords Select Committee on Economic Affairs 2010, p. 16). For this reason, the accounting standards-setting organizations have struggled to determine when a PPP project should be included in the government's balance sheet.

4.1 PPPs and fiscal accounting

Because PPPs are relatively recent, there is little agreement over how to account for them in the balance sheet, if at all. Indeed, most governments treat PPPs off the balance sheet, which implies that public debt figures do not adequately express future commitments. For example, between 1992 and April 2009, the UK awarded 669 PPP contracts, with estimated investment of GBP 55 billion. Only 96 projects, amounting to 23 percent of total investment, were on the balance sheet despite the fact that PPPs imply an estimated obligation of GBP 91 billion up to the year 2032. Taking projects off balance sheet allows governments to elude spending and debt caps. Under public provision, on the other hand, caps on spending or net fiscal debt are reasonably effective in controlling the bias towards spending because projects must be included in the budget.

Most governments treat PPPs off the balance sheet, which implies that public debt figures do not adequately express future commitments.

How are PPPs accounted for in practice? According to Hemming (2006), there is a hierarchy of government accounting standards. The International Public Sector Accounting Standard (IPSAS) is the highest level. When no rule in the IPSAS covers a given issue, government entities should comply with the International Financing Reporting Standards (IFRS) under the interpretation of the International Accounting Standards (IAS). But these general principles still allow considerable latitude to the government. Eurostat (2004) made somewhat more precise recommendations based on the source of project revenues and who bears construction, availability and demand risks. If 50 percent or more of the project's revenues come from user fees, the project is considered off-balance sheet. If not, Eurostat recommends that assets built by PPPs be classified as nongovernmental and therefore recorded off the balance sheet if the private partner bears construction risk, and either of availability or demand risk. The Eurostat approach can be gamed by determined governments because of its formal nature. For example, it has problems in the case of minimum-revenue guarantees that might come into effect in the future. They are considered a risk transfer if they are "not likely" to be called, and this allows for excessive discretion.

The UK Generally Acknowledged Accounting Principles (GAAP) are less formal and focus more on the substance of risk transfer by considering a project to be on the balance sheet if *(i)* the Public Works Authority (PWA) is responsible for the debt under default, or if *(ii)* the level of risk is excessive and would only be assumed if lenders faced no risks, or if *(iii)* the PWA decides *ex post* the conditions by which the PFI contract is fulfilled (Yescombe 2007, p. 72). Moreover, the UK GAAP requires that any other risks borne by the PWA should be quantified and their NPV should be compared to the NPV of the project. If the remaining risks represent a substantial fraction of the NPV of the project, the project should be on the balance sheet of the government.
This means that the

> "UK GAAP only includes the liabilities if the balance of risk and reward was with the public sector." (House of Lords Select Committee on Economic Affairs, 2010, paragraph 56)

However, since the interpretation of "balance" was left to public bodies and their auditors, this led to most PFI projects not being included in the Public Sector Net Debt Statistics. This changed in 2009, when the UK accounting practices began to abide by the IFRS standards. Under this standard, assets which are controlled by the public sector, and this includes most PFI projects, have to be included in the departmental balance sheets (House of Lords Select Committee on Economic Affairs 2010).

Note that in the case of the UK government, the use of PPPs for government investment was not associated to credit rationing. Even though the government used the concept of Value for Money in order to choose between PFI and public provision, there was a bias towards PFI investment. From the point of view of the government, PFI allowed (off-balance sheet) public investment while still nominally complying with the Maastricht Treaty limits on government budget deficits.

How should PPPs be accounted for in the budget? The starting point is to note that PPPs have long-term implications and therefore the focus should be on the *intertemporal* budget.

Since PPPs do not alter the intertemporal budget constraint, they should be treated as standard government investment.

As we have already seen, PPPs change the timing of government revenues and disbursements and the composition of financing but do not alter the intertemporal budget constraint. The main conclusion is that PPPs should be treated as standard government investment.

To see why, consider first a PPP project fully financed by future payments from the budget (see the lower half of Table 1). From an accounting point of view, a PPP just substitutes debt with the concessionaire for standard government debt. Thus, there is no reason to treat PPPs differently from projects under public provision. It follows that upon award of the PPP, the present value of the contract should be considered as government capital expenditure and government debt should be increased by the same amount.

In the case of projects whose main source of revenues is user fees (see the upper half of Table 1), the analysis is somewhat different but reaches a similar conclusion. To see this, consider the simplest example in which there is perfect certainty that the project will pay for itself (including normal profits and interest) during the lifetime of the PPP. As mentioned above, when comparing columns (1) and (2) in Table 1, the project will have no effect on the intertemporal budget of the government. Under public provision, project revenues from user fees would have accrued to the government and would have been registered as revenues during each year of the operational phase. At the same time, the government would have made interest and principal payments to pay back the debt. Under a PPP, therefore, one should, as before, register user fees as current revenues and credit those revenues as payments for interest and principal of the "debt" with the concessionaire.[11]

Our proposal runs somewhat contrary to the Eurostat rules, and it is interesting to discuss why. Even under public provision, construction risks are usually allocated to the private firm. Hence, Eurostat rules imply that the government can take the PPP off-balance sheet when either availability or demand risk is assumed by the concessionaire. The problem with the Eurostat rules is that they take a static view of risk allocation. Once we use an intertemporal approach, it is clear that, even if the firm bears all the demand risk during the life of the contract, the discounted budget still is the residual risk claimant. Furthermore, when quality is contractible, as arguably is the case for most PPP

11 The case when the project requires subsidies as well as user fees in all states can be treated in the same way. See Engel *et al.* (2007) for a generalization of this point to the case in which the PPP does not generate enough revenue to finance the upfront investment in all states.

investments in the transportation sector, demand risk will be mainly exogenous and therefore does not provide useful incentives. To the extent that taxpayers bear exogenous risk at a lower cost than the firm, the optimal contract then eliminates risk for the firm, so the effect on the government budget is identical to that of public provision.

Finally, we note that the link between the project and the public budget is severed only under privatization. In that case, the project is sold in exchange for a one-off payment and all further risks are transferred to the firm. This is not the case with PPP contracts where, at the margin, cash flows from the project always substitute for either taxes or subsidies.

Summing up, the conclusion is that from a public-finance perspective, there is a strong presumption that PPPs are analogous to public provision. In essence, PPPs remain public projects, and should be treated as such for government accounting purposes.

4.2 Government revenue guarantees

As we have mentioned before, some concessions can be financed in part or completely with user fee revenue. Guarantees can make a project bankable. It has become common for governments to grant revenue guarantees to concessionaires, especially when concessions have a fixed term. Guarantees are contingent subsidies and they have an effect on the intertemporal budget. Nevertheless, their contingent nature makes it difficult to account for them in the budget.

As Hemming (2006, p. 40) notes, future obligations will probably remain hidden under current accounting standards. For one thing, cash accounting makes guarantees apparent only when they are paid, in which case they appear as current expenditure. For another, accrual accounting records the guarantee as a government liability only if the government considers the probability of making a payment to be higher than 0.5 and if it can make a reasonable estimate of the payment.

Under these rules, guarantees are recorded only when they are called, unless the government makes a provision and sets funds aside. Even worse, as Hemming (2006, p. 42) notes, most countries have poor records of the guarantees they have provided to the private partners and, when information exists, it is locked within individual agencies and ministries. Some countries (*e.g.* New Zealand, Colombia and Chile) have undertaken efforts to quantify guarantees within an accrual framework by estimating the expected outlays and correcting for the degree of risk involved (*e.g. via* value-at-risk type measures). The problem is that any rule that relies on a probabilistic assessment can be manipulated because these probabilities are a matter of judgment. Hence, guarantees can be used to soften the budget constraint of the incumbent government allowing it to sidestep normal budgetary procedures and parliamentary oversight.

In our view, government guarantees do not warrant special treatment since they are subsumed in the obligations of the government. When the full amount invested is accounted as government capital expenditure, as we argued in Section 4.1, and public debt is increased by the same amount, guarantees are implicitly included and there is no need to make value judgments on the cost of a contingent guarantee.

Treating PPPs like government investment in fiscal accounting makes the arduous evaluation of contingent guarantees unnecessary.

Accounting for capital and debt payments in the balance sheet is somewhat trickier. As in the case of the optimal contract, this debt is backed by a combination of user fee revenue, guarantees, and possible renegotiations of the concession contract. The different items are combined in different proportions as events unfold. In the case of fixed-term PPPs the private partner assumes risk and may receive capital gains or losses over the life of the concession. Thus, one needs to adopt a

convention for the balance sheet treatment of project revenues and the gradual extinction of the guarantee as the concession unfolds. In any case, the guarantee will be extinguished *a fortiori* when the concession ends.

4.3 Renegotiations

One of the problems facing PPPs is the renegotiation of the PPP contract. There are various justifiable reasons for renegotiating a contract like a changing environment, new information or the discovery of design errors. For these reasons, all parties, including the public, may stand to gain in renegotiating contracts in some cases. But in other cases, the only reason to modify the contract is to benefit one or both active parties: either the procuring authority (in the case of expropriation of the PPP, for example) or the project sponsor (by helping a failing project with a length extension, or lowering the technical standards), or both parties at the expense of the public. The problem is that it is difficult to discriminate between justifiable and non-justifiable renegotiations.

During the construction stage, renegotiations also occur under public provision. The difference is that PPPs have a longer time horizon and have additional dimensions for renegotiation: a change in contract length, in user fees, in service quality standards, among others. Even when renegotiations are justifiable, the results may not be fair given the fact that renegotiations occur in the context of bilateral monopoly.

If contract renegotiation is made too easy, the favourable incentive properties of PPPs are lost.

On the one hand, renegotiations lower the risk of failure, which may help attract willing lenders. But on the other hand, the possibility of renegotiating the contract to the benefit of the firm negates many welfare benefits of PPPs. If the sponsor knows that not being efficient (in demand prediction, cost reduction, project design, service quality *etc.*) does not increase the risk of losses or project failure, the incentive properties of PPPs are lost. Moreover, the results of renegotiation tend to favour sponsors that have strong lobbying skills at the expense of technical expertise. As a consequence, firms that have an advantage in bidding for PPPs with governments are also those that are known to renegotiate their contracts. As in the case of guarantees, renegotiations allow incumbent governments to sidestep budgetary spending and debt limits and thus lead to excessive current spending on infrastructure.

Under public provision, that is, when the government hires a construction company to build infrastructure but controls the project thereafter, caps on spending or on net fiscal debt are reasonably effective in controlling this bias because any additional expenditure agreed in renegotiations must be included in the budget. In contrast to public provision, renegotiations of PPP contracts can be used to elude spending caps because of defective fiscal accounting standards. Essentially, PPP arrangements bundle finance and construction, so the firm can increase "lending" to the government by renegotiating the contract in return for payments to be made by future administrations. Under the usual fiscal accounting rules, neither the additional investments that take place after renegotiations nor the future obligations originating from the renegotiated agreement are accounted for in the balance sheet.

The solution to the spending bias is no different to what we have already discussed for PPPs in general: any additions to the project should be counted as current capital expenditures and therefore be accounted for as debt.

Is there any evidence of the use of renegotiations to anticipate government spending? If spending anticipation through renegotiations were a real issue, four features should be observable. First, firms should lowball their bids, expecting to recover normal or supernormal profits in future renegotiations. Second, additional works should be included when contracts are renegotiated, *i.e.*, the additional payments should be in exchange for additional investments by the private partner. Third, there should

be major renegotiations shortly after the award of the contract, *i.e.* during the construction phase. Fourth, an important fraction of the costs of the renegotiation process should be borne by future administrations.

While there is little systematic data on renegotiations, Engel *et al.* (2009) have compiled information on the 50 PPP concessions awarded in Chile between 1993 and 2006. Total investment increased *via* renegotiation from USD 8.4 billion to USD 11.3 billion, *i.e.* by nearly one-third. Most of the increase (83 percent of the total amount) was the result of 78 bilateral renegotiations, while the rest were decisions of arbitration panels. For the USD 2.3 billion awarded in bilateral renegotiations, we find that only 35 percent of the additional cost was paid by the administration that renegotiated. Moreover, 84 percent of the USD 2.3 billion corresponds to payments for additional works, while the remaining 16 percent corresponds to additional payments for works that were included in the original contract. 78 percent of the total USD 2.3 billion was awarded during the construction phase. Finally, we observe that even though specific provisions in Chilean concessions law limit the amounts that can be renegotiated, these limits were routinely exceeded.

5. Conclusion

PPPs make sense not for financial reasons but for their organizational form that matches the economics of infrastructure projects, improving accountability.

It is perhaps fair to say that the alleged financial advantages of PPPs have been one of the main reasons for their popularity. Newspaper articles often mention that PPPs release government funds, thus expanding the set of projects that governments can undertake. By contrast, we conclude that there is no *prima facie* financial reason to prefer PPPs over public provision and that PPPs hardly ever free public funds.

Our conclusion rests on the observation that PPPs affect the intertemporal government budget in much the same way as public provision. With a PPP the current government saves in investment outlays. But then it either relinquishes future user fee revenue (if the PPP is financed with user fees) or future tax revenues (if the PPP is financed with payments from the government budget). The exceptions are the case of credit-constrained governments and even then, the increased availability of funds occurs only under very special conditions. Hence, the case for PPPs must rest on something else, notably on efficiency gains associated to bundling construction, maintenance and operations, and not on their purported financial advantages.

From a public-finance point of view, PPPs have disadvantages. Since fiscal accounting rules keep most PPPs off the balance sheet, governments have used them to anticipate spending and to sidestep the normal budgetary process, much in the same way that off-balance sheet vehicles helped banks to elude capital requirements and prudential regulation. We conclude that, from the point of view of the government budget, PPPs should be treated as conventional government investment.

We are less convinced that PPP financing is inherently more costly than public provision financed with government debt. Indeed, with adequate contracting, PPPs can replicate the intertemporal risk profile of public provision. Hence, the so-called PPP premium may reflect faulty contractual schemes, which inefficiently assign exogenous risks to the private partner. In addition, the PPP premium may reflect endogenous risks that cannot be meaningfully separated from the incentive structure which is partly responsible for the efficiency gains under PPPs. For these reasons, the observed higher cost of capital under PPP should not be interpreted as evidence against this contractual option.

Lastly, PPPs require sophisticated financial engineering. Contrary to public provision, a PPP isolates the infrastructure and its cash flows by creating a special purpose vehicle (SPV). This organizational form conforms well to the basic economics of infrastructure projects and contributes to better accountability.

Annex. Proof of Result 4

To prove Result 4 (see Box 2), we begin by analyzing the planner's problem. When designing the PPP contract, the planner can choose the length of the contract and the subsidy for each demand state. We assume that the firm's effort, and whether it succeeds in cutting costs, cannot be contracted upon. The firm's surplus in state *i* now is:

$$PS_i = p(e)\left[PVR_i(T_i)+S_i+\theta-I-ke\right]+(1-p(e))\left[PVR_i(T_i)+S_i-I-ke\right] = PVR_i(T_i)+S_i-I+p(e)\theta-ke$$

Compared with (B3) in Box 1, the above expression includes an extra term, $p(e)\theta - ke$, representing the expected gain from efforts in innovation. Defining $\tilde{\alpha} \equiv \alpha/(1+\lambda-\alpha)$, the planner's problem described in (B6) and (B7) becomes:

$$\min_{\{e\geq 0, T_i\geq 0, S_i\geq 0; i=H,L\}} \sum_{i=H,L} \pi_i\left[PVR_i(T_i)+S_i\right]-\tilde{\alpha}\left[p(e)\theta-ke\right] \tag{A1}$$

$$\text{s.t.}\quad p(e)\sum_{i=H,L}\pi_i u\left[PVR_i(T_i)+S_i+\theta-I-ke\right]+\left[1-p(e)\right]\sum_{i=H,L}\pi_i u\left[PVR_i(T_i)+S_i-I-ke\right]\geq u(0) \tag{A2}$$

$$e \text{ solves the firm's maximisation problem, given } T_L, T_H, S_L, S_H. \tag{A3}$$

Note that, since both *e* and θ are not contractible, the user fees and subsidies received by the firm do not depend on the effort it makes or whether this effort results in an innovation or not. Finally, the incentive compatibility constraint (A3) captures the fact that the firm will choose *e* that maximizes its expected utility given the value of T_i and S_i set by the planner.

As before, user fees and subsidies are perfect substitutes, allowing us to denote $PVR_i(T_i)+S_i$ by R_i in what follows. Also, an argument similar to the one we used to prove the Irrelevance result shows that total revenue accrued to the firm under the optimal contract will be the same in both demand states so that $R_H=R_L$. Denoting this common value by *R*, we rewrite the planner's problem as:

$$\min_{\{R\geq 0\}} R-\tilde{\alpha}\left[p(e)\theta-ke\right] \tag{A4}$$

$$\text{s.t.}\quad p(e)u(R+\theta-I-ke)+\left[1-p(e)\right]u(R-I-ke)\geq u(0) \tag{A5}$$

$$p'(e)\left\{u(R+\theta-I-ke)-u(R-I-ke)\right\} = k\left\{p(e)u'(R+\theta-I-ke)+\left[1-p(e)\right]u'(R-I-ke)\right\} \tag{A6}$$

To derive the first-order condition (A6), which characterizes the firm's optimal choice of effort given *R* and which assures an interior solution, we have used the following lemma:

Lemma 1. If the planner specifies R, the firm chooses effort e that satisfies Equation (A6).

Proof. Given *R*, the firm solves:

$$\max_{e\geq 0} p(e)u(R+\theta-I-ke)+\left[1-p(e)\right]u(R-I-ke)$$

Calculating the first-order condition with respect to *e* and rearranging terms leads to (A6).

It follows from Result 3 in Box 2 that under public provision the planner's objective function (A5) attains the value of *I*. We show next that the planner can do better under a PPP than under public provision. We consider the case where the planner sets $R=I$ in a PPP contract, and find conditions ensuring that the firm chooses positive effort, leading to a value smaller than *I* for the planner's objective function. The following two lemmas are used to prove this result.

Lemma 2. Assume the planner sets $R = I$ and condition (B8) holds (see Box 2). Then the firm's optimal effort is strictly positive.

Proof. The firm solves:

$\max_{e \geq 0} G(e) = p(e)\,u(\theta - ke) + [1 - p(e)]\,u(-ke)$

Since $G'(e) = p'(e)\,[\,u(\theta - ke) - u(-ke)\,] - k\,\{p(e)u'(\theta - ke) + [1 - p(e)]\,u'(-ke)\}$, we have that $G'(0) = p'(0)\,[u(\theta) - u(0)\,] - ku'(0)$, where we have used $p(0) = 0$. It follows that $G'(0) > 0$ if and only if:

$$p'(0) > \frac{ku'(0)}{u(\theta) - u(0)}$$

The sufficient condition (B8) follows from the above inequality and noting that strict concavity of u implies $u(\theta) - u(0) > \theta u'(\theta)$.

Lemma 3. If $e > 0$ is the firm's optimal choice given some value of R, then:

$p(e)\theta > ke$

Proof. Since e is optimal, the firm must do at least as well under e as when it chooses $e = 0$. Using the mean value theorem twice, we have:

$$p(e)\,u(R + \theta - I - ke) + [1 - p(e)]\,u(R - I - ke) \geq u(R - I) \tag{A7}$$

$$\Rightarrow \quad p(e)\{u(R - I) + (\theta - ke)u'(\xi_1)\} + [1 - p(e)]\{u(R - I) - keu'(\xi_2)\} \geq u(R - I) \tag{A8}$$

$$\Rightarrow \quad p(e)\theta \geq \left\{ p(e) + \frac{u'(\xi_2)}{u'(\xi_1)}[1 - p(e)] \right\} ke \tag{A9}$$

$$\Rightarrow \quad p(e)\theta > ke \tag{A10}$$

where in the last two steps we used strict concavity of u and that $R - I - ke < \xi_2 < R - I$ and $R - I \leq \xi_1 \leq R - I + \theta - ke$, so that $\xi_2 < \xi_1$.[12]

Finally, we are ready to prove Result 4.

Proof of Result 4. Assume the planner sets $R = I$ in the PPP contract. It follows from Lemma 2 that the firm will choose strictly positive effort. Lemma 3 then shows that the planner's objective function (A4) will take a value strictly smaller than I.

12 To have $\xi_2 < \xi_1$, we also used that $ke < \theta$. If this were not the case, the firm would spend more resources on effort than the benefits it would obtain in the best possible outcome.

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