PUBLIC-PRIVATE PARTNERSHIPS: WHEN AND HOW

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July 19, 2008[1]

Abstract

When are public-private partnerships (PPPs) better than conventional provision and regulated privatization? And should PPP contracts be structured and governed when this is the case?

We show that the defining features of a PPP are (i) bundling of construction and operation, (ii) private but temporary ownership of assets and (iii) intertemporal risk sharing with the public sector. Thus some characteristics of PPPs are akin to privatization while others are similar to conventional provision. Since incentives for efficient building and management are related to bundling, PPPs are closer to privatization in this regard. As the discounted government budget under a PPP is similar to that under conventional provision, PPPs are closer to conventional provision when it comes to budgetary accounting. We also show that avoiding distortionary taxation and relieving strained government budgets are weak arguments for PPPs.

We examine the institutional requirements for a successful PPP program and emphasize the need for an independent supervisor of PPPs (and in general of all public works) and a Committee of Experts to award when conflicts or the need for renegotiation arises. Lack of rule of law alters the choice between conventional provision and PPPs in favor of the former, as there is less risk of regulatory takings in a short term construction contract than in a long lived PPP.

In the case where quality service is contractible, the the PPP contract that optimally balances demand risk, user-fee distortions and the opportunity cost of public funds, features a minimum revenue guarantee and a revenue cap that differ from those observed in practice. This contract can be implemented via a competitive auction with realistic informational requirements.

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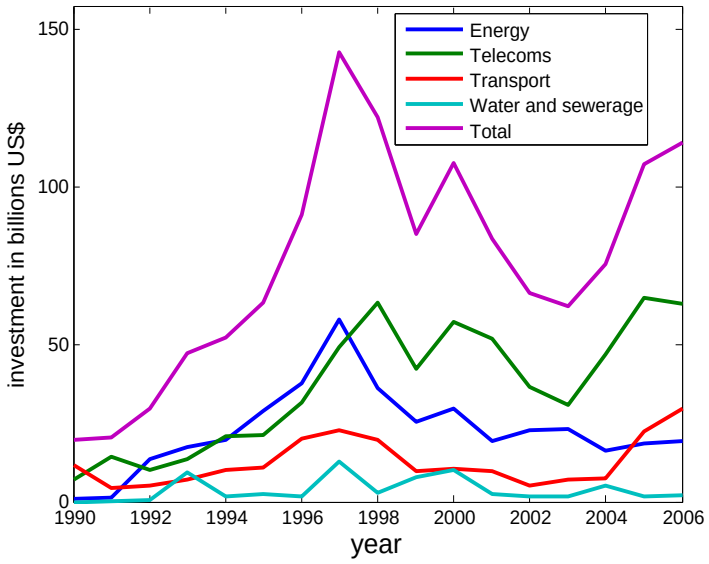
1 Introduction

The use of Public-Private Partnerships (PPPs) in the provision of infrastructure services has increased substantially since the early 1990s, as illustrated by Figure 1 that shows the evolution of investment commitments in infrastructure projects with private participation in developing countries, by sector and in total, during the 1990-2006 period (Source: World Bank and PPIAF, PPI Project Database).[2,3,4,5,6] As privatizations became increasingly unpopular (see Table 1 with the evolution of the fraction of the population, in 17 countries in Latin America, that agrees or strongly agrees with the statement that privatization has been beneficial), PPPs emerged as a "third way," promising the advantages of privatization while avoiding its pitfalls.

Figure 1: Investment in projects with significant private participation



[2]This does not correspond to the exact concept of public-private partnerships but constitutes a reasonable (and the best available) proxy.

[3]The surge in PPPs is also reflected in the financial press. For example, articles in the Financial Times mentioning this concept increased twenty-fold over the last decade, from 50 in 1995 to 1,153 in 2004.

[4]With 14% of public investment done under the so-called Private Finance Initiative, Britain is the country where PPPs account for the largest fraction of public investments (Hemming, 2006).

[5]We adopt a broad concept of infrastructure that includes social, economic, hard, soft, institutional, personal, material, and public infrastructure. In light of this broad approach, infrastructure that has been provided via PPPs include roads, bridges, tunnels, railways, ports, airports, air traffic control systems, water and sanitation plants, hospitals, schools, prisons, and social housing.

[6]There also exists a rich set of acronyms to describe specific PPP arrangements, including BLT, BLTM, BOT, DBOT, DBFO, DBFO/M, JV and ROT. The B usually stands for build, the L for lease, the R for rehabilitate, the T for transfer, the O for operate, the D for design, the F for finance, and the M for manage. JV stands for "joint venture".

Table 1: SUPPORT FOR PRIVATIZATION IN LATIN AMERICA

	ARG	BOL	BRA	COL	CRI	CHI	ECU	SLV	GUA
1998	39	52	49	40	59	50	52	53	61
2001	17	24	49	13	31	43	33	25	22
2004	25	25	35	26	n.a.	30	26	22	2
2007	19	43	45	33	29	33	45	38	26
	HON	MEX	NIC	PAN	PAR	PER	URU	VEN	*Avge.*
1998	46	50	46	20	46	43	43	51	*46.3*
2001	21	28	31	37	34	22	23	49	*29.4*
2004	20	37	21	12	n.a.	29	n.a.	41	*25.7*
2007	33	40	29	27	22	32	n.a.	47	*33.8*

Source: Latinobarometro

There exists no single definition of a PPP, yet most definitions mention participation by the public and private sector coupled to a contract that influences risk sharing among parties.[7] A defining characteristic of a PPP, compared with the conventional approach to the provision of infrastructure, is that it bundles investment and service provision into a single long term contract.[8] By contrast, under conventional provision, which is also referred to as "public provision" or the "traditional approach," the firm that builds the infrastructure takes no responsibility for its long term performance after the relatively short term construction warranty has expired.[9]

[7] For example, Grimsey and Lewis (2004) define PPPs as "...arrangements whereby private parties participate in, or provide support for, the provision of infrastructure, and [...] a project results in a contract for a private entity to deliver public infrastructure-based services." The U.S. National Council for Public-Private Partnerships defines a PPP as "a contractual agreement between a public agency (federal, state or local) and a private sector entity [whereby] the skills and assets of each [...] are shared in delivering a service or facility for the use of the general public. In addition [...], each party shares in the risks and rewards potential in the delivery of the service and/or facility." According to the Canadian Council for Public-Private Partnerships, a PPP is "a cooperative venture between the public and private sectors, built on the expertise of each partner, that best meets clearly defined public needs through the appropriate allocation of resources, risks and rewards." Finally, according to the BBC, "any collaboration between public bodies, such as local authorities or central government, and private companies tends to be referred to a public-private partnership (PPP)."

[8] It follows that our definition of PPP involves an upfront investment by the firm either building new infrastructure or rehabilitating existing infrastructure. A maintenance and operations contract does not quality as a PPP according to this definition.

[9] This paper focuses on three broad organizational forms: conventional provision, PPPs and privatization. Each one of these forms include a number of contractual arrangements. For example, Figure 2.1 in Guasch (2004) includes outsourcing, performance agreements and management contracts under conventional provision; leasing (also known as *affermage*), franchises, concessions and build-operate-transfer (BOT) under PPPs; and build-own-operate (BOO), divestiture by license, divestiture by sale and private supply and operation under privatization. Note that the 11 organizational forms mentioned by Guasch are ordered in terms of increasing degree of private participation.

For the duration of a PPP contract, which can be thirty years or more, the concessionaire will build, manage, maintain and control the assets, in exchange for some combination of user fees and government transfers, which are its compensation for the investment and other costs. Even though, in principle, the firm is the residual claimant during the contract, while the government is the residual claimant after the contract, these claims are often ambiguous due to contract incompleteness. On the other hand, the main characteristics that distinguish PPPs from privatization is that public planning is an important aspect of PPPs, plus the fact that contracts are periodically reassigned.

For the three organizational forms we consider —the conventional approach, PPPs, and privatization— we asume that private firms build, maintain and operate the infrastructure project. The difference between these organizational forms derives from asset ownership (or control), whether the firm builds and operates the project, and which is the entity in charge of planning. Under both a PPP and privatization the same firm builds, operates and maintains the infrastructure, while under conventional provision the firm building the infrastructure has no role in maintenance and operations.[10] Also, only a PPP and privatization involve asset ownership by the private firm involved, in the case of PPP ownership is temporary and partial while under privatization it is indefinite and complete, restricted only by general legislation. The advantage of partial control and reversion to government ownership (of PPPs and conventional provision)is that the government can use this power to solve coordination and planning problems, in contrast to the case of privatization.

As mentioned above, our definition of PPP assumes that the firm is remunerated via a combination of user fees and government transfers. Government transfers are a combination of subsidies, guarantees, shadow fees and availability payments.[11] Some authors reserve the PPP term for projects that cannot be financed without government transfers, referring to projects that can be financed via user fees as *concessions*. We do not make this distinction and use the terms PPP and concession interchangeably.

Many arguments have been given for why PPPs may help governments provide infrastructure in a more efficient manner. Some practitioners and governments claim that PPPs relieve strained budgets and release public funds;[12] others argue that PPPs are appealing because finance is delegated to private firms subject to the discipline of financial markets; still others argue, perhaps cynically, that it is a reasonable compromise for outright privatization, often made difficult by political considerations. PPPs have also been heralded for bringing infrastructure provision closer to the advantages of competition, since they are often adjudicated in competitive auctions — competition *for* the field when a natural monopoly infrastructure rules out competition *in* the field. Further-

[10] Under conventional provision building, maintenance and operation are "contracted out" to different firms.

[11] Shadow fees are paid directly by the government to the firm based on usage of the service; users face no fees in this case. Availability payments are regular payments made by the government to the firm conditional on the contracted service being available.

[12] "The boom is good news for governments with overstretched public finances: many local and national authorities have found themselves sitting on toll roads, ports and airports that they can sell for billions of dollars to fund other public services." *Financial Times,* July 5, 2007.

more, it was hoped that PPPs would help filter 'white elephants', defined as projects with negative social value, in the case where firms are financed mainly with user fees, since in this case projects that are not profitable will fail to attract a concessionaire.

Despite these seemingly reasonable arguments, however, the experience with PPPs has been mixed. Whereas in some cases expectations were met, in many other cases contracts were renegotiated in favor of the concessionaire, or conversely, subject to regulatory takings (Guasch, 2004). PPPs were also routinely used to circumvent budgetary oversight and anticipate government spending, while generous government guarantees often canceled the potential of PPPs to filter white elephants. Frequently deadlines were not met, or projects required substantial subsidies to be completed and operated, and these subsidies were added to the original contract in opaque manner and without the benefit of competition.[13]

The purpose of this paper is to answer the questions of (i) *when* are PPPs to be preferred over conventional provision or outright privatization, and (ii) if the government decides to undertake a project using a PPP, what are the appropriate rules to use to structure, allocate and enforce the contract (*how*)?

Question (i) is to a large extent a matter of organizational form and productive efficiency. Different organizational forms imply different assignments of control rights on how to invest and manage the assets. Why should we add PPPs to the possible organizational forms in which resources are allocated? Which are the fundamental reasons why bundling might enhance efficiency? When answering the *when* question, we also address the extent to which PPPs are justified on the grounds that they help governments relieve strained budgets, and conclude that this argument is incorrect in many cases. We also compare alternative organizational forms according to the extent to which they mitigate or exacerbate various sources of government failure in the overall provision of infrastructure (mainly via the conventional approach).

In answering the question of *how* PPPs should be provided, we stress the importance of risk allocation, specifically in the form of the large demand uncertainty present in many PPP projects. We emphasize the fact that the temporary nature of PPPs contracts can sometimes be used to improve welfare substantially, since it allows for state-contingent contract terms and therefore makes feasible risk allocations that are not available under privatization. We also extract some important lessons from the experience with PPPs during the last two decades when discussing the institutional design and governance for PPPs.

The remainder of the paper is organized as follows. Section 2 covers the *when PPPs* question, while section 3 answers *how*. Various case studies are considered in Section 4; the main conclusions obtained throughout the paper are summarized in Section 5. In the appendix we develop a

[13]This does not mean that the conventional approach to infrastructure provision, with the government contracting a private firm to build the project, would have done better. For an early evaluation of infrastructure PPPs, see Economic Planning Advisory Commission (EPAC) (1995), *Final Report of the Private Infrastructure Task Force*, Australian Government Publishing Service, Canberra. For more recent evaluations, see Engel et al. (2003) and Grimsey and Lewis (2007).

benchmark model (Appendix A) that we use to synthesize and unificy the growing literature on PPPs (Appendix B) and to derive the optimal PPP contract (Appendix C).[14,15]

2 When

In this section we study the conditions that determine when PPPs yield higher social welfare than the alternatives. We assume throughout that private firms build, operate and maintain the infrastructure under all organizational forms—conventional provision, PPPs, or privatization. Thus, by assumption, the advantages of a PPP do not arise from private participation but from its incentive structure. In Section 2.1 we informally discuss conditions under which a PPP is the best alternative; in Appendices A and B we provide a formal model. Section 2.2 adopts a public finance perspective and studies to what extent the case for PPPs stands on the premise that they relieve public budgets; Appendix C provides a formal discussion. Last, as discussed in the introduction, pervasive renegotiations and poor fiscal accounting are associated to PPPs. This motivates Section 2.3.

2.1 Bundling, ownership and efficiency

Assume a benevolent and efficient government that does not suffer any of the normal failures of real governments. While extreme, this assumption is a benchmark that we use in this and the next section, leaving the final section for an examination of the effects of departing from the benchmark.

The literature has identified two main characteristics of PPPs. One is that it bundles financing, building and operation, which are delivered by the same firm. Second, while the PPP contract lasts, the private firm has a degree of control (ownership rights) and autonomy in managing the assets, for instance, in the choice of quantity and quality of the inputs. Thus, as pointed out by Hart (2003) and Bennet and Iossa (2006), the case of PPPs stands and falls on the incentives induced by these characteristics.[16]

It is obvious that, other things equal, bundling stimulates investments that cut life-cycle costs. Since a firm with a PPP contract enjoys partial or total ownership rights and keeps most of the gains from cost cutting, these are strong incentives, and even stronger under privatization, because the firm owns the assets completely and indefinitely. This is important, because many infrastructure projects, operation and maintenance costs depend on investments made during the initial construction stage. A potential problem is that there are investments that reduce life-cycle costs while lowering service quality and consumer welfare, which makes them undesirable. For example, in-

[14] Appendices A and B are novel. Appendix C follows closely the model in Engel, Fischer and Galetovic (2008).

[15] The papers in this literature include Grout (1997), Besley and Ghatak (2001), Hart (2003), Bentz, Grout and Halonen (2005), Dewatripont and Legros (2005), Bennett and Iossa (2006), and Martimort and Pouyet (forthcoming).

[16] A second strand of the literature studies how PPPs alters incentives and contracting under moral hazard. See Bentz et al. (2001), Martimort and Puyet (2007) and Iossa and Martimort (2008).

Table 2: ORGANIZATIONAL FORMS

	Characteristic		
	Bundling	Ownership	Regulated prices
Liberalization	yes	private, permanent	no
Conventional	no	public	yes
PPP	yes	private, temporary	yes
Regulated privatization	yes	private, permanent	yes

vesting in more durable but less reflective paint for road surfaces marking might lower operational costs but increases the risks of night driving. The fact that cost saving investments can be detrimental in some cases is a major problem in bundling infrastructure, which we analyze below.

To compare PPPs with alternatives forms of infrastructure provision, we begin wby analyzing a service that is produced under constant or decreasing returns to scale, and for which user fees can be charged. Elementary economics shows that the optimal organizational form is privatization plus price deregulation, i.e. market liberalization. First, because competition forces firms to internalize consumer surplus and to provide the socially optimal level of service quality—there is no need to impose service standards. Second, because private ownership and competition induce the optimal amount of life-cycle cost savings. Of course, careful market design might be required, as is the case of the wholesale electricity market, but there are well known solutions to this problem.

Market liberalization is unfeasible when users cannot be charged, either because the infrastructure is not excludable or because society prefers not to charge users (as, for example, in the case of countries with universal healthcare). Market liberalization is also inappropriate under increasing returns, because the infrastructure is a natural monopoly. In these cases the relative standing of a PPP relative to, on the one hand, conventional provision and, on the other hand, regulated privatization, depends on the specific characteristics of the project. In particular, it matters whether quality and quantity can be contracted and enforced and whether planning is required to solve future coordination problems.

If quality is contractible, the government can specify the desired service standards, letting the firm choose the optimal combination of inputs to achieve the standards. For example, service standards, such as the wait before obtaining a berth or transshipment rates, can be specified and enforced when seaports are privatized or contracted as a PPP. They include the time ships need to wait before obtaining a berth and the speed with which cargo is unloaded. This implies that cost cutting investments that lower service quality can be excluded. Thus ownership, which implies bundling, increases welfare in the absence of planning and coordination issues. If coordination and planning issues override other considerations, PPPs are preferred because they provide more control to the planning unit.

Things are less clear cut when quality is not contractible, since the firm can make cost-saving investments that lower service quality. If the quality of inputs is positively related to the quality of outputs and input quality can be enforced, the government can limit welfare reducing cost/cutting by specifying inputs. There is a cost, since the rigidity introduced by specifying inputs may inhibit the firm from adopting new and better technologies (see Box **??** for an example). Given the input requirements, under bundling the firm will choose the profit maximizing combination of cost-saving and quality-reducing investment, subject to the constraints imposed by the government. If quality reduction is the main result of bundling, conventional provision is the best option. By contrast, if the benefits of cost-cutting overweigh the costs of quality reduction, regulated privatization is preferred if fees can be charged, while a PPP should be chosen otherwise.

BOX 2.1 (Education and input specification) *It can be argued that in the case of primary and secondary education important aspects of educational quality sought by parents and society are not contractible.*[17] *A variety of inputs (measured as students per teacher, the experience and education of teachers, equipment) can be specified that are partially related to the quality of education. Specifying these inputs may help attain reasonable levels of educational quality, yet it may also limit the extent to which the school can implement innovative options that increase efficiency. For example, requiring a small number of students per teacher may limit expenditures on innovative software that partly substitutes for in classroom teaching.* ∎

Table 3 summarizes the conclusions. PPPs emerge as the preferred alternative when quality is contractible and user fees are ruled out. When quality is not contractible, PPPs still dominate conventional provision when life-cycle cost cutting dominates over service quality considerations. Last, conventional provision is the preferred organizational form when quality is not contractible and the main concern.

Table 3: COST-CUTTING INCENTIVES AND OPTIMAL ORGANIZATIONAL FORMS

Environment			Organizational form
Increasing returns	User fees possible	Quality contractible	
no	yes	—	Liberalization
—	no	yes	PPP
—	no	no	PPP or conventional provision
yes	yes	yes	Regulated privatization (*)
yes	yes	no	Privatization or conventional provision

[17] This reflects the fact that standardized tests represent only a partial measure of quality.

(*): If planning issues are important, PPPs or conventional provision may dominate privatization.

2.2 Public finance perspective

The most common argument in favor of PPPs among practitioners and politicians is that they relieve strained government budgets. According to this line of thought, this frees up government resources that can be spent on other projects with high social return. Even though *prima facie* this argument seems unobjectionable, we argue that the reasoning is unconvincing. We show that the resources saved by the government upfront when choosing a PPP over alternatives such as conventional provision are offset by the loss of future revenues.

We compare the public finance implications of conventional provision and provision under a PPP, assuming no rents for the firm (by competition for the concession or for the contract in the case of conventional provision) and that user fee revenue does not depend on the organizational form under which the infrastructure is provided.[18] We show that the government's present discounted revenue is the same in both cases.

Denote the upfront investment in the project by I. For simplicity we ignore operational and maintenance costs, even though what follows can be easily extended to incorporate these costs. We then have that under conventional provision the expected present value of government revenues is given by:

$$\text{EPV(Gov Income)} = \text{EPV}_0^{\infty}(\text{Fees}) - I, \tag{1}$$

where $\text{EPV}_0^{\infty}(\text{Fees})$ denotes discounted user fee revenues during the lifetime of the infrastructure, which we assume does not depreciate or become outdated, so that it lasts forever.

We denote by T the contract length under a PPP. The government is the residual claimant of revenues in this case, and therefore collects user fees after the concession ends.[19] It follows that net government revenues are equal to the difference between the user fees it collects and the transfers it makes to the firm:

$$\text{EPV(Gov Income)} = \text{EPV}_T^{\infty}(\text{Fees}) - \text{EPV(Gov Transf)}. \tag{2}$$

The expressions for government income in (1) and (2) look quite different, suggesting that the present discounted government budget will vary across organizational forms. We show next that this is not the case, that both expressions are identical.

Under a PPP, the firm's discounted profits are equal to the difference between its income (either

[18] This is a strong assumption, as one of the advantages of PPPs is that user fees are less prone to being manipulated by populist governments (see Section 2.3).

[19] Alternatively, the government could re-auction the project, in which case we assume that by competition for the new concession, it collects an amount equal to the present vale of user fees from that point onward.

from user fees or government transfers) and its investment:

$$\text{EPV(Firm Profits)} = \text{EPV}_0^T\text{(Fees)} + \text{EPV(Gov Transf)} - I.$$

By assumption, the above expression equals zero, which implies that

$$\text{EPV(Gov Transf)} = I - \text{EPV}_0^T\text{(Fees)},$$

and substituting this expression for EPV(Gov Transf) in (2) yields

$$\text{EPV(Gov Income)} = \text{EPV}_0^\infty\text{(Fees)} - I \tag{3}$$

which corresponds to the same expression we obtained in (1) for the case of conventional provision. Thus, we have shown that the future user revenue lost to the government by ceding income flows to the private sector is an exact offset of the initial investment savings made by the government by not having to finance the project.

A variant of the budget relief argument in favor of PPPs is that PPPs allow governments to invest in socially desirable projects during periods of severe credit constraints. In this case the choice is not between PPP and conventional provision, but between a PPP and not providing the service at all. In order to evaluate the validity of this argument, we need additional information on the cause of the credit constraints.

If the government cannot borrow because there is a high probability that it will default on its debt, is it realistic to assume that firms will be willing to invest in a project where they need to collect user fees over a long period of time to make a profit? If the firm can be given credible assurances that it will collect the income stream generated by the project, the answer may be positive. However, in many cases we cannot provide such a neat division between the revenue stream derived from the project and other potential sources of government revenue. In such cases, the viability of the PPP approach is affected by the weakness of the government's balance sheet.[20] The case in which this line of reasoning is most attractive is when there is good reason to believe that liquidity constraints will be short-lived, since in this case a firm with access to financing at a reasonable price can build the project now and have the expectation of not being expropriated of its contractual rights to user fees (or *future* subsidies, availability payments or shadow tolls). In this case, users stand to benefit from the earlier implementation of the project at only a minor additional cost due to risk, when compared with the option of waiting until the government's liquidity constraints have disappeared and it can build the project.[21]

[20] Consider Argentina's regulatory takings of PPPs after the 2001 crisis.

[21] Liquidity constraints correspond to the case where the government's cost of funds is infinite. A less extreme version is when the government has access to financing, but at a considerably higher cost than private firms. The same caveats discussed above apply in this case: whether this justifies choosing a PPP will depend on the reason why lenders are prepared to finance the same project at a lower cost when it is carried out as a PPP.

An alternative argument in favor of PPPs, which is also related to public finance, is the "cost of public funds argument." According to this doctrine, the government collects distortionary taxes to finance infrastructure projects, while the private sector can finance projects without these distortions. It follows that PPPs (or privatization) is to be preferred to conventional provision.

The previous argument is incorrect, and in the appendix we provide a formal model that shows it. Intuitively, assume that there is a cost of raising public funds, so that a dollar collected by the government has a cost that is more than a dollar to society, say $1+\lambda$, with $\lambda > 0$. We also assume that the project can be financed either by user fees or with subsidies. The difference between the two approaches is that only subsidies involve distortionary taxation.

The government will save λ dollars per dollar invested by the firm in the infrastructure project. However, these savings are offset by the lower user fees collected by government, since under a PPP it collects user fees only once the concession has ended. while under conventional provision it can start collecting user fees once the project is available to users. Thus, for every dollar of user fees given up to the concessionaire, the government forgoes the opportunity of reducing distortionary taxation elsewhere in the economy. As long as the cost-of-public-funds parameter λ does not vary over time, these effects cancel out. Thus user-fee and subsidy financing are perfect substitutes at the margin and the distortionary cost of taxation does not provide a rationale for the use of PPPs.

Summing up, once we consider the intertemporal government budget, the case in favor of PPPs based on the relaxation of the governments budget constraints is weak. The initial savings of government under a PPP are equal, in present value, to the amounts it surrenders in user fees it could have collected under conventional provision.

2.3 Government failure

In the previous section we assumed that government is efficient, but there are various ways in which the government falls short of this standard. There is corruption, excess bureaucracy and general incompetence. This implies that some of the choices in Table 3, which gives the optimal organizational form considering an efficient government, should be modified when we include the possibility of government inefficiency.

We first review the problems encountered by governments in general when providing infrastructure (Section 2.3.1). Then problems that can be mitigated under PPPs (Section 2.3.2) and problems that are exacerbated by PPPs (Section 2.3.3).

2.3.1 Challenges for public provision of infrastructure[22]

There are three main challenges governments face when providing infrastructure services, independently of the mechanism used to provide these services. First, which type of infrastructure to

[22]This section benefited from conversations with Eduardo Bitrán and Mario Waissbluth. The bills to reform the PPP legislation and the Ministry of Public Works are another source for what follows.

build, that is, adequate planning. Second, ensuring that the projects that are built provide adequate service. Third, ensuring that government is not overcharged for the construction, operation and maintenance of infrastructure.

Strategic planning in infrastructure is typically weak or even absent in developing countries. Social project evaluation is usually toothless, which means that projects are often chosen to satisfy short term political objectives, resulting in white elephants and over-engineering. Even when procedures to filter poor projects are in place, costs are routinely underestimated while demand is typically overestimated (see, for example, Tables 4.1 and 4.2 in Flyvbjerg et al., 2002).

Most developing countries have little institutional separation between the agencies in charge of strategic planning and policy design, and those involved in execution of projects, and enforcement of contracts. This inadequate institutional design results in an array of problems. First, there are obvious conflicts of interest between these tasks, leading to the emphasis of some responsibilities at the expense of others. For example, new infrastructure projects are politically more attractive than enforcing contracts. Since contract enforcement makes it harder to find firms willing to participate in new projects, enforcement becomes even less attractive.[23] It is therefore not surprising that public works in developing countries suffer delays and cost overruns, and that the bonds posted to ensure deadlines and quality standards are seldom collected, even when deadlines and standards are not satisfied.

Another problem caused by poor institutional design is the lack of supervision of maintenance of existing projects. Since building new projects is more attractive politically, governments typically spend too little on maintenance, until the project deteriorates sufficiently that the public complains and the government reacts. The cost of stop-and-go approach to maintenance is much higher (some estimates suggest cost multiples of 3 to 1) than what would have been the cost of continuous maintenance, without including the social cost of lower service quality.

Finally, poor institutional design weakens the public agency against pressures from the construction industry and politicians, and makes it difficult to hire high level professionals. Moreover, there is high risk of corruption in public work agencies with poor check-and-balances, since poorly paid government employees must oversee projects involving large investments, in the absence of institutional back up.

The capture of the public agency, either by the construction lobby and by politicians, leads to construction of the wrong projects at an excessive cost. When the government is in urgent need infrastructure projects before an election, private firms have more bargaining power and can overcharge. When construction lobby influences the projects that are built, it is also likely that there is little competition for the projects, resulting in higher prices.

Summing up, the poor institutional design of the public works authority in most developing countries exacerbates a host of agency problems, resulting in the wrong projects being built, poor

[23] The claim that strict enforcement dissuades participants may be spurious, as we show in the next section, but the threat may be effective against nervous politicians.

maintenance of existing infrastructure, and high prices paid for infrastructure services.

2.3.2 Potential advantages of PPPs

Next we consider some of the problems with conventional provision of infrastructure described above that can be mitigated with PPPs.

White elephants and over-engineered projects

White elephants, defined as projects with negative social value (i.e., whose social costs exceed their social benefits), are pervasive throughout the world, reflecting the fact that the political process may lead governments to build projects that would not have been accepted had the project been subjected to a rigorous process of social project evaluation. The obvious solution is to implement a program of social project evaluation, so as to protect society against white elephants.[24] This option fails in many developing (and some industrialized) countries. Below we consider alternative options that become available when a *market test* is combined with private participation.

White elephants can be filtered by selecting an organizational form where the firm that builds and maintains the infrastructure is financed mainly via user fees. In this case private firms will participate in the project only if it is privately profitable to do so, a good proxy for social desirability.[25] In this context, infrastructure privatization helps countries with weak systems for social project evaluation.[26]

Privatizations have the advantage that firms will not be interested in the project if it is a white elephant. PPPs also can be structured to avoid white elephants, if the firm's main source of income is derived from user fees. If shadow tolls or availability payments are used to pay for the project, PPPs do not filter white elephants and social evaluation of the project is required.

Government guarantees, a topic we cover in detail when considering risk related issues in Section 3, are another factor that reduces the filtering ability (for white elephants) of PPPs, since the

[24] One difficulty of social program evaluation is interference by the executive power, specially when convinced that a statesman's vision is superior to the pedestrian technicality of social evaluation. An escape valve for these pressures would be to assign the President a fraction of public works investment (say 5-10%), without undergoing social project evaluation for his or her pet projects, in exchange for lack of interference with the rest of the public works budget.

[25] This is an old and powerful idea, going back to Adam Smith "The greater part of public works may easily be so managed, as to afford a particular revenue sufficient for defraying their own expense, without bringing any burden upon the general revenue of society [...] When high roads [...] are in this manner made and supported by the commerce that is carried on by means of them, they can be made only where that commerce requires them. Their expence too, their grandeur and magnificence, must be suited to what that commerce can afford to pay. [...] A magnificent road cannot be made [...] merely because it happens to lead to the country villa of the intendant of the province, or to that of some great lord to whom the intendant finds it convenient to make his court.", *The Wealth of Nations*. V.1.III.1.

[26] A common problem is that projects are over-engineered, and therefore investment is larger than the social optimum. Standard social evaluation does not filter these projects, so long as their social profitability exceeds the hurdle rate. Linking the firm's revenue to demand realization, as is the case under privatization and PPPs, won't filter these projects either.

lowered risk in bad states of the world can raise the profitability of socially wasteful projects.

Improving maintenance

Incentives to maintain infrastructure provided under a PPP are larger than under conventional provision. By lowering maintenance expenditure, the government frees resources that can be used for political advantage. On the other hand, the concessionaire of a PPP is subject to monitoring by the fee-paying public, or by the treasury in the case of annual availability contracts. This implies that government does not benefit when the firm underspends on maintenance.

Regulating user fees, Demsetz auctions and renegotiations

Another type of government failure occurs when the service is provided under conditions of market power. In this case, user fees must be regulated, but this if often difficult. Under conventional provision, the main concern is that user fees might be set at a low level in response to political considerations (see Box 2.2). Similarly, under conventional provision some powerful users are often charged below the marginal cost they impose on maintenance and operation.[27] Since PPPs are more insulated from political pressure, the hope is this contractual form (and privatization) will make possible charging fees closer to marginal costs.

BOX 2.2 (Indiana Toll Road and toll indexation) *Tolls at the Indiana Toll Road in the United States remained unchanged in nominal terms for more than 20 years, falling substantially in real terms, under state ownership and management. When the road was contracted as a PPP in January of 2006, tolls doubled and were indexed to inflation. Other U.S. states have since adopted toll indexation, among them Florida, Pennsylvania and Texas.* ∎

In developing countries, the rates charged by public providers are often so low that they lead to overconsumption and under-investment. After privatization of the utilities, rates are increased (in some cases leading to protests and re-nationalization) but investment also goes up, improving the quality of service while reducing wasteful consumption. The risk of setting user fees too low has been at the heart of macroeconomic instability in many developing countries in the (not so distant) past.

In the case of privatization, user fees may be set at a level that generates excess rents, reflecting regulatory capture, or they may be set at a low level, due to regulatory takings in response to political pressures. There exists a vast literature to address these problems.

An alternative to the regulator setting prices is that prices be set via a competitive process. Chadwick argued, long ago, that PPPs avoid regulatory shortcomings when the firm is chosen via

[27] For example, road deterioration is proportional to more than the third power (by some accounts, the fourth power) of axle weight. This implies that tolls paid by trucks are much lower than the maintenance cost that they cause.

a competitive auction, since this dissipates *ex-ante* rents (see Chadwick, 1859 and Demsetz, 1967). Competition *for* the field can be a close substitute for competition *in* the field. For example, if the bidding variable is the user fee that will be charged during the concession term, a competitive auction achieves second best pricing in the absence of congestion effects.

A prerequisite to reap the potential benefits from auctioning PPPs is that there is real competition for the contract. This is often not the case. In some countries (e.g., Brazil) the PPP legislation excludes foreign participants. In other cases (e.g., Colombia and Argentina in recent years), the government's overt or implicit objective is that concession projects be spread evenly among the main domestic construction firms. In both cases incentives to compete are diluted and as a result, the cost of infrastructure rises and the quality may be lower.

As pointed out by Oliver Williamson (1976, 1985), the problem with Demsetz auctions is that the competitive process at the time of the auction turns into a bilateral monopoly relationship over the life of the contract. Since the investment is sunk, there is ample opportunity for opportunistic behavior by the government, as the firm cannot take its investment elsewhere. Similarly, for many types of infrastructure it is difficult for the government (for legal, technical, political or other reasons) to take over the infrastructure service without major service disruptions. This implies that it is difficult to punish noncompliance by the firm and thus it has has incentives to behave opportunistically. Opportunities for hold up, by the firm or the government, are plentiful adding to risk.

It is not surprising, therefore, that Guasch (2004) found pervasive evidence of renegotiations when he analyzed more than 1,000 infrastructure concessions granted in Latin America between 1985 and 2000. More than half of the original contracts suffered substantial changes in sectors with finite term contracts (54.7% in the transport sector; 74.4% in the water sector) — the average time between adjudication and the first renegotiation of the contract was slightly over 3 years, and most renegotiations were initiated by firms.

When opportunistic renegotiations by firms are pervasive, selecting the concessionaire in a competitive auction will be less beneficial than suggested by the literature on Demsetz auctions. The selected firms will be biased towards lobbying and renegotiation rather than towards technical expertise.[28]

Summing up, PPP contracts are long-lived, incomplete contracts. Unforseen circumstances will emerge that require welfare improving *ex-post* renegotiations. The challenge, of course, is to distinguish between "good faith" and "bad faith" renegotiations. Ideally, we would like a concession contract that allows for the former while avoiding the latter. We return to this topic in Section 3 and discuss institutional changes and specific PPP contract characteristics that avoid "bad faith"

[28] See Engel et al (2008) for a formal analysis. Intuitively, the argument is that under competition, firms that survive cannot be relatively worse in both dimensions (renegotiation and technical ability), because they would be outperformed by firms that are better in the two dimensions. Hence, there will be a frontier of surviving firms, in which better lobbying and renegotiating ability is associated to poorer technical ability and viceversa. This also means that firms that better in the technical dimension will be at a disadvantage in countries with a higher propensity to renegotiate contracts (which will attract lobbying biased firms), and will gravitate to other countries.

renegotiations and therefore help reap the benefits from competitive auctions.

2.3.3 Potential disadvantages of PPPs[29]

Periodic recontracting under PPPs is more costly than the single auction necessary to privatize an infrastructure service. This makes privatization more attractive than a PPP.[30]

An important type of government failure is caused by the tendency of governments, prompted by the election cycle, to discount the future. As we have mentioned before, governments would like to anticipate infrastructure spending, in the expectation of increasing their chances of being reelected. Anticipating infrastructure expenditures under conventional provision is complicated by budgetary controls (e.g., congressional approval) that limit the government's ability to impose liabilities on future administrations. By contrast, privatization by selling state-owned companies can provide resources for the current administration to spend with little oversight. PPPs can also be used to anticipate government spending, since they are often subject to laxer supervision than the budget.

The policy recommendation is straightforward. To make sure that the contractual form used to provide infrastructure is driven by social welfare considerations, the choice of organizational form should be independent of the possibility of anticipating spending. This can be achieved by an effective program of social project evaluation, as well as by including in the budget the future liabilities contracted during the current period via PPPs. In the case of the revenue from privatizations, fiscal rules that smooth spending of resources received on a one-time basis may help. Likewise, some countries have defined appropriate calculations for the value at risk associated with liabilities on future administrations imposed by PPP investments.

3 How

This section deals with *how* PPPs once the analysis of the preceding section suggests that a PPP is the best option. In this section we describe summarily the practical considerations on governance and the political economy of PPPs that are required before proceeding with a successful policy of developing infrastructure based on this mechanism. We also consider some issues of institutional design, in particular, the design of the PPP unit within the government and the legal environment necessary for a reasonably successful program of PPPs. Finally, we analyze in some detail efficient PPP contracts under different demand and contractual conditions.

[29] As discussed above, renegotiations are one of the main consequences of government failure under PPP. We studied renegotiations in the section on potential advantages of PPPs, since it is the downside to the potential advantages of assigning PPPs via competitive auctions, but it could have been included just as well in this section.

[30] Note, however, that the longer horizon under privatization means that the premium due to demand risk could be higher.

3.1 Two basic contractual principles

Renegotiations of PPP contracts have been pervasive and many are inefficient. There are many motivations, but two contractual premises seem to make them the normal state of affairs. One is the so-called "principle of financial equilibrium". As Guasch (2004, p. 35) points out, in regulated markets firms expect revenue streams that ensure reasonable profits. If unable to earn these profits, they expect a change in contract terms. Second, the firm is responsible for all investment and has the exclusive right to use the assets and exploit the project. Thus any change in the project must be agreed with the firm. Both premises are reasonable and necessary—investors should earn a normal expected rate of return and ownership rights are a hallmark of PPPs. Nevertheless, they must be complemented and their scope narrowed to ensure proper incentives.

Recall that PPPs are useful when quality is contractible. Thus service standards should be a central part of the PPP contract and the firm should bear the costs of meeting them. Ex ante financial equilibrium should follow from a prudent bid, and not from ex post renegotiation justified by costs which are higher than expected.[31] Focusing on quality standards also provides incentives for appropriate maintenance.[32]

Similarly, if the government decides to raise service standards and additional investments are needed to meet them, the firm should be compensated at market values. Thus, additional investments should be tendered in competitive auctions and revenues increased only to ensure a normal return on additional investments.[33] Any renegotiation should be subject to independent review, a topic which we discuss next.

3.2 The governance of PPPs

As mentioned in Section 2, in many countries the same public works agency is in charge of planning the infrastructure, designing and awarding the PPP contract, monitoring compliance and renegotiating. This is bad governance. One reason is that public works agencies tend to be biased in favor of building as much as possible—project selection is inefficient and building is a goal in itself. Also, there is an inherent conflict of interest between promotion on the one hand and regulation and monitoring compliance on the other. Last, contracts are usually renegotiated behind close doors and bilateral agreements are not reviewed independently. This allows public works agencies to cover up their mistakes and stimulates their carelessness when designing and awarding PPP contracts.[34] An appropriate governance fosters independent project selection and evaluation; separates contract design and award from contract monitoring; and subjects renegotiations to in-

[31] Guasch (2004, p. 37) calls this "the sanctity of the bid".

[32] Additional incentives for maintaining the infrastructure toward the end of the contract term may be needed. When the state of assets can be verified by third parties, bonds posted by the firm constitute one possible mechanism.

[33] More precisely, to ensure zero change in the firm's zero net present value of profits.

[34] It also allows governments to anticipate spending—see Section 2.3.3 and below.

dependent review.

The recommendation is to relieve the unit that writes and awards PPP contracts from planning, project selection and contract enforcement. Before awarding contracts, a planning agency should design, evaluate and select projects. In turn, an external board should review the cost-benefit evaluations that support the chosen projects and the PPP contracts written to implement them. After contracts are awarded, a PPP superintendency should ensure compliance with the contract, monitor performance standards and service quality, and provide information to users and the public. At the same time, a panel of experts should review contract renegotiations and adjudicate conflicts. As mentioned above, when evaluating renegotiations the panel should ensure that the contractual modification neither increases nor decreases the project's profitability, thus eliminating the firm's incentives to behave opportunistically. The panel should also inform the public of the extent to which poor contract design motivated the renegotiation, thereby providing incentives for the unit that writes and awards PPP contracts to avoid careless project design.

The planning agency and the PPP unit must execute the incumbent government's policies, although they should probably be staffed by career civil servants. On the other hand, the external review board, the superintendency and the panel of experts should be financially and formally independent from the executive and their acts should be subject to strict transparency requirements.

3.3 Legal environment

PPPs are long lived contracts and their viability depends on the legal environment and the protection both of property rights of the private firm and of the rights of the public. In the absence of rule of law, honest investors in PPPs can expect to be fleeced, or suffer from regulatory takings, so that they will not participate in PPP projects in those countries. Instead, the firms that will be attracted are those with expertise in gaming the system. Alternatively, honest firms that participate will ask for such high rates of return to cover the risk of expropriation, that the country may be made better off by the conventional provision of infrastructure projects, since this approach may attract firms that would not dare participate in a long term PPP.

Poor countries sometimes have the option of resorting to international financial institutions (IFIs) such as the World Bank to provide insurance against expropriation for investors. Involvement by IFIs is justified by arguing that they have better information than conventional banks and that they can threaten to withdraw aid that is valuable to the government should it act opportunistically with the concessionaire. Nonetheless, this approach may be useful for a small number of projects that are expected to provide major externalities, it is unlikely that this approach can be the basis of a fully fledged PPP program.

The policy recommendation is to improve the legal environment and the protection of property rights prior to attempting to introduce PPPs, since they are more sensitive to deficiencies in this area than conventional provision of infrastructure.

3.4 Risk allocation

As mentioned in Section 2.3.2, PPP contracts serve as a market test to avoid white elephants. We also mentioned that this filtering ability is reduced in the presence of government guarantees. However, most PPP contracts include different forms of insurance against revenue risk, and this insurance is ultimately paid by taxpayers. The risks that are usually insured against are demand risk, construction and maintenance risk, as well as policy risk (see Box 3.1 for a description of risk factors).

Firms ask for guarantees so they can unload demand risk. This risk is large, since making accurate demand forecasts, even in a medium term horizon, is extremely difficult. Firms are unable to diversify these risks, possibly due to agency problems within the firm. As we argue in Section 3.5, the right way of dealing with this problem is by choosing the appropriate auction mechanism. A second source of the demand for guarantees is construction and maintenance risk. Here, firms often press for cost-sharing agreements with the government even though they control the sources of risk.

BOX 3.1 (A classification of risks faced by a concessionaire) [35]

With a typical concession contract, where the concession term is fixed in advance, and in the absence of government guarantees, the concessionaire faces the following risks:

Demand risk. *This risk arises when demand forecasts are unreliable, which happens most of the time. Demand forecasts are based on estimates of future growth of the overall economy, and deviations from this growth rate by the region in the country relevant for the project at stake. An increase or decrease by one or two percentage points of the demand growth rate over a long time period can have huge effects on the project's returns. Demand forecasts also depend on estimates of the macroeconomic cycle, which are tied to the aggregate performance of the economy, and on estimates of microeconomic conditions, which reflect local demand fluctuations. Box 3.2 shows that both sources of demand risk are important in Chile, even during the most stable decade in the country's history. Box 3.3 shows that, even in industrialized countries, where the quantity and quality of information available to make demand forecasts is considerably larger than in developing countries, demand forecasts can make huge mistakes, even in the short run.*

Demand risk may also be due to uncertainty on the changes in the income-elasticity of demand for motor vehicles and on uncertainty about the toll rate elasticity. Either of these sources of risk may throw off demand forecasts, which are usually inaccurate in the short term (three to five years) and all but useless in the long term.

Construction and operating risk. *Construction and operating risk exists because the costs of building and maintenance generally differ from projections. These risks can be large for specific infrastructures, such as tunnels.*

Policy risk. *Many private infrastructure projects are subject to policy-induced risk, which may take*

[35] Based on EFG (1997e). An extensive analysis of risk allocation and valuation in PPPs appears in Irwin (2007).

two forms. Actions by different government agencies may unintentionally affect the profits of the concession. For example, a devaluation may lead to a major reduction in the concessionaire's return, especially if this firm is foreign owned and values its returns in foreign currency. Or a change in environmental standards may require additional investments. In these cases the government is not acting opportunistically, at least vis-a-vis the concessionaire, since these policies are not motivated by the desire to impinge on the profitability of the concession.

A second class of policy risks occurs when the government implements policies which affect the profitability of the concessionaire without increasing overall welfare (see Box 3.4 for an example). The government may build or expand infrastructure that competes with the concession and charge subsidized user fees, for example, or it may reduce user fees in response to political pressures.

Distinguishing between both kinds of policy risk may be difficult in practice. It is also sometimes difficult to distinguish between demand and policy risk, since many kind of policy decisions can affect demand. ∎

BOX 3.2 (Demand uncertainty is very high in Chile) [36]

Table 4: DEMAND UNCERTAINTY IN CHILEAN TOLLROADS

	'86	'87	'88	'89	'90	'91	'92	'93	'94
Angost.:	8.8	15.0	11.7	4,5	8.7	12.4	6.7	7.8	9.4
Zapata:	21.5	14.4	13.1	8.1	7.2	5.2	2.9	3.9	4.9
Lampa:	3.8	13.4	15.9	8.9	6.8	18.0	8.8	16.2	12.5

Table 4 shows the increase in the number of motor vehicles paying tolls during the 1986–1995 period in three of the main tolled roads in Chile.[37] *Since tolls remained approximately constant (in real terms) during this period, fluctuations in growth rates are due mainly to demand fluctuations.* Macroeconomic risk *is reflected, for example, in the fact that vehicle flows grew much faster during 1988 than during 1990.* Microeconomic risk *is apparent in most years: the growth of vehicle flow fluctuates considerably around the annual average from one tollbooth to another.* ∎

BOX 3.3 (Demand risk and the Dulles Greenway) [38]

[36] Based on Engel, Fischer and Galetovic (1996).

[37] The rates correspond to the growth in the flow of vehicles from one year to the next. For example, the vehicle flow through the Angostura tollbooth grew 8.8% between 1986 and 1987. These flows are representative, covering the three busiest highways near Santiago.

[38] Based on Engel, Fischer and Galetovic (2006).

The Dulles Greenway is a 22 km. road joining Leesburg, Virginia, with the Western end of the Dulles toll road in the Washington DC area. When the concession was granted in the mid 1990s, two consulting companies independently forecasted a ridership of 35,000 daily vehicles if the toll was set at $1.75. Actual traffic turned out to be 8,500 daily vehicles, partly because public pressure led the State of Virginia to widen an untolled alternative. ∎

BOX 3.4 (Policy risk for Argentine utilities) *The contracts signed by the government of Argentina and foreign utility companies during the 1990s set user fees in dollars. After the crisis and devaluation of 2001, the Argentine government kept user fee values constant in local currency, which implied a reduction of two-thirds in foreign currency.* ∎

A basic principle in optimal risk management is that the agent best positioned to manage a specific risk should bear this risk.[39] This suggests that firms should bear construction and operating risks. Regarding policy risk, it is unrealistic to have government bear the risk associated with unintended consequences of its actions. Furthermore, there is no reason why the government should bear specific policy risks. For example government often grant foreign concessionaires insurance against devaluations. Not only does this discriminate against local investors, it also discriminates against foreign firms in other sectors of the economy that must bear exchange rate risk. By contrast, the risk of "intentional" government actions can be mitigated by an appropriate contract, that explicitly rules out the most likely risk factors of this type, and by an effective conflict resolution mechanism, as described in Section 3.2. Finally, to the extent that demand risk is largely beyond the firm's control, there is no reason why the firm should bear this risk, an idea we develop further in the following section.

3.5 The optimal contract

The analysis of this section provides an overview of the features of the optimal contract for PPPs from a public finance perspective (see Appendix C for a formal derivation and Engel et al (2007) for formal extensions that relax many of the simplifying assumptions we make below). We first derive the contract that would be chosen by a planner that maximizes social welfare and then show how this contract can be implemented via a competitive auction with realistic informational assumptions.

We assume that the planner requires a large sunk infrastructure investment to provide services. There are various ways in which it can finance the investment, such as conventional provision, shadow tolls, availability contracts, user fee revenues and subsidies. We assume imperfect diversification by the firm among projects so firms are risk averse. Firms participate voluntarily, so they

[39] Irwin (2007, p. 14) is more precise: each risk should be allocated to maximize project value, taking account of moral hazard, adverse selection and risk-bearing preferences.

must at least attain the same level of utility as from not participating. We also assume competition and firms with identical technology. Under these conditions, the planner maximize the expected present value of user welfare over the life of the project.[40]

Demand follows a probability distribution that is determined exogenously. Thus what follows is relevant for infrastructure where quality standards are contractible, an assumption we make in throughout this section. As we saw in Section 2.1, PPPs are the optimal choice when quality is contractible and either fees cannot be charged or planning is necessary.

3.5.1 No user fees

When it is impossible to charge user fees that pay for a relevant fraction of the costs of the infrastructure, there are three alternatives to provide for the project. First, the planner can use conventional provision. Second, it is possible to use shadow tolls, where the government pays the private operator a fixed fee for each user of the infrastructure. Finally, it can pay a fixed periodic fee, contingent on quality of service standard being met, under an availability contract. These three options have advantages and disadvantages in different environments, so the choice of contract is not unique but depends on the characteristics of the project.

Shadow tolls introduce demand risk, and this will increase the risk premium charged by the winning bid. Since having the firm bear this risk brings no countervailing benefit, this approach should be deprecated. The purported benefit of shadow tolls is that, as they are demand dependent, they avoid white elephants. Consider, however, that a project in which all the payments are made by the government is a project that should be subjected to careful social evaluation, so the benefits of filtering white elephants are limited, if present at all. For example, these benefits disappear completely if shadow tolls are set too high.

3.5.2 User fees

When it is possible to collect significant user fees, conventional provision is still an option (the government collects the user fee revenue in this case). The alternative is to use the revenues to compensate, at least partially, a private provider of the infrastructure project. We have already shown, in Section 2.2, that the choice between public or private provision does not hinge upon the existence of distortionary taxation.

Thus, in the absence of government inefficiency, private or conventional provision (or even intermediate cases, with partial subsidies and lower user fees) are equivalent options. Motivated by the arguments of Section 2.3.3 on government failure, we now assume that $\$1+\zeta$ units of expenditure are required by the government to obtain the same results that the private sector would obtain with \$1, and we assume $\zeta > 0$.[41] The basic advantage of PPPs financed by user fees as compared to

[40] It is possible to incorporate producer surplus in the government's objective function, see Appendix C.

[41] For example, if subsidies are monetary transfers from the government to the concessionaire, then $\zeta > 0$ means that some of the resources are wasted in the process, perhaps because of agency problems faced by

the use of public funds for the project, is that the government does not participate directly in funding for the project. In the absence of other considerations, this results in the savings of ζ per \$1, which tilts the balance towards PPPs financed by user fees. The problem is that there is a downside to financing via user fees: it introduces demand risk into the financing of the project. Since the firm is risk averse, high levels of risk may discourage using user fees to finance the concessionaire. In order to determine the optimal contract, it is therefore necessary to balance the cost of using government funds to subsidize the project in some states of the world against the costs of increased risk when the revenue of the firm depends on demand.

Table 5: Classification of demand states under optimal contract

	Contract length is finite	Contract lasts indefinitely
No subsidy	High demand	Intermediate demand
Positive subsidy	Never optimal	Low demand

The optimal contract specifies a state contingent combination of user fee revenue and subsidies. The basic insight is that user fee revenues *in a given state* are always better than subsidy finance *in that state*. Hence subsidies should be used only once user fees have been exhausted and we can classify demand states into three groups, as in Table 5, according to the whether under the optimal contract all user fees are transferred to the concessionaire and, should this be the case, according to whether subsidies are paid out or not. In high demand states the firm collects user fees for a finite amount of time, in intermediate demand states it collects user fees indefinitely but receives no subsidies, in low demand states it collects user fees forever and receives transfers from the government.

More specifically, we show that the optimal contract features a lower and an upper bound on the firm's present value of user fee revenue. These bounds are such that in all states generating more user fees than the upper bound, the concession ends when the bound is reached, and if the state is such that the lower bound will never be reached, the government subsidizes the difference (the former are high demand states, the latter low demand states). In intermediate cases, when demand ensures that the present value of user fee revenues lie between the two bounds, the concession runs forever, but the firm does not receive a subsidy. Thus, the optimal contract reduces risk but does not eliminate it altogether, because to do so would require much larger subsidies, with an efficiency cost that exceeds the cost of having the firm bear some risk.

The two thresholds that characterize the optimal contract correspond to a minimum income guarantee and a cap on the firm's present discounted revenue. These differ in important ways from

the budgetary authority when monitoring the government agency in charge of the resource transfer.

income guarantees and revenue-sharing agreements observed in practice. Minimum income guarantees are routine in many types of PPPs. However, most real world contracts have a fixed term and therefore do not follow the prescriptions laid out above.[42] These contracts would be closer to the optimal contract if their durations were longer in low demand states, when guarantees are paid out. Thus, real world contracts pay excessive guarantees in low demand states.

Real world revenue sharing agreements also do not coincide with the revenue cap that characterizes the optimal contract.[43] When governments impose revenue sharing arrangements, they split revenues in excess of a given threshold with the concessionaire in fixed proportions. By contrast, the optimal contract described above suggests assigning all the revenue in excess of a given threshold to the government—the windfall profits tax rate should be 100%.

More generally, the rationale behind real-world guarantees and revenue sharing schemes is to reduce the risk borne by the concessionaire. By contrast, the rationale behind the optimal contract is to optimally trade off insurance on one hand, and the use of user fees and subsidies on the other. This is why the concession lasts indefinitely when subsidies (i.e., guarantees) are granted; the term is variable in high demand states; and the concessionaire's revenue in high demand states is higher than in low demand states.

3.5.3 High demand projects and PVR contracts

Two particular cases of the optimal contract are worth mentioning. First, if the project can be financed with user fees in all demand states, that is, if we have a high demand *project*, then the optimal contract involves providing full insurance to the firm. The higher demand turns out to be, the shorter the optimal concession term. Since firms have no advantage bearing demand risk and the project can finance itself in all demand states, it is optimal to fully ensure the firm against demand risk. This avoids paying the firm any risk premium without the need to pay costly subsidies.

The optimal contract can be implemented via a present-value-of-revenue (PVR) auction in this case (see Engel et al. (1997, 2001) for formal analysis). The planner sets the discount rate and user fee schedule, and firms bid the present value of user fee revenue they desire. The firm that makes the lowest bid wins and the contract term lasts until the winning firm collects the user fees it demanded in its bid.

The United Kingdom was probably the first country to use a contract similar to PVR. Both the Queen Elizabeth II Bridge on the Thames River and the Second Severn bridges on the Severn estuary were franchised for a variable term. The franchises will last until toll collections pay off the debt issued to finance the bridges and are predicted to do so several years before the maximum franchise

[42] For example, often the planner sets the contract length and firms bid on the lowest user fee. Alternatively, when congestion is a concern, the planner can set the user fee and firms bid on the shortest concession term. In both cases the length of the concession term is determined before the concession begins and cannot adapt to demand realizations.

[43] Profit sharing agreements should be avoided altogether, since firms can (and do) use transfer pricing and other gimmicks to inflate their coats and thereby avoid sharing profits.

period. Chile was the first country to use an outright PVR auction. In February of 1998, a franchise to improve the Santiago-Valparaíso highway was assigned in a PVR auction (see Box 4.2 for details).

A PVR contract reduces risk: When demand is less than expected, the franchise period is longer, while the period is shorter if demand is unexpectedly high. Assuming that the project is profitable in the long run so that repayment eventually can occur, all demand-side risks have been eliminated. This can reduce the risk premium demanded by the firm significantly compared to fixed term concessions (e.g., by one third in the case considered by Engel at al. (2001)).

PVR franchises should attract investors at lower interest rates than traditional Demsetz franchises. Toll revenues are the same under both, but the franchise term is variable under PVR. If demand is low, the franchise holder of a Demsetz-awarded contract may default; in contrast, a PVR concession is extended until toll revenue equals the bid, which rules out default. Of course, under PVR, the bondholders do not know when they will be repaid, but that is less costly than not being paid at all.

PVR schemes also reduce the need for guarantees because the risk to investors is much smaller. For example, when the Chilean government used PVR to auction the highway joining Santiago with Valparaíso, it did not have to offer guarantees, in contrast to previous highway franchises using traditional fixed-term auctions (see Box ...). Thus PPPs are more likely to filter white elephants under PVR contracts.

The PVR approach also reduces the likelihood of opportunistic behavior. Traditional fixed term contracts are renegotiated by extending the length of the concession, increasing user fees, or providing a government transfer. Extending the concession term with a PVR contract is not possible because, by definition, the term is variable. Increasing user fees is ineffective because it shortens the concesion term without increasing overall income. Government transfers are not logically impossible under PVR but, because the concessionaire cannot claim that it will receive less toll revenue than expected, a government transfer would be difficult to rationalize to the public. Also, to the extent that firms are more likely to act opportunistically under financial duress, PVR contracts reduce the incentives firms have to engage in "bad faith" renegotiations, since scenarios with losses for the firm are less likely under PVR.

PVR concessions allow adaptation to changing circumstances not easily possible in standard fixed term contracts (see Boxes 3.5 and 3.6 for illustrative examples). They also allow for more flexibility in setting user fees (see Box **??**).

BOX 3.5 (Airport concessions in Argentina) *In 1997 the Argentine government decided to end the fixed term airport concessions in order to reauction them under new terms. In order to do this, the government had to compensate the present franchise-holders. The former Economics minister, Domingo Cavallo, claimed publicly that some government employees, swayed by the concessionaires, had written a decree that provided a compensation of US$400 million, while the fair compensation, in his opinion, was of the order of US$40 m.*[44] *No such ambiguity would be possible under a PVR contract.*

[44] *El Mercurio*, February 6th, 1997, page B5.

BOX 3.6 (The Orange County SR91 Holdup) *The California Orange County 91 express lanes concession in California is a ten-mile privately-owned toll section of the congested State Route 91, the Riverside Freeway, running from Anaheim to Riverside in California.*[45] *Motorists use the express lanes to get relief from congestion by paying up to almost $11 for a round trip. The concessionaire was allowed to raise tolls freely in order to relieve congestion, which lead to several hikes. By early 2000, 33,000 daily trips brought the express lanes to the brink of congestion at peak time and the franchise was a financial success. Yet users were suffering enormous congestion in the freeway, and an expansion became urgent. The problem was that when the contract was signed, cash-strapped Orange County accepted a "non-compete clause" that prevented any expansion in capacity until the year 2035.*

A protracted negotiation followed. The situation became increasingly troublesome for the Orange County Transportation Authority (OCTA), which was empowered to negotiate the purchase of the tollway. Unfortunately, the value of the tollway was controversial since, strictly speaking, it should be the present value of profits from the 91 Express Lanes if the franchise continued as originally planned. Even though the lanes cost $130MM to build, initially the company's value was set at $274MM in a controversial (and ultimately unsuccessful) attempt at a buyout by a non-profit associated to Orange County. Years of negotiations followed, with frustrated commuters of the 91 Freeway stuck in traffic in the meantime. Finally the express lanes were bought by a government agency for $207 million in 2003.

If the 91 Express Lanes had been a PVR franchise, finding a fair price at which to buy back the project would have been straightforward, since there is an obvious candidate for a fair buyout value under PVR: take whatever income (in present value) the project has generated so far, compare it to the present value of toll revenue the franchise holder asked for initially and pay the difference (minus expected maintenance and operation costs) to the owner of the franchise. Since this is what the franchise holder would have obtained if the franchise had run its course, she has nothing to complain.

BOX 3.7 (PVR, urban highways and toll flexibility) *Setting the appropriate toll for an urban highway project is very difficult. Unless traffic forecasters are unusually fortunate in their estimates as to the sensitivity of traffic to prices, the resulting tolls are likely to be incorrect – either so low that they*

[45] The toll portion, which is known as the 91 Express Lanes, is in the median of the freeway. It is separated from other traffic by a buffer zone. The 91 Express Lanes project was developed under a program authorized by the California legislature in 1989. The partnership raised $126 million in financing from several sources, including $65 million in variable-rate loans from Citibank and two French banks and $35 million in a 24-year loan from Cigna.

create congestion or so high that the highway is underutilized. One possibility is to allow fees to respond directly to congestion so they are never too low. But the result can be monopoly pricing as in the case of the Orange County 91 Express Lanes.

Under PVR, transit authorities can include toll flexibility in the concession contract. The guiding principle of the PVR franchise is to allow the winning bidder always to collect its required present value. In order to induce the franchise holder to accept toll flexibility, however, the contract has to recognize that lower tolls not only increase the time required to earn the desired revenue, but also increase traffic and therefore increase maintenance costs. Under fixed term contracts, by contrast, no simple approach to incorporate toll flexibility exists, since the concessionaire's profits are very sensitive to variations in tolls.

Because maintenance costs are roughly proportional to road usage, the original PVR contract could be specified so that the revenue target is net of maintenance costs. With that adjustment, the only effect of a change in tolls is a change in the total operational costs over the length of the contract – costs that are predictable and represent a minor fraction of total costs. PVR franchises then allow the transit authority to change tolls to the efficient level without harming the franchise holder. Of course, a lower limit must be set for tolls because, otherwise, the franchise holder might never obtain the revenue stipulated in the winning bid. ∎

While PVR schemes have a big advantage in terms of reduced risk, the downside is that the concessionaire has no incentive to increase demand for the infrastructure project because any action that increases demand will shorten the term of the franchise. Projects earn their income regardless of efforts of the concessionaire. By contrast, demand increasing investments are more attractive under fixed term franchise. That suggests that the PVR method is applicable only in cases in which quality of service is contractible. Also, an important assumption underlying our analysis is that major investments are not needed frequently. Thus roads and ports are natural candidates for PVR while mobile telephony is not.

3.5.4 Low demand projects and availability contracts

A second particular case of the general optimal contract described above is when the project cannot be financed via user fees in any demand scenario, that is, when we have a low demand *project*.[46] In this case the optimal contract again fully ensures the firm and all states are low demand states. It is best not merely to subsidize in all states, but to eliminate all risk for the concessionaire, so it receives full insurance and does not charge a risk premium.

[46] In a low demand project all states are low demand while in a high demand project all states are high demand. Finally, in an intermediate demand project, that is, a project that can be financed via user fees in some demand states but not in all, the optimal contract can involve high, intermediate and low demand states (it always to involve at least two type of states).

This contract can be implemented via a competitive auction, where firms bid on the present value of revenue they want to obtain combining user fees and government transfers. The concession contract lasts indefinitely, the firm collects all user fees and the government pays the firm the difference between the user fees it collects and the sum it bid.

PPPs do not filter white elephants in this case, since the concessionaire's revenue is unrelated to demand realizations. This is not surprising, since low demand projects, by definition, are not profitable without subsidies. Thus social project evaluation is particularly important for these projects.

Availability contracts have become increasingly popular in many countries (e.g., France, the United Kingdom and the United States). Under these contracts, the government provides incentives to the firm to provide the service standards specified in the concession contract by making regular payments conditional on the contracted service being available.[47] These contracts are often auctioned to the firm that demands the lowest annual availability payment. The resulting contract then is the same as the optimal contract described above for a low demand project. Availability payments pay for the upfront investment and the concessionaire makes a normal profit on this investment regardless of demand realizations. This contract is optimal, from a public finance perspective, if no user fees can be charged (e.g., hospitals in countries with universal healthcare) or user fees are insufficient to pay for the project in all demand scenarios. As mentioned above, the ability of filtering white elephants is lost while the government does not need to compensate the firm for bearing risk.

3.5.5 General implementation

As mentioned above when describing the optimal contract in the general case, for projects for which demand in some states is insufficient to remunerate the investment while in other states it is more than sufficient, total insurance for the concessionaire is suboptimal. The optimal contract then is defined by upper and lower revenue bounds, chosen so that the marginal cost of risk to the concessionaire is equal to the marginal cost of the subsidies.

Surprisingly, in all these cases, the optimal contract can be replicated by a two-threshold auction in which the planner needs to know only the shadow cost of funds, the parameter describing the inefficiency of government and the distribution of demand for the project. Firms bid the minimum income guarantee they desire, and the cap on their discounted revenues, and these bids are combined into a scoring function based on the information above. The lowest score wins the contract. If user fee revenue turns out to be below the minimum income guarantee demanded by the concessionaire, the government pays the difference. If user fee revenue exceeds the upper cap bid by the firm, the contract ends once this threshold is attained and the government collects user fees from then onward. No subsidies are paid out in this case. Finally, if user fees are above the income guarantee but below the revenue cap, the firm collects user fees indefinitely but receives no

[47] When operational costs are significant and vary with demand, the government makes an additional payment to the concessionaire that reflects operation costs.

transfers from the government.

3.6 Budgetary accounting

The results in the preceding section can be used to argue that, as far as the risk profile of the government's budget is concerned, PPPs are much closer to public provision than to privatization. Our starting point to derive this insight is that when thinking about the risk allocation implied by PPPs, what matters is the *intertemporal* risk profile of cash flows, not the year-to-year risk profile. This has interesting implications: for low and high demand projects, an optimal PPP contract replicates the net cash flow streams of conventional provision, state by state (see Table 6, which assumes an additive risk premium and denotes present discounted user fees by UF and the corresponding average by E[UF]). Essentially, all residual risk is transferred to the government, and the concessionaire recovers the upfront investment I in all states, as in the case of conventional provision.

Table 6: Average discounted budget: public provision vs. PPPs

	Public provision	PPP	Privatization
Upfront surplus:	$-I$	0	E[UF] $-$ I $-$ Risk Premium
Discounted user fees:	UF	UF $-$ I	
Total:	UF $-$ I	UF $-$ I	E[UF] $-$ I $-$ Risk Premium

Under privatization, the project is sold for a one-time payment and all risk is transferred to the firm. Moreover, the link between the project and the public budget is permanently severed. This is not the case with a PPP, where at the margin cash flows from the project always substitute for either taxes or subsidies. The conclusion, then, is that from a public finance perspective there is a strong presumption that PPPs are analogous to conventional provision—in essence, they remain public projects, and should be treated as such.

4 PPPs in Latin America

In this section we examine the experience of highway PPPs in Argentina, Mexico, Colombia and Chile. As these country studies suggest, there are many pitfalls that weaken the arguments for PPPs in this sector. In Colombia, investment targets have not been met, some projects were awarded but never started, and the government has paid large sums in cost overruns and traffic guarantees. In Argentina, the main problem has been that concessions were expensive for the government and for highway users. There were repeated contract renegotiations, which usually seem to favor concessionaires. It is conceivable that in some specific cases, most users ended up worse off. Chile seems

to have been somewhat more successful at avoiding the major pitfalls of highway concessions, having completely renovated its road system in time at a reasonable cost. Nevertheless, contract renegotiations have been common, leading to an increase of 30% in the budget of the projects when compared with their original estimates. The regulation of concessions contracts has been lax and there are signs of future renegotiations, to the detriment of users and taxpayers.

4.1 Argentina[48]

The Argentine franchise program began in 1990 and was the second major franchise program in Latin America, after Mexico's.[49] In 1989-90, the first stage of franchises, the government auctioned twelve 12-year intercity concessions (see table 7 for the main characteristics of the concessions). Traffic levels on these roads were sufficiently high (2,000 to 2,500 vehicles/day) for the private viability of maintenance, rehabilitation and capacity improvements, but were not high enough to build totally new roads (see Estache, 1999).[50] There was no toll revenue guarantee nor a profit sharing mechanism. Tolls were indexed to inflation to protect franchise holders. Service quality was measured by a quality index which was supposed to improve over the life of the concession. It was estimated that the service quality requirements would demand large investments in paving during the first few years of the franchise. Among other things, concessionaires were required to make the improvements before collecting tolls. This first round of auctions was very successful in attracting bidders, with more than a hundred bids for the simultaneous auction of the twelve franchises.[51] The most important bidding variable in this first round of auctions was the rent (or *canon*) that would be paid to the government.[52] The total amount bid in canons was US$890 million a year in 1990 dollars.

However, in the first instance of a pattern that was to repeat itself regularly, after only five months the government decided to renegotiate the contracts.[53] The main reason was the new policy of *convertibilidad*, which declared illegal all indexing provisions in contracts. Two further rea-

[48] The sources used for this case study are Estache, A., "Argentina's Transport: Privatization and Re-Regulation," Policy Research Working Paper 2249, Washington, DC: World Bank, 1999; Jose Luis Nicolini, "Toll Road Concessions in Argentina", Instituto de Investigaciones Económicas, Universidad de Buenos Aires, June 2001; Georgina Cipoletta Tomassian and Ricardo J. Sánchez, "Análisis del régimen de concesiones viales en Argentina", CEPAL February 2008; World Bank, Annex 1 to the World Bank Seminar on Asian Toll Development in an Era of Financial Crisis, "Financing the Road Sector in Argentina: Lessons from the Past,"

[49] At this time, there are two classes of concessions. First, two remaining highway systems franchised in the 1990t's, the Corredores Viales N°18 (Caminos del Uruguay) and N°29 (Caminos del Valle), with expiration dates in 2018 and 2013, respectively. Second, 6 Corredores Viales franchised in 2003 for a period of 5 years, these last consisting of almost 8,000 km of roads.

[50] Tolls were set uniformly across all concessions on the basis of distance and type of vehicle. Tolls were set as multiples of the basic toll for cars of US$1.50/100km.

[51] Note however, that participation was restricted to domestic firms, and that the award process was marred by criticisms of lack of transparency, see Cipoletta and Sanchez (2008).

[52] Other variables like lowest toll, highest quality or investment were also used, but only occasionally.

[53] See World Bank (1999) or, for all the details, Cipoletta and Sanchez (2008).

Table 7: Characteristics of the 1990 interurban franchises, Argentina

Corridor	Road	Length in equivalent Km. (6)	Toll Tariff $/100Km (1)	AADT (Average per Toll Station) in 2000 (4)	Provincial Location	Concessionaire	Main Firms
1	3 and 252	690	1,84	2649	Buenos Aires	SEMACAR S.A	Dycasa; Perales Aguiar
2	205	305	1,84	3302	Buenos Aires	SEMACAR S.A.	
3	7	524	1,93	3590	Cordoba-S. Luis-Mendoza	CAMINOS DEL OESTE	Techint; Santa Maria
4	8 and 193	729	1,67	3217	Buenos Aires-Santa Fé-Cordoba-San Luis	CAMINOS DEL OESTE	
5	7	503	1,84	2770	Buenos Aires-Cordoba	NUEVAS RUTAS S.A.	Necon; Chediack
6	188	487	2,10	1409	Buenos Aires-La Pampa	COVICO U.T.E.	**(2)**
7	9, A012	489	3,05	10974	Buenos Aires-Sant Fe	SERVICIOS VIALES	Sideco Americana (Macri);
8	11, A009	743	1,27	1888	Santa Fe-Chaco	SERVICIOS VIALES	Lippstad SA
9	33	241	1,82	3691	Santa Fe	SERVICIOS VIALES	
10	9	497	1,89	4516	Rosario (Sta. Fe)-Cordoba	COVICENTRO S.A	Caminos Australes (Roggio); CCI (Aragon); Supercemento; Dyopsa
11	34	722	1,78	2640	Santa Fe-Sant. del Estero	COVINORTE S.A	
12	9 and 34	490	1,86	282	Santiago del Estero, Tucuman y Salta y Jujuy	CONCANOR S.A.	
13	16 and 12	954	2,17	2541	Corrientes-Chaco- Misiones	VIRGEN DE ITATI UTE	Chacofi; EAC; Nazar; Supercemento; Dyopsa
14	19	288	1,90	2617	Santa Fe y Cordoba	RUTAS DEL VALLE	Geope; Sycic; Luciano
16	226	413	1,98	2466	Buenos Aires	CAMINO DEL ABRA	Coarco S.C.A; Equimac
17	5	548	1,93	3386	Buenos Aires-La Pampa	NUEVAS RUTAS S.A.	Necon; Chediack
18	12,14,193,15, 117,13	700	2,21	n.a.	Buenos Aires-Entre Rios-Corrientes	CAMINOS DEL RIO URUGUAY	Welbers; Conevial; Babic; Codi; Eaca; Parenti Mai
20	36,38,A5	358	2,41	2474	Cordoba	RED VIAL CENTRO	Roggio; Afema; Boeto; Romero Cammisa; Arvial
Total		**9681**					
Average			**1.97**	**3298 (5)**			

Notes:

(1)January 2001 Toll Tariff Including 21% Value Added Tax

(2)Nordeste, Glikstein; Estructuras; Delta; Asfalsud; ICF; Enretto Bonfanti; Coemic; Guerechet

(3)Toll Station Revenue divided by the Basic Toll Rate.

(4)Of the 8860 Km network, 821 Km have two lanes per direction

Source: Nicolini, 2001.

sons to renegotiate the contracts were, first, that several concessionaires were collecting tolls before performing the investments required in their contracts, and second, the pressures by users unsatisfied with paying tolls. During a period lasting from January to April 1991, tolls were suspended until contracts were renegotiated. After the renegotiation, tolls were reduced by 50% and in exchange, the canon was eliminated. In fact, the government granted subsidies totalling US$57 million per year to the firms.[54] The program of road improvements changed. Though the road franchises became less attractive as business propositions, firms were receiving money rather than making payments. The resources for the compensations came from a trust fund created by a fuel tax.

Another round of renegotiations began in 1995, because higher than expected traffic led to congestion and the need for new investments. The government threatened to auction the expansion projects in order to force the franchise holders to accept extensions of the franchise term in exchange for the required investment.[55] The negotiations were direct and dragged on until November 2000, except in the case of CV N°18, which signed an agreement in 1996, extending the concession until 2018. Nevertheless, at least US$900 million in improvements agreed to in the 1995 renegotiations were not be built before the franchises ended, in 2003.[56]

The negotiations were completed by December 2000. These specified additional government grants for the franchise holder, mainly because previous grants had not been paid. In exchange, the franchise holders agreed to some additional investment, and to a freeze in tolls until the end of the concessions. It is noteworthy that the ratio of normal expenditures (routine maintenance, exploitation, administration, and user services) to total revenues of the concessionaires averaged over the length of the franchises was 46%, with the remaining paying for the 20% of the franchised network that was reconstructed, the 35% that was repaved and profits.[57]

In 1994 there was a second round of franchises for the four freeway accesses to Buenos Aires, which run down to 2018. These contracts were better designed than the interurban contracts, and franchises were awarded solely on the basis of the smallest toll, with franchise lengths of 22 years and no subsidies. The number of bidders was small, with at most two per franchise. The contracts These franchises have involved investments of around US$ 1.7 billion, and represent 2,291 equivalent km, and had revenues of US$ 290 million in 2000.[58] It is interesting to note that the Buenos Aires contracts contained a *trigger clause* that limited the profit rate. In the cases in which the target profit rate was reached, either tolls would have to fall or the franchisee would have to undertake additional investments. As in the first-round franchises, contracts were amended fre-

[54] In 1992, a further renegotiation increased the government payments to US$63 million, both extended the contracts and postponed the date of enforcement of quality standards by one year, and erased all complaints, sanctions and penalties against the concessionaires.

[55] According to Estache (1999), who quotes the Public Works Secretary, the franchises were extremely profitable, at least until 1998, with rates of return between 26 and 38%.

[56] One of the reasons being that not all the government payments agreed upon were not made in full, because the resources n the trust funds were directed towards other projects.

[57] Nicolini 2001, using data from the Secretar'ia de Obras P'ublicas de Argentina.

[58] An exception to this story is the La Plata-Buenos Aires access, which was awarded during the 1980's, and is well behind schedule, but continues to collect tolls.

quently, five times since 1996, due to the trigger clause. Since these investments are not auctioned competitively, franchisees—which are owned by construction firms—chose to make additional investments, so as to avoid sharing profits with the government, keeping the extra revenue within the firm. Note that these trigger clauses may lead to inefficiencies. On the one hand, if the road generates large revenues, it is probably close to congestion so lowering tolls may be inappropriate. On the other hand, unlimited expansion due to the trigger program may lead to overcapacity or congestion at the points at which the franchised highway interconnects with the rest of the road network, as there is no coordination with the rest of the highway network.

Clearly the quality of roads improved as a result of the franchise program (Nicolini (2001), also Cipoletta and Sanchez (2008)). Intercity traffic increased from 73 million to 106 million traffic equivalent units from 1991 to 1998 (see World Bank [1999]), though it remained approximately constant between 1996 and 1999 and declined after the economic crisis of 2001. Intercity toll revenues were approximately US$275 million a year (pre-2001 crisis), plus an additional promised US$68 million in grants from the central government, i.e., approximately US$ 350 million per year until the crisis (See Table 8). This is a large sum, considering that the franchises only had 821 km of two lane intercity highways. As a comparison, the budget for public expenditures in roads was only around US$500 million of which 35% went to pay interest. Note, however, after the crisis the peso was devalued to one third of its former value, so during the last two years of the franchises, the revenue of the interurban concessions ran to about US$ 150 million.

Table 8: Total revenue of Argentina interurban concessions 1990-2003, current A$

Period	Toll revenue	Gov. Compensation	Total revenue
1(11/90-10/91)	61.915.532	17.841.259	79.756.791
2(11/91-10/92)	168.579.592	55.069.267	223.648.859
3(11/92-10/93)	207.937.218	69.998.802	277.936.020
4(11/93-10/94)	253.501.989	57.664.699	311.166.688
5(11/94-10/95)	258.125.574	74.203.689	332.329.263
6(11/95-10/96)	282.388.326	29.139.259	311.527.585
7(11/96-10/97)	316.812.644	81.467.654	398.280.298
8(11/97-10/98)	354.137.219	80.484.808	434.622.027
9(11/98-10/99)	343.811.007	86.248.220	430.059.227
10(11/99-10/00)	286.671.542	85.871.227	372.542.769
11(11/00-10/01)	246.484.285	514.145.100	760.629.385
12(11/01-10/02)	166.712.305	280.490.496	447.202.801
13(11/02-10/03)	186.633.478	278.159.155	464.792.633
TOTAL	3.133.710.711	1.710.783.635	4.844.494.346

Source: Cipoletta and Sanchez, 2008.

The Argentine experience in this first period shows the social costs that may be caused by franchise contracts that overlook important issues. For instance, since the location of the toll booths was not specified, *in some cases* the franchise holder placed them strategically so as to maximize revenue, by charging relatively high tolls to users of small sections of the franchised highway. This led to a much higher average cost per traveled kilometer than the originally anticipated rate of approximately 1.5 US cents/km, because the average trip was short but paid the full toll. In fact, it has been shown that for the average 25 km car trip, users were worse off than before the franchises.[59]

Another remarkable fact is that reported operating costs of the inter-urban franchises ranged between 40 and 60% of net-of-VAT toll revenues. What is most surprising is that a large fraction, which has been estimated at around 40% of expenditures, was spent on administration and collection, and that of this fraction, more than two-thirds was spent collecting tolls. In fact, 21% of gross toll revenues were spent on administration and collection, which is similar to expenditures on maintenance. A possible explanation for these costs is that many intercity roads had low traffic densities, which means that collecting tolls can be expensive. In fact, according to Nicolini (2001), routine maintenance costs, which are equivalent to US$ 5,960/km, are also fairly high by international standards.An alternative explanation is that profits were being diverted in order to delay the application of the trigger clause that would have franchise holders share revenues with the government. This is consistent with the large gap that existed between profit rates estimated by the association of concessionaires (12.4%) and independent estimates (26–38%, see footnote 55). Note that in addition to toll revenue, we must add the annual compensations agreed to in 1997 after the tolls were reduced, which amount to 26% of total toll revenues. Recall that these franchises did not require new construction, but rather rehabilitation, maintenance and capacity improvements.

We can try to obtain rough estimates of the gross margins of the interurban concessionaires. There are estimations that investment levels for the years 1-9 of the intercity franchises were US$1,448 million for the 9,681 km of the twelve initial concessions, or approximately US$ 15 thousand/km/year.[60]. Adding the US$ 12.5 thousand/km/year in routine maintenance, exploitation, administration and user services, we obtain average expenditures on 27.5 thousand/km/year. We can compare these annual expenditures with average yearly revenue of US$ 41.3 thousand/km (toll revenue of US$ 30,5 thousand/km/year plus compensation subsidies amounting to US$ 10,8 thousand/km/year).[61] The profitability of the franchises depends crucially, therefore, on the timing of the initial investments.

In October of 2003 the National Comptroller (*'Auditoría General de la Nación'*) published a lengthy report reviewing the main conclusions of its audits of franchised highways during the 1993-2003 period. The report provides further evidence on weak enforcement of franchise contracts. For example, the equipment needed to measure a highway's friction coefficient had been out-of-service since 1994, so that this index had not been measured for any franchised highways since then (p. 34 of the report). The rugosity index, however, has been collected by the Dirección Nacional de Viali-

[59] See World Bank (1999).
[60] Cited in "Financing the Road Sector in Argentina: Lessons from the Past".
[61] Data from Nicolini 2001.

dad (1990) and the Órgano de Control de los Corredores Viales Nacionales (later years), and it shows an improvement, going from 3.52 (1990) to 3.03 (1997 and 1998), reflecting the public perception of an improvement in road quality during the period.

More generally, highway quality immediately after construction had typically been considerably below specifications, and had often deteriorated faster than allowed by the contract specifications. Building delays had also been recurrent, while fines to which the government was entitled had seldom been collected and were eventually canceled in the 2003 auctions.

When the 1990 concessions ended in 2003 (excluding the aforementioned CV N°18 and 29), the government proceeded to reauction 17 franchises, grouping them into 6 new "Corredores Viales", representing 7,951 km of highways. Under the new scheme, concessions would last only 5 years and the firms' responsibility for the highway was limited to maintenance and operations, with all new investment financed by the government, under the aegis of the Sistema de Transporte Integrado (SIT), funded by the fuel tax. Toll were set by the government and toll revenues were pooled and then distributed according to a predetermined scheme, which was the basis for the adjudication of the franchises. Less than 1,350 km of the 7,951 km of franchised roads were assigned to previous concessionaires (Cipoletta and Sanchez, 2008). During this period road quality worsened, because lack of supervision meant that not all the necessary maintenance work was performed. The revenue of the firms was substantially lower than under the previous regime, reflecting the less ambitious character of the new scheme. Moreover, the SIT, which was supposed to use its resources (from the fuel tax fund) to finance additional investment in roads, began to use the resources to provide additional compensation to concessionaires (because of toll reductions decreed by the government), but specially to subsidize transport by buses, trains and trucks. Government inefficiency and led to delays in realized investment, which impacted the quality of the roads. Thus, for the period from the award of the franchises to October 2007, the total amount invested in the 6 Corredores Viales amounted to only A$421 million.

Summing up, the original Argentine concessions program succeeded in providing a significant upgrade to the country's highway network. Yet this upgrade appears to have been expensive, in particular because of the incentives to pad costs in maintenance, administration and collection, and the continuous process of renegotiations that seem to have benefited concessionaires at the expense of toll users and tax payers. The failures of the original program led the Kirchner administration to move toward a hybrid system, where new projects and significant additions to capacity are financed directly by the government, with results that appear to be much worse than the original approach. Perhaps the main conclusion of this country study is the importance of stable rules in the successful development of a franchise program.

4.2 Mexico[62]

Mexico was the first country in Latin America to experiment with highway privatization. In the late 1980's, the country was successful with three demonstration projects, and this led to a program to build more than 4,000 km of toll highways in 1989, under the recently inaugurated Salinas' government. Under the scheme, the Transportation Secretariat selected roads to be offered, and specified the *maximum tolls* in real terms (**Check discrepancy between Ortiz, Bain and Carniado and WB (2003)**). The projects were to be privately financed (in contrast to the three demonstration projects), with approximately 70% of financing being provided by banks or other external sources of finance. The government provided a partial guarantee of costs and traffic projections by providing the option of concession extensions. Concessions were awarded competitively (but only to domestic firms) on the basis of the shortest concession period, which legally could not exceed 15 years.

The program appeared to be successful at first, with 52 privatized toll roads and 5,500 km of highway. The required investment amounted to approximately US$ 13 billion, of which approximately 50% corresponded to bank credit, 29% to various public sector grants or other contributions and the remaining 30% was contributed by firms. A few years later, the program collapsed, and 20 concessions were taken over by government and incorporated into a public trust fund, the FARAC. According to Ortiz, Bain and Carniado (2008), equity holders lost perhaps Us$ 3 billion. The remaining concessions were extended by terms of, on average, 20 years, and in some cases, for much longer periods. For example, the Mexico-Toluca concession was extended from its original two years and four months to its current 42 years (Rogozinsky and Tovar (xxxx)).

The reasons for the collapse, which appears to have cost the government US$13 billion, are multiple. First, the concession were awarded on the basis of the shortest term of the franchise, which meant that tariffs were set at the highest possible level (**See discrepancy above.**). The terms were on average shorter than ten years, which put enormous financial pressure on the projects. Second, inadequate preparatory design work and technical studies, which led to late changes in design and specifications, leading to delays and cost overruns. This was compounded by short deadlines for submissions, which led to inadequate evaluations by the private firms. Moreover, in many cases the rights of way, environmental permits and other approvals had not been obtained, creating conflicts with communities and leading to changes in the routes.[63] Third, many of the projects were privately unfeasible due to low traffic flows and because of inadequate account of the price elasticity of de-

[62] The sources of information used for this case study are: Fabiola Ortiz, Robert Bain and Santiago Carniado (2008), "A Credit Review Of MexicoŠs Toll Road Sector: Stable And Strong", *Standard & Poors, Infrastructure Finance*, September 2006; World Bank (2003), "Private Solutions for Infrastructure In Mexico", *A Country Framework Report*; Jaques Rogozinski and Ramiro Tovar, "Private Infrastructure Concessions: The 1989-1994 National Highway Program in Mexico", http://ssrn.com/abstract=138273; Amado Athie, "Public-Private Partnerships for Highways in Mexico: Federal Perspectives", Presentation of the Secretaría de Comunicaciones y Transporte, May 2007.

[63] For example, the Cuernavaca-Acapulco toll road had cost overruns of 200% and was delayed 30 months, see Ortiz, Bain and Carniado (2008).

mand for tolled roads, which combined with the very high tolls resulting from the bidding process, led to overestimates in traffic forecasts (on average, usage was 30% below expectations, see Ortiz, Bain and Carniado (2008)). In this context, it is important to recall that a constitutional requirement of a free alternative road increased the price elasticity for the tolled road. Fourth, the financial health of many projects was predicated on macro stability, and was devastated by the financial crisis of 1994 that led to devaluation of the Mexican peso with respect to the dollar. Finally, lack of international competition, with most participants being construction firms focussed primarily on the profits from upfront construction, and which lacked experience in the maintenance, operations and financial management (maintenance and operations was substantially more expensive than expected). Since these companies had lobbying capacity with the government, they assumed an implicit government guarantee for cost overruns and traffic prediction overestimates. In fact there was underbidding and overvaluation of costs, because when financial problems began, these led to franchise extensions. Moreover, nationalized banks were unable to monitor exaggerated construction bills (WB 2003).

The bailout that followed began by first extending the concession lengths, but this was insufficient in many cases, where traffic shortfalls or cost overruns made the projects unviable in all conditions. The peso devaluation of 1994 exacerbated these problems, and extended them to the bank system, which had extended loans to the projects. In 1997, the government assumed ownership and bank liabilities of 23 toll roads under a trust fund, the FARAC.[64] FARAC operated the toll roads and lowered tolls to more realistic levels to enhance use and increase revenue, with reductions of 40% in the case of trucks. Around a quarter of the original franchises were earning reasonable rates of return, while the remainder appeared to be financially weak by 2003 (WB). In conclusion, even though the projects were built, the first wave of Mexican toll roads was a spectacular failure (Ortiz, Bain and Carniado (2008)).

The Mexican government has learnt from this painful experience, and now operates road infrastructure projects using PPPs under two modes: the New Concession Model and the PPS model. The New Concession Model is a traditional program with cost recovery based on user fees, but in which the many deficiencies of the first wave of toll roads have been corrected. The PPS model is used in the case of toll free roads or other projects in the health, education and transport sectors, and corresponds to availability contracts, in which the government pays partly on asset availability and partly on the basis of shadow tolls.

4.2.1 The New Concession Model

Under this approach, the projects are awarded to firms that meet technical, economic and legal conditions and which require the minimum subsidy for the project. The process of awarding projects is more transparent and bidders may propose changes that improve the project. The Trans-

[64] According to Ortiz, Bain and Carniado (2008), there was no compensation to equity holders, who may have lost US$ 3 Billion.

port Secretariat sets an average maximum toll, (AMT) but allows the firm to rebalance tolls for individual classes of vehicles. All bids must be accompanied by in-depth traffic and revenue studies, and in general the technical ability in the country for these studies has increased. There is now more competition for the projects and the bidders are usually combinations of domestic and international firms, which have knowledge and experience with managing and operating tolls roads. The contracts assign the costs of overruns to the successful bidder, but changes required by the Transport Secretariat are reimbursed in full. There is a committee supervising the quality of construction work. In order to reduce uncertainty, rights of way are fully secured before awarding the project. Finally, the financial structures of the projects are designed to resist stress, and a large fraction of the financial resources are local, reducing the foreign exchange risk of the project. The new approach seems to be successful, with projects amounting to US$1.5 billion under construction by May 2007 (Athie) and several other under progress, see table 9. There is strong competition for the projects: the Morelia-Salamanca toll road attracted 5 bidders.[65]

Table 9: Projects under construction and in progress under the New Concession Model

Project	Length (Km)	Amount (US$ Mill)
Awarded Concessions		
Matehuala Bypass	14,2	39,6
Mexicali Bypass	41,0	73,3
Amozoc-Perote	103,0	171,6
Tepic-Villa Unión	152,0	281,1
Morelia-Salamanca	83,0	161,9
Northern Bypass of Mexico City	223,0	543,5
Tecpan Bypass	4,0	16,3
Monterrey-Saltillo and Saltillo Bypass	92,0	256,1
Bids In Progress		
Perote-Xalapa and Xalapa Bypass	60,0	247,3
Arriaga-Ocozocoautla	93,0	199,0
San Luis Río Colorado International Bridge	0,4	7,4
Reynosa-Anzaldúas International Bridge	10,0	60,1
Irapuato Bypass	29,5	57,4
Total	905,1	2114,6

Source: Athie (2007).

[65]Note however that all biders were associations of Mexican firms. Interestingly, there was a tie since to firms asked for no contribution from the government. The resolution of the tie was based on the firm that offered the lowest cost of construction, according to the tender rules. This strange tie condition may be related to the memory of the implicit guarantees and cost overvaluation by contractors in the first generation of toll roads.

4.2.2 The PPS model

Under the PPS model, the government promises to make periodic payments from the Transportation Secretariat budget, but there is some residual traffic risk in terms of shadow tolls. The Secretariat provides the conceptual design of the project and a list of requirements, and the decision criteria is the lowest net present value of annual payments. The duration of the contract is between 15 and 30 years. Table 10 summarizes the experience with highway PPS.

Table 10: Projects under PPS, under construction and bids in progress

Project	Length (Km)	Amount (US$ mill)
Awarded Concessions		
Matehuala Bypass	14,2	39,6
Mexicali Bypass	41,0	73,3
Amozoc-Perote	103,0	171,6
Tepic-Villa Unión	152,0	281,1
Morelia-Salamanca	83,0	161,9
Northern Bypass of Mexico City	223,0	543,5
Tecpan Bypass	4,0	16,3
Monterrey-Saltillo and Saltillo Bypass	92,0	256,1
Bids In Progress		
Perote-Xalapa and Xalapa Bypass	60,0	247,3
Arriaga-Ocozocoautla	93,0	199,0
San Luis Río Colorado International Bridge	0,4	7,4
Reynosa-Anzaldúas International Bridge	10,0	60,1
Irapuato Bypass	29,5	57,4
Total	905,1	2114,6

Source Athie (2007).

Mexico has developed another program, known as the Highway Asset Utilization program, under which the Secretariat assigns through a bidding process of an already existing tolled highway. The firm is responsible for maintenance and operation, and receives toll revenue in exchange. The bidding variable is the amount to be paid, and which is preassigned to build a new highway, normally (but not always) with some local affiliation to the auctioned highway. Examples of affiliation are the Reynosa Bypass and Rio Bravo Dona International Bridge, to be financed with the revenue from the auction of the Reynosa-Matamoros highway and the Reynosa-Phar International Bridge. The table 11 summarizes the state of the different approaches to PPPs in Mexico as of May 2007.

To conclude, the initial Mexican toll roads program was a case study of failure. The causes of the problems were the lack of serious technical and economic studies, lack of experience of successful bidders and the government, firms underbidding and assuming an implicit government guarantee,

Table 11: Summary of projects in progress and under preparation

Project	Concessions		PPS		Assets		Period
	Length (Km)	Amount (US$ mill)	Length (Km)	Amount (US$ mill)	Length (Km)	Amount (US$ mill)	
Awarded	712,2	1543,4	213,0	269,3	–	–	Before 2007
Bids in progress	192,9	571,2	229,0	946,5	144,0	923,4	2007
Preparation	148,1	461,6	376,0	480,6	74,0	173,6	2007-2008
Others	717,5	2049,7	938,0	712,8	799,2	2156,0	2008-2011
Total	1.770,7	4.625,9	1.756,0	2.409,2	1.017,2	3.253,0	

Source: Athie (2007).

and finally, an inappropriate bidding variable. The cost to the country was very large and is not fully completed.[66] However, the coubtry has learnt from the experience, and has designed a new approach to infrastructure PPPs that corrects the errors of the first generation. The new program seems to be more successful in avoiding the pitfalls of the previous experience, but time will test if this surmise holds true under more stressful conditions.

4.3 Colombia

The first generation of highway franchises, which involved investments of US$1,076 million in 13 projects (**Check and compare with table below.**), was awarded during the mid-nineties, as seen in table 12. It is clear in retrospect that this first wave of highway PPPs had severe problems. Seven out of 13 projects were not awarded in an auction, but assigned in direct negotiations after no bidders showed up at the auction (and two projects adjudicated by auction had only one valid proposal).[67] A partial list of the additional problems detected in the first round of franchises is as follows:[68]

1. Invías did not define the definite route of the roads in detail.[69] This meant that Invías was unable to expropriate the required land in time and led to construction delays.

2. The auction process was short and Invías had no international "road shows" to attract international bidders. This meant that most auctions had no bidders and most projects were handed to Colombian firms directly.

[66] See "Bumps ahead for a toll-road push", *Los Angeles Times*, April 20, 2007, concerning the quality and cost of the Cuernavaca-Acapulco Autopista del Sol.

[67] In addition, many projects started out late due to lack of financing. In fact, by 1999, one project awarded in 1995 and one awarded in 1996 had still not obtained financing.

[68] From "Evaluación de las Concesiones Viales," Contraloría General de la República de Colombia, 2001.

[69] Invías is the Spanish acronym for Instituto Nacional de Vías, the government agency responsible for highways of national importance.

Table 12: First generation concessions in Colombia

Project	Length	Investment (US$ mill)
Santa Marta - Paraguachón	250 km	49
Cartagena - Barranquilla	109 km	14
Desarrollo Vial Oriente de Medellín	349 km	99
El Cortijo - La Punta - El Vino	31 km	32
Fontibón - Facatativá - Los Alpes	41 km	75
Desarrollo Vial Norte de Bogotá	48 km	87
Los Patios - La Calera - Guasca y El Salitre - Sopó - Briceño	50 km	9
Malla Vial del Meta	190 km	47
Bogotá - Cáqueza	49 km	94
Girardot - Espinal - Neiva	150 km	39
Armenia - Pereira - Manizales	219 km	131
Total	1,486km	676

3. Projects were franchised on the basis of feasibility studies, before the final project was defined. Moreover, traffic studies were preliminary.

4. Invías did not assess the financial health of bidders. Some winners (or firms that negotiated directly with Invías) could not obtain financing, which led to delays.[70]

5. Contracts were incomplete: there were no conflict resolution mechanisms, nor rules for payment of guarantees, or *step-in* procedures for possession of the franchise by lenders.

Because of these shortcomings, the first round of franchises was plagued by contract renegotiations, delays, large payments for traffic and cost guarantees, and cost overruns in plot expropriations. On average, traffic was 40% lower than predicted by Invías, while costs were 40% above their contracted values. More than 40% of cost overruns were due to higher expropriation costs.[71] A further 58% of cost overruns were due to design changes and the inclusion of additional features to the project. In addition, there were compensations for toll revenue below guaranteed levels, adding in total to US$ 133.8 million (2203 dollars), representing 25,3% of the initial investments of US$ 529.7 million (M. C'ardenas 2003).

In the second generation of franchises, some of the errors of the first generation were avoided, since the projects were more fully developed before tendering, traffic demand was studied more

[70] Despite this difficulty, the average delay of the first round franchises was 17 months, against the average of 3.5 years for similar government projects. Hidalgo, Darío. "Los impactos en las concesiones viales en Colombia: Vamos por buen camino?", *Estrategia*, June 30, 1997, cited in Pérez and Yovanovich, "Información Sectorial Sector Carreteras", Corporación Financiera del Valle S.A., February 1999.

[71] Note that there were construction cost guarantees offered by the government.

carefully, and the rights of way and environmental permits were the responsibility of the government, and in some cases were obtained before tendering. The second round of franchises included only two projects, for a total of US$ 504 million and 1041 km. Unfortunately, the first project was canceled due to breach of contract, while the second was late (in part because of problems with rights of way) and financially weak. It is interesting to note that, in contrast to the first round, variable franchise terms were used. The franchise ends when a predetermined level of accumulated revenue is collected. This is similar to the PVR mechanism discussed above, yet without discounting revenue flows, which means that some of the incentives to renegotiate remain, since the franchise owner bears more risk than under a standard PVR franchise.

Currently, Colombia is in its third generation of highway concessions. The differences between the second and third generations are fairly small, at least given the focus of this paper. First, there is the introduction of the concept of *graduality*, which implies that projects are adapted and expanded –within the scope of the contract– as demand for the road increases. Clearly, the lack of competition for these required additional investments can be very profitable to the concessionaire. Second, the adjudication system is simpler, since the main bidding variable is the level of accumulated toll revenues.[72] As of June 2008, there were 10 concessions awarded under the new scheme. The characteristics of the Colombian concessions are given in table 13.

Table 13: Characteristics of Colombian concessions as of 2004

Project	Km		
	Construction	Rehabilitation	Maintenance
Armenia - Pereira - Manizales	66,4	110	219
Bogotá - Villavicencio	9,2	16,3	86
Bogotá(Puente El Cortijo) - Siberia - La Punta - El Vino	15	31	31
Carreteras Nacionales del Meta	2,8	180,9	190
Cartagena - Barranquilla	0	63	109
Desarrollo Vial del Norte de Bogotá	46	48	48
Desarrollo Vial Oriente de Medellín y Valle de Rionegro	45,7	168,4	349,1
Fontibón - Facatativa - Los Alpes	20	41	41
Los Patios - La Calera - Guasca y El Salitre - Sopo - Briceño	0	50	50
Neiva - Espinal - Girardot	11,2	138,8	150
Santa Marta - Riohacha - Paraguachón	0	170	250
Malla Vial del Valle del Cauca y Cauca	110,3	293,5	403,8
Briceño - Tunja - Sogamoso	31,2	189	203,8
Zipaquirá - Palenque	7	370	377
Bogotá - Girardot	121	87,75	121
TOTAL	485,8	1957,65	2628,7

Source: INCO June 2004.

Any fair evaluation of Colombian highway franchises, however, must consider that the benchmark should not be perfection but rather the experience with government-mandated construction. Even though concession contracts were renegotiated, and in many cases projects were delayed,

[72] This is similar to PVR for the case of an infinitely patient firm.

the average delay was about two years less than before the program. Similarly, most concession contracts had cost overruns, yet the amount of the cost overruns were only about one third of the amounts under government mandated construction.

Summing up, the main shortcomings of the Colombian approach to highway PPPs have two origins. First, lack of experience with auctions and undue haste in preparing the first round of auctions. Haste led to constant changes in the projects, which increased costs. The lack of experience shows in not having promoted competitive auctions via "road shows", which led to auctions with few bidders. Another facet of inexperience is the lack of concern for financial guarantees, with no penalties for firms that could not finance the project.

A second source of problems has been the inattention to incentives, which coupled with traffic and construction guarantees, meant large contingent claims on the Colombian government.[73] The current generation of franchises seem to have improved on some of the more obvious mistakes of the past, but we believe that the use of total revenue instead of discounted total revenue as a bidding variable is a mistake, and that the concept of graduality provides the wrong incentives to concession owners.

4.4 Chile

Chile has, by now, a mature and successful highway concession system, specially when compared to the countries described above. Nevertheless, there have been problems, the major one being the magnitude and generality of renegotiations of the original contracts (see table 14).

4.4.1 History of the Chilean franchise system

In 1991 the Chilean congress passed a law that allows the government to concession most public works, including roads, seaports, airports, reservoirs, hospitals and jails.[74] By the end of 2007, all main highways, most airports and several other projects had been concessioned. The total cumulative investment in 50 concessions awarded by the Ministry of Public Works (MOP), which is summarized in Table 14, is about US$11,3 billion, about 10% of current Chilean GDP.[75] Around 88% of that amount has been invested in highways.

Concessions must be awarded in competitive auctions open to any firm, national or foreign. The law is quite flexible, leaving ample room to adapt the contract to each project. For example, the tendering variables can include user fees, a subsidy from the state, the term of the concession, income guaranteed by the state, revenue paid by the franchise holder to the state for preexisting infrastructure, risk assumed by the bidder during the construction or operation stages, quality of

[73] The Colombian government has put a lot of conceptual effort into valuing the contingent guarantees it offered in the franchises, but less effort has been spent improving incentives, and avoiding renegotiation of contracts and financial arrangements.

[74] DFL 164 and DS 240, 1991.

[75] This figure does not include seaports, which are concessioned in a separate program.

the technical offer, fraction of revenue (beyond a certain threshold) shared with the state (or users), and total income from the concession.

Table 14: Main characteristics of the Chilean PPP system(UF)

	Budgeted cost	Total renegotiated value	Total Investment	Fraction of total	Number of works	Fraction of total	Average length of franchise
Ruta 5	71.885.711	20.544.456	92.430.167	0,33	8	0,16	23,8
Interurban highways	52.95 1.424	10.453.407	63.404.831	0,22	13	0,26	27,7
Urban highways	60.613.607	33.288.928	93.902.535	0,33	5	0,1	31,6
Highways	185.450.742	64.286.791	249.737.533	0,88	26	0,52	27,3
Airports	8.798.114	1.202.048	10.000.162	0,04	10	0,2	13,1
Jails	7.414.824	2.661.785	10.076.609	0,04	3	0,06	22,5
Reservoirs	4.13 1.579	413,094	4.544.673	0,02	2	0,04	27,5
Transantiago	4.884.764	645,599	5.530.363	0,02	5	0,1	15,8
Public Infrastructure	4.243.082	24,153	4.267.235	0,02	4	0,08	23,2
Other concessions	29.472.363	4.946.679	34.419.042	0,12	24	0,48	18,8
Total or average	214.923.105	69.233.470	284.156.575	1	50	1	22,7

Source: EFGH 2008.

Note: Currently, 1UF=US$ 40.

The usual procedure to finance a concession involves several stages. To begin, bidders must offer bonds (*bonos de garantía*) that can be called in by the government if the bidder cannot finance the project. Moreover, similar bonds are callable if construction targets are not achieved by predetermined dates or quality maintenance standards are not met. Once the concession is awarded, banks lend money for construction of the road. The law stipulates that banks are the only financial institutions that may lend to finance construction. Last, a construction is completed, the concessionaire can issue bonds backed by toll revenues (securitization). These coupon bonds are usually bought by private pension funds and insurance companies. The law stipulates that the franchise owner cannot securitize more than 70% of the debt in order to induce good behavior in the maintenance and operational phase of the franchise.

The law states that the concessionaire must build the project within the time limits established in the contract, providing thereafter an uninterrupted service of a quality consistent with the terms of his bid. MOP supervises the construction and operation of the project, and is allowed to fine, suspend or even terminate the concession should the franchise holder fail to meet his obligations. The law also establishes a dispute resolution mechanism to review conflicts between the state and the concessionaire.

Highway concessions 26 highways were concessioned between 1993 and 2007 (Table 14), involving investments of about US$10 billion. Projects can be classified into three groups:

- The Pan-American Highway (Ruta 5), which runs from La Serena in the North to Puerto Montt in the South, which was divided into 8 double lane segments and extends over approximately 1,500 kilometers.
- 13 interurban highways. They include some that join Santiago with nearby cities (Los Andes, San Antonio, Valparaíso), and a number of local roads (e.g., Camino de la Madera, Nogales-Puchuncaví, Acceso Norte a Concepción);
- Five urban highways in Santiago

The program was launched in 1993 with the 23-year long El Melón tunnel concession. The auction was unnecessarily complex (see Box 4.1), but this can be forgiven as the initial test of a new system.

BOX 4.1 (The First Chilean Concession) *The auction mechanism used for El Melón tunnel was unnecessarily complex. Firms bid on a weighted average of seven variables: annual subsidy by or payment to the state, toll level and structure (composed by six different tolls, with different weights for different classes of vehicles), term of the franchise, minimum income guarantee, degree of construction risk borne by the franchise holder, score on the basis of additional services, and CPI adjustment formula. While only two of these variables (toll rate structure and payment to the state) were given weights that would have an effect on the final outcome, the result of the tender was unexpected. Four firms presented bids for the franchise and they all demanded the maximum toll and franchise term allowed by the auction. The selection was decided solely based upon the annual payment to the state. This outcome was inefficient, since a lower toll and a smaller annual payment to the state would have been better. Apparently, the weights on the toll rate variable were set incorrectly. Another surprise was that the winner outbid the second-highest bid by almost a factor of three.*

Subsequently MOP experimented with other tendering mechanisms. For example, the Acceso Norte to Concepción, the Nogales-Puchuncaví Road, and the Santiago-San Antonio (Ruta 78) highways were awarded to the firm bidding the lowest toll. By contrast, most segments of the Pan American highway were auctioned using a mechanism that made firms compete first on tolls and then, when a lower bound was reached, on either the shortest franchise term or a yearly payment to the state (which was described as a "payment for preexisting infrastructure") since the government wanted similar tolls per kilometer in all of the Pan-American highway. Moreover, some segments, which were thought to be privately unprofitable, were awarded subsidies, which were supposed to be similar to the amounts collected as payments for existing infrastructure. The highway that joins Santiago with Valparaíso and Viña del Mar in the coast was the first that awarded with a PVR auction (during 2008, several additional projects were awarded using a PVR auction). Most tenders were reasonably competitive, because with few exceptions, the number of bidders was between three and six.

BOX 4.2 (First PVR Auction) *The Route 68 concession, joining Santiago with Valparaíso and Viña del Mar, was auctioned in February of 1998. It was the first road franchised with a PVR auction.*[76] *Under this scheme, the regulator fixes user fees and announces a discount rate, and the franchise is awarded to the firm that bids the least present value of toll revenue.*[77] *The franchise ends when the present value of toll revenue is equal to the winning bid. By letting the franchise length depend on demand realizations, PVR auctions reduce risk born by the franchise holder substantially.*[78] *This should lower the demand for traffic guarantees. The Route 68 concession contemplated major improvements and extensions of the 130 kilometer highway and the construction of three new tunnels. Five firms presented bids, one of which was disqualified on technical grounds. For the first time in the Chilean concessions program, minimum traffic guarantees were not included for free, but instead were optional and at a cost. That the pricing of guarantees by the government was not way off the mark can be inferred from the fact that two of the bidders chose to buy a guarantee, while the winner declined. Bidders could choose between two rates to discount their annual incomes: either a fixed (real) rate of 6.5% or a variable (real) rate given by the average rate of the Chilean financial system for operations between 90 and 365 days. A 4% risk premium was added to both discount rates. Three firms, including the winner, chose the option with a fixed discount rate. Somewhat surprisingly, the present value of revenue demanded by the winner turned out to be* below *construction and maintenance costs estimated by MOP.*[79] *One possible explanation for this outcome is that the regulator set a risk premium (and hence the discount rate) that was too high, neglecting the fact that PVR auctions substantially reduce the risk faced by the franchise holder. A return on capital in the 10–20% range is obtained if a more reasonable risk premium (in the 1–2% range) is considered.*

It is also interesting to mention that, apart from the pressure exerted by the Ministry of Finance, the main reason why MOP decided to use the PVR mechanism is that it facilitates defining a fair compensation should the ministry decide to terminate the franchise early. This feature of PVR is relevant in this case since MOP estimates that at some moment before the franchise ends, demand will have increased sufficiently to justify a substantial expansion of an alternative highway (La Dormida) that competes with some sections of Route 68. Thus, the contract of the Route 68 concession allows MOP to buy back the franchise at any moment after the twelfth year of the franchise, compensating the franchise holder with the difference between the winning bid and the revenue already cashed, minus a simple estimate of savings in maintenance and operational costs due to early termination. No such simple compensation is available if the franchise term is fixed.

[76] Even though firms did not bid on the present value of revenue, the franchise contract underlying the building of the Queen Elizabeth II bridge, tendered in 1987 in the UK, is similar to the PVR franchise. In a series of papers, beginning with Engel et al. (1996), we highlighted the advantages of this approach and formally derived many of its properties, including scenarios where it is the best possible auction mechanism (see Engel et al. [2001]).

[77] The discount rate should be a good estimate of the costs of funds faced by franchise holders and could be variable (such as LIBOR plus some fixed risk premium).

[78] Associated welfare gains can be considerable. Engel et al. (2001) show that with parameters typical for developing countries, welfare gains are of the order of 30% of the investment in the highway.

[79] The winner bid US$374 million while the MOP estimated costs to be US$379 million.

The particulars of concession contracts vary, but they also share common features. Fifteen out of the 26 highway concessions have been awarded with subsidies and all of them received minimum income guarantees. Thus, direct and contingent subsidies are almost a given when it comes to highways. At the same time, 22 highway contracts include revenue sharing between the state and the concessionaire.

One of the main virtues of the Chilean concessions program is that legislation has been effective at dispelling fears of expropriation. An important part of the credit rests with the reforms implemented in Chile since the mid-seventies which considerably strengthened property rights. Perhaps the most evident indicator that there is little fear of expropriation is that concessionaires have been quite happy with the "build now, regulate later" approach followed by MOP—so far there is no independent regulator of concessions, an idea that the industry has vigorously opposed. Another merit of the Concessions Law is that it specifies that all concessions must be awarded in competitive auctions, open to foreign firms. This proviso limits the scope for regulatory capture and outright corruption.

One of the main shortcomings of the Chilean concessions program, however, is the lack of an external regulatory framework. MOP has been in charge of designing, implementing, supervising and renegotiating contracts. Each project has been designed independently and its rules are defined by the specific contract. The tension between the pressures for the success of a concessions program measured in terms of construction and the enforcement of contracts is evident. MOP, as most sectoral ministries under similar circumstances, has opted for development over regulation. Moreover, because MOP renegotiates the contracts it has awarded, it has incentives and the opportunity of covering up its mistakes. (For an example, see Box 4.3 which describes the case of Tribasa.)

BOX 4.3 (MOP as contract supervisor) *Tribasa, a large infrastructure company, had been an important participant in the first stage in Mexico's franchise program. At the time, it was saved from bankruptcy by the Mexican government. Notwithstanding that experience, it became an important and aggressive participant in the initial stages of Chile's infrastructure program and was awarded three major franchises: Acceso Norte a Concepción, Chillán-Collipulli and Santiago-Los Vilos (which had complementary contracts worth almost 50% of the original project).*

After completing the Acceso Norte a Concepción it ran into liquidity problems and sold Chillán-Collipulli in July 1999. Moreover, Acceso Norte a Concepción has been plagued by unconfirmed rumors of deficient construction and supervisors of the projects at MOP are under investigation. In the year 2000, Tribasa was late in completing the stages of the Santiago-Los Vilos section of the Pan American highway. Surprisingly, MOP was willing to allow the delays to accumulate without collecting the guarantees Tribasa had posted.[80] *Eventually, public pressure forced MOP to acknowledge there was a breach of contract. The franchise was transferred from Tribasa to another concessionaire without a formal auction procedure.*

[80] At the time Tribasa was filing for bankruptcy in Mexico, and later went bankrupt in Chile as well.

There is also evidence that MOP has been lax in enforcing concession contracts. For example, a report issued by the National Comptroller (*Contraloría General de la República*) in October of 2002 concludes that the ministry relies solely on traffic data provided by franchise owners, having neglected to set up independent procedures to collect this information.[81] This is worrisome, since government guarantees are triggered by low traffic flows, so that firms have incentives to underreport traffic.[82]

Finally, MOP has probably auctioned projects with low social returns. Chile has had a social evaluation program of government financed projects for more than three decades. This procedure, which is performed by the Ministry of Planning, ranks projects according to their social return and screens projects with low returns. On occassion, MOP seems to have subverted this procedure, by removing the least cost-effective parts of the projects submitted to the Planning Ministry. The omitted components were reincorporated after the approval and adjudication of the project, via so-called *complementary contracts* with the franchise holder, which are negotiated in private.[83] MOP has often mentioned that it has estimated the expected outlays generated by traffic guarantees, but these estimates have never been made public. In those cases in which subsidies have been provided, the social project evaluations that justify the subsidies have not been made public either.

It has been fortunate that MOP's objective of attracting bidders conflicted with those of the Ministry of Finance, which is responsible for the budgetary process. This has forced a more independent evaluation of the toll road program. Indeed, press reports suggest that on more than one occasion the Ministry of Finance successfully stopped MOP from offering particularly generous government guarantees to franchise holders. The Ministry of Finance worries that the budget will be affected if guarantees become effective. More generally, however, MOP can transfer rents to franchise owners via favorable regulations. These transfers are unlikely to worry the Ministry of Finance if the budget is not affected.

Renegotiation of concession contracts During the early years of the franchise program, the government avoided renegotiations even in those cases in which they would have increased welfare, as in the case of the El Melón Tunnel, perhaps to build a reputation for not renegotiating (see Box 4.4) Indeed, renegotiations were limited until 2001. Substantial amounts were renegotiated in 2001, 2003, 2005 and 2007. As of the end of 2007, the 50 concessions that MOP awarded between 1993 and 2007 had been renegotiated 144 times, averaging 2.9 per concession. Highways tend to be renegotiated more. The 26 concessions have been renegotiated 109 times, 4.2 per concession. Most renegotiations have led either to increase the payments received by the concessionaire for the original project or to upgrades to the original project.

Renegotiations can be either bilateral or under the supervision of a commission set up to adju-

[81] "Contraloría critica sistema de control de concesiones", *La Tercera*, April 22, 2003.

[82] Moreover, in the case of Route 68, the concession length is inversely related to traffic flows.

[83] See "Informe de la U. de Chile revela suerte de embaucamiento del MOP a Mideplan," *La Segunda*, May 13, 2003.

Table 15: Renegotiations and total investment in PPPs in Chile (UF)

	Budgeted investment (Technical offer)	Bilateral renegotiation	Conciliations and arbitration	Total renegotiated	Total investment	Renegotiation as fraction of budgeted	Renegotiation as fraction of investment
Ruta 5	71.885.711	15.866.047	4.678.409	20.544.456	92.430.167	0,29	0,22
Interurban roads	52.951.424	6.972.069	3.481.338	10.453.407	63.404.831	0,2	0,16
Autopistas urbanas	60.613.607	33.288.928	0	33.288.928	93.902.535	0,55	0,35
Highways	185.450.742	56.127.044	8.159.747	64.286.791	249.737.533	0,35	0,26
Airports	8.798.114	1.139.836	62,212	1.202.048	10.000.162	0,14	0,12
Jails	7.414.824	0	2.661.785	2.661.785	10.076.609	0,36	0,26
Reservoirs	4.131.579	197,212	215,882	413.094	4.544.673	0,1	0,09
Transantiago	4.884.764	0	645,599	645.599	5.530.363	0,13	0,12
Public Infrastructure	4.243.082	24,153	0	24.153	4.267.235	0,01	0,01
Other concessions	29.472.363	1.361.201	3.585.478	4.946.679	34.419.042	0,17	0,14
Total or average	214.923.105	57.488.245	11.745.225	69.233.470	284.156.575	0,32	0,24

Source: EFGH 2008.

Note: Currently, 1UF=US$ 40.

dicate disputes. In a bilateral renegotiation MOP and the concessionaire reach an agreement which is not revised by an independent third party. If, on the other hand, the parties fail to agree, they can appeal to a commission which first tries to conciliate and then arbitrates. A little above half of all renegotiations (74 out of 144) have been bilateral. Nevertheless, as can be deduced from Table 15, about 83% of the additional amounts conceded to concessionaires have been granted after a bilateral renegotiation, hence without external scrutiny (see Box 4.4 for an example). Almost all bilateral renegotiations have been initiated by MOP and occurred before the project was completed. By contrast, most renegotiations with a commission have adjudicated conflicts that have occurred after the project was completed.

BOX 4.4 (Renegotiation without supervision by third parties) *After signing the concession contract for Route 78, MOP required additional works that were not included in the original contract. The franchise holder asked for a compensation for the additional construction and the ministry decided to increase tolls by 18.1% during a five year period. No further explanation was given (public opinion learned of the agreement only after it was signed), and the calculations that led to the compensation were not made public.*[84]

The amounts renegotiated are substantial. As can be deduced from Table 14, of the US$11.3 billion invested in 50 concessions, US$ 2.7 billion were added after a renegotiation. Of these, at least US$ 1,4 billion were additional works. In other words, about one in every four dollars invested has been added after the contract was awarded. Alternatively, the total amount invested has been increased by about one-third after contract award.

There are several means to increase the concessionaire's revenues or compensate him for additional works, among them direct payments from the government, tariff increases and term exten-

[84] See "Estado compensará a privados por concesión", *El Mercurio*, July 15, 1997, page C8.

sions. Nevertheless, the most used form of compensation is a direct payment from the government—almost 70% of the total amount renegotiated. This does not mean an immediate impact on the public budget, however. Indeed, two thirds of these direct payments will be paid by future administrations.

5 Conclusion

This paper asks *when* and *how* a government should use PPPs to provide specific infrastructure projects. This conclusion we synthetize our answers.

The defining characteristics of a PPP are three: bundled provision of construction and operation; private but temporary ownership of assets; and substantial intertemporal risk bearing by the public sector. On the one hand, this organizational form is akin to privatization: ownership and control over operational decisions rests to a great extent in the private firm and the cash flow generated by the project accrues to the concessionaire. On the other hand, temporary and state contingent ownership implies that a PPP is akin to conventional provision. In fact, most of the project's intertemporal risk should be borne by the government and then the impact on the intertemporal public budget resembles conventional provision. Therefore a PPP will be the adequate organizational form when its three defining characteristics induce a more efficient resource allocation than permanent privatization or conventional unbundled conventional provision.

A straightforward but important implication is that infrastructure should be privatized and liberalized whenever competition is feasible. A PPP (or any other means of infrastructure provision) should be considered only when increasing returns or the inability to charge consumers prevent competition and its case rests almost exclusively on efficiency. Indeed, we have shown that the argument in favor of PPPs cannot rest on the usual claim that they relieve the public budget, even when all the revenue received by the concessionaire comes from user fees.

When is a PPP more efficient? In general, bundling induces the concessionaire to partially internalize life-cycle costs. Private ownership, however, stimulates cost-cutting investments to the full extent, because the concessionaire receives all the benefits of investments that reduce life-cycle costs. Thus, when the main concern is to provide strong incentives to reduce or control life-cycle costs, a PPP is superior to conventional unbundled provision. Nevertheless, even here the case for a PPP is not clear cut, because regulated privatization provides even stronger incentives. Additional characteristics of the infrastructure project will then determine which mechanism is better. For example, if demand risk is largely exogenous and there is a large upfront investment, a PPP provides for (i) an auction of the project, (ii) a better distribution of risk, and (iii) the government keeps the planning authority. This may be useful, for example, when managing a network of highways. On the other hand, if continuous reinvestment and expansion is a feature of the infrastructure, as in a water utility or an electricity distributor, privatization may be a better idea, for a PPP would require continuous bargaining and recontracting.

But investments may also affect the quality of service. When quality of service is the main concern and objective standards cannot be enforced, the case for a PPP weakens because a concessionaire ignores consumer surplus when investing. Even worse, some investments that reduce life cycle costs may also deteriorate quality of service. In that case, conventional provision allows some internalization of consumer surplus and generally beats a PPP.

Assuming that a PPP is the most efficient way for providing a given infrastructure, how should the contract be structured? We provide conditions under which the optimal contract features a minimum revenue guarantee (a state contingent subsidy) and a revenue cap. Revenue caps and especially minimum revenue guarantees have been extensively used in PPPs, but the optimal contract is quite different from the contracts observed in the real world. In practice, most concessions are fixed term, e.g. 30 years. In the optimal PPP contract, the concession should last as long as possible in those states where the firm receives guarantee payments, and the term should be finite and variable in states in which the revenue cap is binding.

The logic behind the optimal contract is as follows. Bundling implies that PPP contracts are intertemporal by definition. If the government can bear risk at a lower cost, then it pays to reduce the risk born by the concessionaire, through a minimum revenue guarantee in low-demand states and/or through a revenue cap and variable-term concession in high-demand states. Nevertheless, if subsidy finance is more expensive at the margin than user fees because the government spends inefficiently, then it pays to minimize subsidies and finance as much as possible with user fees. Hence, in low-demand states where subsidies are paid, the concession must last as long as possible, while in high-demand states the concession should last a finite and variable term, to balance the cost of risk against the cost of subsidies. Finally, if all states are high demand, the optimal concession term is variable and finite, and the concessionaire receives full insurance. If, on the other hand, all states have low demand, the concessionaire also receives full insurance, but this requires subsidies in all states. In both cases, as the concessionaire faces no risk, the impact of the project on the intertemporal budget is the same as with conventional provision.

Thus a PPP shares some characteristics of privatization and of public, conventional provision. Regarding ownership and incentives to invest, a PPP is similar to standard regulated privatization. But on the fiscal side and risk bearing, it is similar to public conventional provision.

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Appendices

A Basic model

A.1 The project

There is a continuum of identical consumers, each with willingness to pay for q units of service given by

$$\int_0^q D(q')dq',$$

with $D(q)$ a standard inverse demand function. There are v consumers in present value, described by a random variable with density function $f(v)$, c.d.f. $F(v)$ and mean $\overline{v}$. This density is bounded from below by $v_{\min}$ and from above by $v_{\max}$ and is common knowledge.

If each consumer uses q units of the service each period, and the expected number of users over the lifetime of the project is $\overline{v}$ in present value, the infrastructure requires a verifiable upfront investment $Iq\overline{v}$. The government decides the capacity of the infrastructure, $q\overline{v}$. After the infrastructure is built, it costs cqv in present value to operate and maintain if no unverifiable investments are made (more on unverifiable investments shortly).[85] Investments do not depreciate.

A risk-neutral government hires private firms to build and operate the infrastructure.[86] If building and operation are bundled we call the firm "concessionaire". If provision is unbundled, we call the firms "builder" and "operator." All firms are identical expected utility maximizers, with preferences represented by the utility function u and outside option $u(0)$.

A.2 Non-verifiable investments

One central lesson of the literature on incomplete contracting and organizations is that the most efficient organizational form and control allocation depends on the type of nonverifiable investments and their relative importance. We follow the literature and assume that a non-verifiable investment can be made.

The additional consumer surplus and operation cost associated with the project when nonverifiable investment equals e in state v are denoted, respectively, by:

$$\Gamma b(e)qv \quad \text{and} \quad \big(1-\gamma a(e)\big)cqv,$$

where Γ and γ can take the values: -1 and 1. This convention implies that $\Gamma=\gamma=1$ is unambiguously welfare improving, for unverifiable investments create value and lower costs in this case. By contrast, $\Gamma=\gamma=-1$ decreases welfare, for investments reduce welfare and increase costs in this case. The cases where $\Gamma=1$ and $\gamma=-1$, or $\Gamma=-1$ and $\gamma=1$, could be welfare improving or welfare decreasing, depending on the values of e and c (and the functions $a(e)$ and $b(e)$. We assume $b(0)=a(0)=0$, $b',a'>0$, $\Gamma b'',\gamma a''<0$ for all $e\in[0,\infty]$. Total nonverifiable investment is $eq\overline{v}$ and total investment is $Iq\overline{v}=(I+e)q\overline{v}$.

[85] Note that investment costs depend on the expected number of users while operation and maintenance costs vary with the actual number of users.

[86] Thus, we rule ignore the possibility of government production.

It follows that total willingness to pay for the project is

$$v \cdot \left[\int_0^q D(q')dq' + \Gamma b(e)q \right] \equiv v \cdot \mathrm{WP}(q),$$

in present value, whereas total costs are

$$\left(\mathscr{I}\overline{v} + \left(1 - \gamma a(e)\right) c v \right) q$$

in present value.

The model captures the intertemporal link between investment and operation costs, which underlies one of the main rationales behind bundling and PPPs. Now the impact of nonverifiable investments may vary. On the one hand, if $\gamma = 1$, they cut operation costs, thereby reducing life-cycle costs.[87] Sometimes *cost-cutting investments* increase consumer surplus ($\Gamma = 1$). For example, skillfull design of a seaport may both reduce the cost of running it and, by speeding up the handling of cargo, reduce ships' demurrage costs. We assume that some investment of this type is always socially beneficial, that is

$$b'(0) + a'(0)c > 1.$$

Some cost cutting investments, however, reduce life-cycle costs at the expense of consumer surplus ($\Gamma = -1$). For example, a quick training program may allow to hire inexperienced personnel and pay them lower salaries but reduces customer satisfaction. We assume

$$-b'(0) + a'(0)c \lesseqgtr 1.$$

Thus, sometimes reducing life-cycle costs at the expense of consumer surplus may be socially useful, but it may also be socially wasteful.

On the other hand, sometimes higher quality, while increasing consumer surplus, also increases life-cycle costs, this is the case where $\Gamma = 1$ and $\gamma = -1$. We call these *quality-enhancing investments*.[88] For example, a sophisticated scanner increases the quality and accuracy of diagnoses but must be operated by skilled personnel, which is more expensive to hire and train. We assume

$$b'(0) - a'(0)c \lesseqgtr 1.$$

This captures the fact that sometimes quality-enhancing investments may be worth their cost, but sometimes they aren't.

A.3 Alternative organizational forms and investment

Bundling and asset ownership One of the defining characteristic of a PPPs is that construction and operation of the infrastructure are bundled together and contracted out to a single firm. By contrast, conventional provision of infrastructure is usually unbundled, as governments contract construction and operation to different firms.

Nevertheless, Bennet and Iossa (2006) recently pointed out that PPPs also transfer the ownership rigths of the assets to the firm that builds and operates the infrastructure. Ownership by the private firm is an important feature of PPPs because it allows the concessionaire to independently

[87] See Hart (2003).

[88] See Bennet and Iossa (2006).

control the assets and operation and decide how to produce the service. By contrast, if the government keeps ownership, it has a say on how the service is produced (for example, it often specifies inputs) and even operational decisions become subject to its approval. As is well known, the allocation of ownership affects disagreement points in bargaining and ex post surplus sharing. Through this, ownership and organizational form affect ex ante incentives to invest and efficiency.

We will compare incentives under several organizational forms, which are depicted schematically in Figure 1. If the government chooses bundling, a single firm builds the infrastructure and provides the service. Nevertheless, the government could choose to own the assets (we call that *public ownership*) or to let the firm own them (*private ownership*). Private ownership, in turn, can be achieved with a PPP or with privatization.

Now if the government chooses unbundled provision, different firms build and operate the infrastructure. The standard arrangement of unbundled provision is *conventional provision*, whereby the government owns the assets and hires two different firms[89]. By contrast, the standard agreement of bundled provision, either a PPP or privatization, implies private ownership of assets. Nevertheless, it should be apparent that private ownership is not necessary for bundled provision, as the government could hire one firm under a long term contract and keep ownership. We call this *public bundling*.

Investment implementation and bargaining To study the economic implications of organizational form we follow Bennet and Iossa (2006) assuming that nonverifiable investments must be implemented before they produce flows. For example, organizational procedures may have to be changed to take advantage of the skills that workers acquired after they were retrained to use a new technology.

Both the participation of the builder and the acquiscience of the owner are necessary for implementation. Under private ownership the builder owns the assets and can implement unilaterally. By contrast, under public ownership the government must approve implementation. We use Nash bargaining and assume that the parties split their bilateral renegotiation surplus 50/50 over the disagreement point.

Disagreement points are determined as follows. We assume that ownership prevents the builder from committing to implement a quality-enhancing investment (which would increase her operation and maintenance costs), or foregoing implementation of a cost-cutting investment. In other words, with private ownership the builder cannot commit to hurt herself and her promises to do so are empty. By contrast, we assume that public ownership enables the builder to commit, perhaps because then the government can punish her for not honoring an agreement reached while bargaining.

The government's objective We want to keep things as simple as possible and deduce minimal condidtions such that a PPP is the optimal organizational form. To do it we assume that the government is benevolent but for one defect, ignoring life-cycle costs when bargaining with the builder and considers only consumer surplus. This assumption is necessary because the case for bundling would be rather weak if governments would routinely internalize life-cycle costs[90]. But, more im-

[89] In principle the government could choose to transfer ownership to two different firms, a builder and an operator. We will ignore this alternativeSee Bennet and Iossa (2006) for an analysis of this alternative.

[90] More generally, organizational form matters only if some transaction cost prevents joint surplus maximization.

portant, it is warranted, because incentives within the government make internalization difficult. For one, often the department or agency in charge of building is not in charge of maintenance. For another, maintenance and operation are paid by future administrations.

At the same time, we assume that the government plans the infrastructure efficiently, regardless of the form of provision. In particular, it chooses the capacity of the infrastructure $q \cdot \overline{v}$ to maximize social welfare anticipating that it will bargain myopically ignoring life cycle costs.

A.4 Public finance

Both conventional provision and PPPs have an impact on the public budget. In standard fashion, we assume that $1+\lambda$, with $\lambda \geq 0$, equals the cost of public funds.

The government can also make state-contingent subsidy transfers $S(v)$ in present value. By "subsidy" we mean any cash transfer from the government to producers. It may be the up-front payment made by the government with conventional provision (in which case $S(v)$ is the same for all v), but it could also be a cash transfer made over time, contingent on v, to supplement revenue from the project under a Build-Operate-and-Transfer (BOT) contract (a so-called 'minimum revenue guarantee').

We assume that the mere handling of funds through the public budget may waste resources. Thus we assume that achieving \$1 of useful spending costs \$1 if financed by the private sector but $1+\zeta$ dollars if financed with a subsidy. Hence

$$(1+\lambda)(1+\zeta)$$

is the shadow cost of one additional dollar of subsidies.

Why introduce ζ? If subsidies are monetary transfers from the government to the concessionaire, then $\zeta > 0$ means that not all the resources reach their intended use, for example, because of agency problems faced by the budgetary authority when monitoring the agency in charge of transferring resources to concessionaires. Thus we distinguish between the social costs of taxation (efficiency on the revenue side), which we capture with λ, and the relative efficiency with which the public sector spends, which we capture with ζ (efficiency on the expenditure side).

In EFG (2008) we show that if the government runs an optimal fiscal policy, then the shadow cost of one additional dollar in subsidies can be assessed from two different, but equivalent, perspectives. On the one hand, one could increase the aggregate tax burden by $1+\zeta$, which would cost society $(1+\lambda)(1+\zeta)$ dollars. On the other hand, the government could achieve the same transfer by reducing current spending by $1+\zeta$ dollars. If fiscal policy is optimal, it can be shown that the opportunity cost is equal to the return of the government's marginal project, which equals $(1+\lambda)(1+\zeta)$.

The distinction between inefficiencies on the revenue and the spending side is unconventional, as the literature typically models only the social cost of taxation. In fact, omitting ζ is mostly harmless if all projects are publicly undertaken, as any inefficiency on the spending side just reduces the net return of public projects and the optimal size of the public sector. Nevertheless one of the effects of many PPPs is to substitute user fee revenue for subsidy financing, thus taking cash flows out of the public budget. This fact, by itself, may make a PPP a better way of undertaking a project.

A.5 Producer surplus, consumer surplus and the planner's problem

The planner's problem Let PS(v) denote producer surplus in state v and CS(v) denote consumer surplus in state v. The planner's objective is to maximize[91]

$$\int [\text{CS}(v) + \text{PS}(v)]\, f(v)\, dv, \tag{4}$$

subject to firms' participation constraints.

Producer surplus To maximize (4), the planner chooses organizational form and the subsidy-user fee combinations received by producers in each state. Denote by $R(v)$ the present value of user fee revenue directly collected by producers in state v and by $S(v)$ the present value of the subsidies they receive. Then

$$\text{PS}(v) = R(v) + S(v) - \left[\mathscr{I}\overline{v} + (1 - \gamma a(e))cv\right] q. \tag{5}$$

Consumer surplus Consumers value the project in $v \cdot \text{WP}(q) - R(v)$. They are also affected by the budgetary impact of the project. On the one hand, user fees can be used to reduce distortionary taxation. Let θ be the fraction of consumers' willingness to pay that can be captured with user fees (which may depend on organizational form—see below). Since producers receive $R(v)$ in state v, the government receives

$$\theta \cdot v \cdot \text{WP}(q) - R(v),$$

which can be used to reduce distortionary taxation elsewhere in the economy. On the other hand, producers receive subsidies $S(v)$ in state v, which cost consumers $(1+\lambda)(1+\zeta)S(v)$. Hence

$$\text{CS}(v) = \left[v \cdot \text{WP}(q) - R(v)\right] + \lambda[\theta \cdot v \cdot \text{WP}(q) - R(v)] - (1+\lambda)(1+\zeta)S(v) \tag{6a}$$

$$= (1+\lambda\theta)\, v \cdot \text{WP}(q) - (1+\lambda)\,[R(v) - (1+\zeta)S(v)] \tag{6b}$$

The ability to charge consumers While in principle $R(v)$ and government revenue are bounded above by $v \cdot \text{WP}(q)$, the capacity to charge for the use of the infrastructure may be limited to a fraction of consumers' wiligness to pay.

The size of θ may depend on the type of the infrastructure, the available technology and the organizational form chosen. Of course, one cannot charge for the use of nonexcludable goods, but technology may make it possible to exclude consumers. For example, until recently tolling of urban highways and streets was hampered by lack of space to install toll boots and the congestion that toll collection would cause—streets were, in fact, nonexcludable goods. But today technology allows free-flow tolling and monitoring. Even then, however, charging may be next to impossible if streets and highways are provided by a public agency, but it may become palatable if the infrastructure is upgraded and "privatized" with a PPP. Last, exogenous legal constraints sometimes may limit the amount that can transferred to producers. For example, in some countries concession terms cannot exceed a given number of years or competition rules may prevent price discrimination.

[91] The planner cares about firms' profits not *per se* but because these constitute a source of income for firms' owners. This, combined with the assumption that the planner can redistribute income among consumers at no social cost and that each project is relatively small compared to the size of the economy, explains why producer surplus, and not the expected utility of the firm's profits, enters the planner's objective function.

Constraints in the ability to charge consumers imply that

$$0 \leq R(v) \leq \theta \cdot v \cdot \mathrm{WP}(q).$$

Note that for sufficiently small θ the benefits created by the project are akin to an externality. Nevertheless, $\theta < 1$ need not hamper efficiency.

B *When*? Efficiency and PPPs

B.1 Incentives and organizational forms

In this section we study how the best organizational form depends on the characteristics of the investment. To proceed we assume the following:

Assumption 1 *(i)* $\zeta = 0$*; (ii)* $\theta = 1$*; (iii) producers are risk neutral.*

B.1.1 The planner's allocation

Tha planner's problem The planner's problem is

$$\max_{q,e,R(v),S(v)} \int \left[(1+\lambda)\, v\mathrm{WP}(q) - \lambda\,(R(v) - S(v)) - (\mathscr{I}\overline{v} + (1-\gamma a(e))c v)\cdot q\right] f(v)\,dv$$

subject to

$$\mathrm{E}_v\left[R(v) + S(v)\right] = \left[\mathscr{I} + (1-\gamma a(e))c\right]\cdot q \cdot \overline{v} \tag{7}$$

Using (7) we can see that $(1+\lambda)\overline{v}$ multiplies all terms. Hence we can rewrite the objective function as

$$\max_{q,e}\left\{\left(\int_0^q D(q')\,dq' + \Gamma b(e)\,q\right) - \left[\mathscr{I} + (1-\gamma a(e))c\right]\cdot q\right\}.$$

We use the superscript * to denote the socially optimal allocation. The first order conditions are

$$\left[D(q^*) + \Gamma b(e^*)\right] - \left[\mathscr{I}^* + (1-\gamma a(e^*))c\right] = 0 \tag{8}$$

and

$$\Gamma b'(e^*) + \gamma a'(e^*)c - 1 \leq 0, \tag{9}$$

with equality if $e^* > 0$. Condition (8) implies that

$$D(q^*) + \Gamma b(e^*) = \mathscr{I}^* + (1-\gamma a(e^*))c,$$

the infrastructure should be expanded until consumers' marginal willingness to pay equals long-run marginal cost. If, in standard fashion, consumers are charged a linear price, then

$$p^* = D(q^*) + \Gamma b(e^*)$$

In other words, price equals long run average and marginal cost.

To study optimal nonverifiable investments, let $\epsilon_b \equiv b'\frac{e}{b}$ be the elasticity of consumer willingness to pay to nonverifiable investment, and define ϵ_a similarly. These are measures of the sensitiv-

ity of consumers' willingness to pay and operation costs to nonverifiable investment. Using them, the first order condition (9) can be rewritten as follows

$$\Gamma \frac{b(e^*)}{e^*}\epsilon_b + \gamma \frac{ca(e^*)}{e^*}\epsilon_a \leq 1,$$

with equality if $e^* = 0$. This condition says that the optimal level of nonverifiable investment depends on the type of investment and the relative sensitivity of benefits and costs. Henceforth we will assume that this expression is greater than one when $\Gamma = \gamma = 1$.

It follows that $e^* > 0$ when nonverifiable investments increase consumer surplus and reduce operation costs. But when cost cutting reduces consumer surplus ($\Gamma = -1$ and $\gamma = 1$) it may be optimal not to invest at all. Similarly, when higher quality increases life-cycle costs ($\Gamma = 1$ and $\gamma = -1$), increasing consumer surplus may not be worth the cost.

B.1.2 Public ownership

Conventional, unbundled provision With conventional provision (cp), operation is unbundled from investment and life-cycle costs are ignored when deciding how much to invest. The operator takes operation costs as given—they are predetermined by investment e^{cp} made by the builder—which are equal to

$$(1 - \gamma a(e^{\text{cp}}))c \cdot q^{\text{cp}} \cdot \overline{v}$$

Competition implies that the government can hire an operator for a fixed per-unit fee

$$P^{\text{cp}} = (1 - \gamma a(e^{\text{cp}}))c.$$

Now investments are made by the builder, who will ignore life-cycle operation costs. Nevertheless, the government does value consumer surplus, and if the builder invests e, then the surplus created by the implementation of nonverifiable investments equals $\Gamma b(e) \cdot q \cdot v$. Nash bargaining implies that the builder will get half the surplus, hence choose e to maximize

$$\frac{1}{2}\Gamma b(e) \cdot q \cdot v.$$

This implies that investment will be determined by the condition

$$\frac{1}{2}\Gamma \frac{b(e^{\text{cp}})}{e^{\text{cp}}}\epsilon_b \leq 1 \tag{10}$$

with equality if $e^{\text{cp}} > 0$. If $\Gamma > 1$, then the builder will invest. If, on the other hand, $\Gamma = -1$, $e^{\text{cp}} = 0$. Hnece:

Result 1 *With conventional provision life-cycle costs are ignored but consumer surplus is partially internalized.*

What will be the infrastructures' size q with conventional provision? Social surplus is

$$\overline{v} \cdot \left(\int_0^q D(q')dq' + \Gamma b(e^{\text{cp}})q \right) - \left[\mathscr{S}^{\text{cp}} + P^{\text{cp}} \right] \cdot q \cdot \overline{v}.$$

Hence, the government will set q^{cp} so that

$$D(q^{\text{cp}}) = I - \left[\Gamma b(e^{\text{cp}}) - (1-\gamma a(e^{\text{cp}}))c - e^{\text{cp}}\right].$$

Note that $q^{\text{cp}} \leq q^*$, because

$$\Gamma b(e^{\text{cp}}) - (1-\gamma a(e^{\text{cp}}))c - e^{\text{cp}} \leq \Gamma b(e^*) - (1-\gamma a(e^*))c - e^*.$$

With conventional provision the net marginal benefit created by nonverifiable investments cannot be greater than the surplus created when the planner maximizes social welfare.

Public bundling While somewhat uncommon, bundling can also be implemented with government ownership. Unlike conventional provision, the government hires only one firm; unlike a PPP, the government keeps ownership and thus control rigths.

With public bundling (pb) it is still the case that the firm cares only for life-cycle costs. But because she needs the government's acquiscence to implement nonverifiable investments, the bilateral surplus created by implementation is now

$$\left[\Gamma b(e) + \gamma a(e)c\right] \cdot q \cdot \overline{v}, \tag{11}$$

hence it includes the effect of implementation on consumer surplus and costs. Nevertheless, with Nash bargaining the concessionaire gets only half of the bilateral surplus created by implementation and investment is determined by the condition

$$\frac{1}{2}\left[\Gamma \frac{b(e^{\text{pb}})}{e^{\text{pb}}}\epsilon_b + \gamma \frac{ca(e^{\text{pb}})}{e^{\text{pb}}}\epsilon_a\right] \leq 1$$

with equality if $e^{\text{pb}} > 0$. Hence:

Result 2 *Public bundling makes the firm partially responsive to consumer surplus, but weakens the incentives to cut life-cycle costs.*

Before proceding, note that public bundling achieves the same allocation as a government that uses conventional provision but internalizes lifecycle costs.

B.1.3 A PPP

With a PPP (3p) the concessionaire fully internalizes life-cycle costs. Nevertheless, because her remuneration, call it $P^{3\text{p}}$, does not depend on consumer surplus, she maximizes

$$P^{3\text{p}} - \left[\mathscr{I} + (1-\gamma a(e))c\right].$$

Investment will be determined by the condition

$$\gamma \frac{ca(e^{3\text{p}})}{e^{3\text{p}}}\epsilon_a \leq 1, \tag{12}$$

with equality if $e^{3\text{p}} > 0$. If $\gamma = 1$, the concessionaire will invest to cut operation costs if ϵ_a is large enough; if $\gamma = -1$, it will minimize operation costs by choosing $e^{3\text{p}} = 0$. Hence:

Result 3 *With a PPP cost-cutting incentives are strong, but the concessionaire ignores consumer surplus.*

Private ownership allows the concessionaire to unilaterally implement cost-cutting investments and discard implementation of quality-enhancing investments, which increase life cycle costs. Thus, with a PPP there is no scope for bargaining and consumer surplus is ignored.

Last, note that, as with conventional provision, $q^{3p} \leq q^*$, for exactly the same reason.

B.1.4 Privatization

Bundling could also be implemented by privatizing the project. In a privatization ownership is permanently transferred to one or many private firms who obtain all their revenues fron consumers and bear all residual risk.

Liberalization with competition Suppose that the project is privatized and that firms can freely choose p, a price per unit sold. In equilibrium, there will be a market price p, so that $R(v) = pq$.

Assume first that competition is feasible. Competition will force the allocation to maximize consumer's willingness to pay

$$\left(\int_0^q D(q')dq' + \Gamma b(e)q\right) - pq$$

subject to

$$pq - \left[\mathscr{I} + (1-\gamma a(e))c\right] \cdot q = 0$$

Substituting the constraint into the objective function shows that a competitve market solves the same problem as the planner. Hence the following result:

Result 4 *Whenever competition is feasible, assets should be privatized and the market liberalized.*

Liberalization with monopoly Assume now, at the other extreme, an unregulated monopoly. He chooses e and q to maximize

$$(D(q) + \Gamma b(e)) \cdot q \cdot \overline{v} - \left[\mathscr{I} + (1-\gamma a(e))c\right] \cdot q \cdot \overline{v}.$$

The first order conditions are now

$$D(q^m) + q^m D'(q^m) + \Gamma b(e^*) - \left[\mathscr{I}^* + (1-\gamma a(e^*))c\right] = 0$$

and

$$\Gamma b'(e^*) + \gamma a'(e^*)c \leq 1,$$

with equality if $e^* > 0$.

An unregulated monopoly invests just as a social planner, because it can raise the price to appropriate the marginal increase in consumer surplus. Nevertheless, just like any monopolist, it produces too little—$q^m < q^*$.

Result 5 *An unregulated monopoly invests efficiently, that is $e^m = e^*$, but produces too little.*

A regulated monopoly Privatization usually comes with price regulation, an obligation to meet demand and a self-financing constraint. If the regulated price p^{r} is exogenous (as, for example, with a price cap), the monopolist chooses e to maximize

$$p^{\mathrm{r}} \cdot q \cdot \overline{v} - \left[\mathscr{I} + (1 - \gamma a(e))c\right] \cdot q \cdot \overline{v},$$

which implies that

$$\gamma \frac{ca(e^{\mathrm{r}})}{e^{\mathrm{r}}} \epsilon_a \leq 1.$$

This is exactly the same condition as in a PPP. A fixed price delinks the monopolist's optimization from consumer surplus, just as with a PPP. Indeed, the self-financing constraint implies that

$$p^{\mathrm{r}} = \left[\mathscr{I}^{\mathrm{r}} + (1 - \gamma a(e^{\mathrm{r}}))c\right],$$

exactly the same remuneration as with a PPP. Hence:

Result 6 *Privatization with regulation is akin to a PPP.*

Result 6 is important, because it indicates that incentives with regulated privatization differ little from a PPP—to some extent, a PPP is an alternative way of regulating. Thus, preference for a PPP must be based on other factors beyond incentives.

B.2 Efficient organizational form with a benevolent government

If competition is feasible, then liberalization achieves the first-best allocation. But if competition is unfeasible, the best form of organization depends on the relative sensitivities of consumer surplus and life-cycle costs to nonverifiable investments, as measured by ϵ_b and ϵ_a. We study this dependence in what follows.

B.2.1 No tradeoff between consumer surplus and cost cutting

Consumer surplus is insensitive to cost-cutting investments Assume that cost-cutting investments ($\gamma = 1$) have little impact on consumer surplus. Then ϵ_b is small, $\frac{b(e^{3\mathrm{p}})}{e^{3\mathrm{p}}}\epsilon_b \approx 0$. Thus

$$\Gamma \frac{b(e^{3\mathrm{p}})}{e^{3\mathrm{p}}} \epsilon_b + \frac{ca(e^{3\mathrm{p}})}{e^{3\mathrm{p}}} \epsilon_a \approx \frac{ca(e^{3\mathrm{p}})}{e^{3\mathrm{p}}} \epsilon_a = 1, \tag{13}$$

and $e^{3\mathrm{p}} \approx e^*$. Thus:

Result 7 *When consumer surplus is insensitive to nonverifiable investments, then a PPP is close to socially optimal and substantially better than conventional provision or public bundling.*

To see why a PPP is substantially better than public ownership, we compare the first order conditions. With a PPP:

$$\frac{ca(e^{3\mathrm{p}})}{e^{3\mathrm{p}}} \epsilon_a = 1;$$

with public bundling:

$$\frac{1}{2} \frac{ca(e^{\mathrm{pb}})}{e^{\mathrm{pb}}} \epsilon_a \approx \frac{1}{2} \left(\Gamma \frac{b(e^{\mathrm{pb}})}{e^{\mathrm{pb}}} \epsilon_b + \frac{ca(e^{\mathrm{pb}})}{e^{\mathrm{pb}}} \epsilon_a \right) = 1.$$

and with conventional provision:

$$\frac{1}{2}\Gamma\frac{b(e^{\text{cp}})}{e^{\text{cp}}}\epsilon_b \approx 0 < 1.$$

The comparison indicates that $0 = e^{\text{cp}} < e^{\text{pb}} < e^{\text{3p}} \approx e^*$. Thus, when ϵ_b is small the main impact of public ownership is to weaken incentives, either because the government appropriates part of the reduction in costs (public bundling) or plainly ignores them (conventional provision). A PPP, by contrast, allows the concessionaire to implement investments without bargaining and to keep all the gains from cost cutting.

It is also apparent that public bundling is better than conventional provision, which yields little or no cost cutting. Nevertheless, Result 7 highlights that bundling is not enough, because public ownership weakens cost cutting even when construction and operation are bundled. Thus, the advantage of a PPP does not stem so much from bundling, which the government could replicate, but from private ownership.

All said, the case for PPPs is still not overwhelming when ϵ_b is small for, as we saw before, regulated privatization provides similar incentives:

Result 8 *If consumer surplus is insensitive to nonverifiable investments, a PPP competes with regulated privatization.*

The result confirms that the case for PPPs is not clear cut even when cost cutting is all that matters. Other characteristics of the environment, which we have not modeled, will determine whether a PPP or regulated privatization is better. For example, it is relatively easy to monitor the quality or availability of a highway or an airport runway and fix them contractually. But a PPP has probably an edge over privatization because it allows the government to retain planning authority and, as transferring the asset at the end of the concession is feasible, an auction is more effective to extract rents.

Life-cycle costs are insensitive to nonverifiable investments We now study the opposite case, when investments have little impact on life-cycle costs. Then ϵ_a is small and there is no investment with a PPP, because

$$\gamma\frac{ca(e)}{e}\epsilon_a \approx 0 < 1.$$

Moreover,

$$\Gamma\frac{b(e)}{e}\epsilon_b + \gamma\frac{ca(e)}{e}\epsilon_a \approx \Gamma\frac{b(e)}{e}\epsilon_b.$$

Now if $\Gamma = -1$,

$$e^{\text{3p}} = e^{\text{cp}} = e^{\text{pb}} = e^* = 0$$

Thus, the following result follows:

Result 9 *If cost cutting reduces consumer surplus but life-cycle costs are insensitive to nonverifiable investments, then organizational form is not important.*

By contrast, if $\Gamma = 1$, public ownership allows partial internalization of consumer surplus and stimulates some investment. And because ϵ_a is small, there is not much difference between conventional provision and public bundling, because

$$\frac{1}{2}\left(\Gamma\frac{b(e)}{e}\epsilon_b - \frac{ca(e)}{e}\epsilon_a\right) \approx \frac{1}{2}\Gamma\frac{b(e)}{e}\epsilon_b$$

and internalization of life-cycle costs is of little value. Hence:

Result 10 *If cost cutting increases consumer surplus but life-cycle costs are insensitive to nonverifiable investments, then public ownership is better than a PPP and there is not much difference between conventional provision and public bundling.*

B.2.2 Both consumer surplus and life-cycle costs respond in similar magnitude

When both consumer surplus and life-cycle costs respond to nonverifiable investment and both effects are of similar magnitude, the optimal organizational form depends on the type of investment.

Cost-cutting investments Consider first $\Gamma = \gamma = 1$. If both consumer surplus and life-cycle costs are affected in by nonverifiable investment, then the concessionaire chooses $e^{3\text{p}}$ such that

$$\frac{ca(e^{3\text{p}})}{e^{3\text{p}}}\epsilon_a = 1;$$

with conventional provision e^{cp} will be such that

$$\frac{1}{2}\frac{b(e^{\text{cp}})}{e^{\text{cp}}}\epsilon_b = 1;$$

and with public bundling, e^{pb} will be such that

$$\frac{1}{2}\left(\frac{b(e^{\text{pb}})}{e^{\text{pb}}}\epsilon_b + \frac{ca(e^{\text{pb}})}{e^{\text{pb}}}\epsilon_a\right) = 1.$$

Now if the impact of e on consumer surplus and life-cycle costs is of similar order of magnitude, any of the three alternantives will yield investments below the social optimum. However, the following result follows:

Result 11 *If both consumer surplus and life-cycle costs are affected in similar magnitude by nonverifiable investment, and cost-cutting investments increase consumer surplus, then a PPP is better than conventional provision and not much different from public bundling.*

As we already know, with a PPP the concessionaire ignores the effect of investments on consumer surplus but fully internalizes the effect on life cycle costs. With conventional provision, on the other hand, the benevolent government ignores life-cycle costs but fully internalizes the effect on consumer surplus. Nevertheless, public ownership implies that the builder gets only half of the increase of consumer surplus, thus further weakening incentives.

With public bundling the firm internalizes life-cycle costs but looses half of the surplus because of public ownership. But, on the other hand, the firm internalizes part of consumer surplus. Thus, public bundling is clearly better than conventional provision, but similar to a PPP.

Consider next cost-cutting investments such that $\Gamma = -1$ and $\gamma = 1$. Now both terms in

$$-\frac{b(e)}{e}\epsilon_b + \frac{ca(e)}{e}\epsilon_a \approx 0 < 1$$

are of similar magnitude, hence $e^* = 0$. Hence:

Result 12 *If both consumer surplus and life-cycle costs are affected in similar magnitude by nonverifiable investment, and cost-cutting investments reduce consumer surplus, then public ownership is better than a PPP and public bundling has no sizable advantage over conventional provision.*

Quality-enhancing investments If $\Gamma = 1$ and $\gamma = -1$ and

$$\frac{b(e)}{e}\epsilon_b - \frac{ca(e)}{e}\epsilon_a \approx 0 < 1$$

and $e^* = 0$. Then:

Result 13 *If both consumer surplus and life-cycle costs are affected in similar magnitude by nonverifiable investment, then a PPP is optimal and similar to public bundling. Conventional provision leads to overinvestment in quality.*

Because

$$\frac{ca(e)}{e}\epsilon_a \approx 0 < 1$$

$e^{3p} = 0$. By contrast, with ϵ_b large conventional provision implies that

$$\frac{1}{2}\frac{b(e^{cp})}{e^{cp}}\epsilon_b = 1$$

hence $e^{cp} > 0$.

C *How*? PPPs and public finance

Assume it has been decided that a project should be done as a PPP. How should the optimal intertemporal contract be structured and allocated? In this section we summarize the findings in EFG (2008) on the basic public finance of PPPs. To proceed we now assume that the concessionaire is risk averse, hence u is concave; and that individual demand is perfectly inelastic and each consumer is willing to pay \$1 for consuming one unit of service. Hence v denotes aggregate willingness to pay in present value. More important, for most of this section we will assume that $\zeta > 0$—financing the concessionaire with subsidies is more expensive than financing her directly with user fees.

C.1 The planner's problem

We begin by restating the planner's problem: maximize

$$\int [\mathrm{CS}(v) + \mathrm{PS}(v)]\, f(v)\, dv, \tag{14}$$

subject to the concessionaire's participation constraint,

$$\int u(\mathrm{PS}(v))\, f(v)\, dv \geq u(0).$$

To maximize (4), the planner chooses how much user fee revenue and subsidy the concessionaire receives in each state v. Hence

$$\mathrm{PS}(v) = R(v) + S(v) - \mathscr{I}. \tag{15}$$

Note that by "subsidy" we mean any cash transfer from the government to the private concessionaire. It may be an up-front payment (in which case $S(v)$ is the same for all v), or a cash transfer made over time, contingent on v, to supplement revenue (a so-called 'minimum revenue guarantee').

Since the concessionaire receives $R(v)$ in state v, the government receives $v - R(v)$ and we have $0 \leq R(v) \leq v$. If the term of the concession is finite and $v - R(v) > 0$, these funds are used to reduce distortionary taxation elsewhere in the economy. Moreover, assuming that willingness to pay is positive at all points in time, we have that $R(v) = v$ only when the concession lasts forever. Thus, consumer surplus is now

$$\begin{aligned} \mathrm{CS}(v) &= [v - R(v) - (1+\lambda)S(v)] + \lambda[v - R(v)] && \text{(16a)} \\ &= (1+\lambda)[v - R(v) - S(v)]. && \text{(16b)} \end{aligned}$$

The first term in the r.h.s. of (16a), $v - R(v) - (1+\lambda)S(v)$, is the difference between users' willingness to pay in state v and the total amount transferred to the concessionaire, where the cost of the subsidy is increased by the tax distortion required to finance it. The term $v - R(v)$ is total revenue collected by the government (after the end of the concession), so the second term in the r.h.s. of (16a) corresponds to the reduction in distortionary taxes due to this increased revenue.

Substituting (15) and (16b) in (4) shows that maximizing the planner's objective function (4) is equivalent to maximizing

$$-(1+\lambda)\int [R(v) + S(v)]f(v)dv.$$

and therefore to minimizing

$$\int [R(v) + S(v)]f(v)dv. \tag{17}$$

Where we have dropped, $\mathscr{I}$ and $(1+\lambda)v$ from the objective function because they do not depend on the planner's choice variables, R and S, and where we have used that $1 + \lambda > 1$. The planner's program can be rewritten as

$$\begin{aligned} &\min_{\{R(v),S(v)\}} \int [R(v) + S(v)]f(v)dv. && \text{(18a)} \\ \text{s.t.} \quad &\int u(R(v) + S(v) - I)f(v)dv \geq u(0), && \text{(18b)} \\ &0 \leq R(v) \leq v, && \text{(18c)} \\ &S(v) \geq 0, && \text{(18d)} \end{aligned}$$

C.2 Irrelevance result

Before deducing the optimal contract,. it is useful to address the common claim that a PPP is desirable because it relieves the public budget by substituting private finance for distortionary tax finance.[92] Does this argument make the case for PPPs?

It follows from the objective function (17) that the per-dollar cost of paying the concessionaire with user fee revenues or subsidies is the same. Thus, social welfare only depends on *total* trans-

[92] An even bolder claim is that $\mathscr{I}$ public funds are permanently liberated with a PPP. But setting up the problem in present value terms immediately exposes this fallacy—the concessionaire must recover its investment by receiving future payments.

fers $\mathcal{T}(v) = R(v) + S(v)$ to the concessionaire, not on the partition between subsidies and user fee revenue. This is the fundamental insight behind the following result:

Proposition 1 (Irrelevance of the cost-of-funds argument) *Any combination of user fee and subsidy schedules that satisfies constraints (18c) and (18d) and such that $\mathcal{T}(v) = \mathcal{I}$ for all v solves the planner's program (18a)–(18d).*

Proof See EFG (2008).

What is the economics of this result? The standard reasoning in favor of PPPs points out that subsidies are an expensive source of finance, because they are financed with distortionary taxes. Yet the multiplicity of optimal subsidy-sales revenue combinations indicates that distortionary taxation ($\lambda > 0$) is not sufficient to prefer private provision. One solution is $R(v) \equiv 0$ and $S(v) \equiv \mathcal{I}$. Another solution is that the concessionaire invests $\mathcal{I}$, collects user-fee revenues equal to $\mathcal{I}$ in present value, and no subsidies are paid.[93] In addition, there is a continuum of combinations where the government provides a partial subsidy.

The intuition for this result is that if the user fee revenue collected by the concessionaire increases by \$1, the government has to levy \$1 in additional taxes to replace this transfer, which costs society $1+\lambda$. This is the same cost that society bears when paying \$1 in additional subsidies. Hence, at the margin the opportunity cost of user fee revenue or subsidizing the concessionaire is exactly the same. The rich set of optimal combinations of state-contingent subsidies and concession terms reflects that user fees and subsidies are perfect substitutes in the planner's objective function.

A similar argument shows that the planner will satisfy the concessionaire's participation constraint with equality. An additional dollar in the concessionaires pocket increases social welfare by 1, but costs $1+\lambda$ to users. Since $1+\lambda > 1$, the planner chooses not to provide rents to the concessionaire. Last, note that the optimal contract provides full insurance to the concessionaire.

C.3 The optimal contract with inefficient subsidies

C.3.1 The planner's problem

An additional advantage of PPPs is that they reduce the sums flowing through the public budget, reducing the inefficiencies associated with subsidy transfers. In this section we derive the optimal contract when subsidy financing is less efficient than user-fee financing.

Formally, introducing ζ implies that the term $(1+\lambda)S(v)$ in (16a) must be replaced by $(1+\lambda)(1+\zeta)S(v)$—the inefficient subsidy transfer increases the magnitude of the tax distortion. The planner's program now is

$$\min_{\{R(v),S(v)\}} \int \{\lambda R(v) + [(1+\lambda)(1+\zeta) - 1]S(v)\} f(v)\,dv. \tag{19a}$$

$$\text{s.t.} \qquad \int u(R(v) + S(v) - \mathcal{I}) f(v)\,dv \geq u(0), \tag{19b}$$

$$0 \leq R(v) \leq v, \tag{19c}$$

$$S(v) \geq 0. \tag{19d}$$

It is apparent from (19a) that if $\zeta > 0$, user fees are a more efficient means of compensating the concessionaire. The cost to society of one dollar in user fees is λ, while a subsidy costs $(1+\lambda)(1+\zeta) -$

[93] This is only possible if $v_{\min} \geq I$, for otherwise the project cannot be financed with user fees in all states.

1. Of course, $\zeta > 0$ is *not* a sufficient argument against subsidizing projects, for the project's social value may exceed $\mathscr{I}$, and user fee revenue may be insufficient to compensate the concessionaire in low demand states. But, as we will see next, $\zeta > 0$ determines the structure of the optimal risk-sharing contract.

C.3.2 Optimal risk-sharing contract: overview

The tradeoff faced by the planner when $\zeta > 0$ is the following: On the one hand, she would like to utilize user fee revenues as far as possible to compensate the concessionaire, in order to avoid paying subsidies. On the other hand, using only user fees may expose the concessionaire to excessive risk, and an efficient contract would insure against low demand states through subsidies.

Figure 1 shows how the trade off is resolved optimally when $v_{\min} < \mathscr{I} < v_{\max}$ (i.e., there are some states of demand in which user fee revenues is smaller than $\mathscr{I}$ while there are others in which revenues are larger than $\mathscr{I}$). The horizontal axis plots the support of v while the vertical axis shows the total revenue received by the concessionaire in each state, $R(v) + S(v)$.

In the next section we show that the optimal contract is characterized by two thresholds, a minimum revenue guarantee m and a revenue cap M. These thresholds, in turn, define three types of demand states. In *low demand* states $v < m$, $R(v) = v$ and $S(v) = m - v$. Hence the concession lasts forever and the concessionaire receives a subsidy to attain the guaranteed minimum revenue m. By contrast, in *high demand* states $v > M$ and $R(v) = M$. Thus the concession ends in finite time and the government gets $v - M$. The remaining cases, which we call *intermediate demand* states, are such that $m \leq v \leq M$, $R(v) = v$ and $S(v) = 0$. In these states the concession lasts indefinitely, but no subsidies are paid.

C.3.3 A taxonomy of demand states

To derive the optimal contract, note that in state v the planner will only resort to subsidies after exhausting user fees—otherwise, it could slightly reduce subsidy payments, which would save $(1 + \lambda)(1 + \zeta) - 1$; and increase $R(v)$, which would cost only λ. Thus:

$$S(v) > 0 \Longrightarrow R(v) = v,$$

or equivalently

$$R(v) < v \Longrightarrow S(v) = 0.$$

Now let $\mu > 0$ denote the multiplier of the concessionaire's participation constraint (19b).[94] The FOC with respect to $R(v)$ for a state v such that the term of the concession is finite leads to

$$u'(R(v) - \mathscr{I}) = \frac{\lambda}{\mu}. \tag{20}$$

While the FOC with respect to $S(v)$ for a state where subsidies are paid leads to

$$u'(v + S(v) - \mathscr{I}) = \frac{(1 + \lambda)(1 + \zeta) - 1}{\mu}, \tag{21}$$

where in both cases we have used that user fee financing dominates subsidy financing. Define m

[94] Note that the participation constraint will hold with equality because $1 + \lambda > \alpha$, hence $\mu > 0$.

and M via

$$u'(m-\mathscr{F}) = \frac{(1+\lambda)(1+\zeta)-1}{\mu}, \tag{22}$$

$$u'(M-\mathscr{F}) = \frac{\lambda}{\mu}, \tag{23}$$

and define $\bar{\zeta}$ via:[95]

$$1+\bar{\zeta} = \frac{(1+\lambda)(1+\zeta)-1}{\lambda}.$$

Since $\zeta > 0$ we have $m < M$ and

$$u'(m-\mathscr{F}) = (1+\bar{\zeta})\,u'(M-\mathscr{F}),$$

It follows from (20) and (23) that in states with $v > M$ no subsidies are paid out and the concession lasts until the concessionaire collects M in present value. The government, on the other hand, collects $v - M$ after the concession ends. Thus, in high demand states the concessionaire's revenue is capped by M and the term of the concession is variable.[96]

Similarly, from (21) and (22) we have that a subsidy equal to $m - v$ is paid in states with $v < m$. Therefore, in low demand states the concession lasts indefinitely and the concessionaire receives a minimum revenue guarantee.

Finally, there is a third class of states of demand such that $m \le v \le M$. In these states the concession lasts indefinitely, for otherwise they would be high demand states. But no subsidies are paid out by the government, for otherwise they would be low demand states. It follows that $R(v) = v$ and $S(v) = 0$ in this class.

We summarize this characterization in the following proposition:

Proposition 2 (A taxonomy of demand states) *The optimal contract is characterized by a minimum revenue guarantee, m, and revenue cap, M, with $m < M$, as follows:*

1. *If $M < v$, the concessionaire collects M in present discounted user fees while the government collects the remaining $v - M$. No subsidies are paid and the concession term is finite. These are high demand states.*

2. *If $m \le v \le M$, the concession lasts indefinitely and no subsidies are paid. Total revenues accrued to the concessionaire in present value equals v and the government budget is unaffected by the concession. These are intermediate demand states.*

3. *If $v < m$, the concession lasts indefinitely and the government grants a subsidy of $m - v$ to the concessionaire. These are low demand states.* ∎

Let us comment on the economics of this taxonomy. In any state with a finite concession term, the social opportunity cost of the last dollar received by the concessionaire is λ; this justifies equalizing the concessionaire's revenue across high demand states by fixing a revenue cap M. On the

[95] Note that $\bar{\zeta} = (1+\lambda)\zeta/\lambda$. It follows that $\bar{\zeta} > 0 \iff \zeta > 0$ and $\bar{\zeta} < 0 \iff \zeta < 0$.

[96] If demand grows at a the same rate in all demand states, this implies that higher values of v correspond to shorter concession terms. This is not necessarily true with more general demand schedules.

other hand, in any low demand state the last dollar paid to the concessionaire comes from a subsidy and costs society $(1+\lambda)(1+\zeta)-1$. Again, this justifies equalizing revenue across low demand states at the minimum revenue guarantee $m < M$.

As can be seen from Figure 1, the difference between λ and $(1+\lambda)(1+\zeta)-1$ introduces a wedge $M-m$ that leads to the emergence of intermediate demand states. To see the intuition, consider one such state, $\widetilde{v}$. It is straightforward to obtain the following inequalities

$$\frac{1}{1+\bar{\zeta}} < \frac{u'(\widetilde{v}-\mathscr{I})}{u'(m-\mathscr{I})} < 1 < \frac{u'(\widetilde{v}-\mathscr{I})}{u'(M-\mathscr{I})} < 1+\bar{\zeta}.$$

These inequalities imply that the concessionaire's marginal utility evaluated at $\widetilde{v}-\mathscr{I}$ is smaller than the marginal utility at m, but higher than the marginal utility at M. In other words, the shadow value of the last dollar received by the concessionaire in state $\widetilde{v}$ is too low to warrant a subsidy, as well as too high to warrant a revenue cap. Consequently, the concession lasts forever, but no subsidies are paid.

C.3.4 A taxonomy of projects

To complete the characterization of the optimal contract, we show how m and M are determined, which leads to a taxonomy of projects.

Consider first the case where user fees can finance the project in all demand states, that is, $v_{\min} \geq \mathscr{I}$. The optimal contract sets $R(v) = M = \mathscr{I} \leq v$ for all v, and the concessionaire receives full insurance—all states are high demand states when $v_{\min} \geq \mathscr{I}$.[97] To see that this contract is optimal, note first that it is clearly feasible. Moreover, no contract can give less than $\mathscr{I}$ on average to the concessionaire, for then the participation constraint would not hold; and had the concessionaire been forced to bear risk, he would have required more than $\mathscr{I}$ on average.

Consider next the case where user fees are never large enough pay for the project, that is, $v_{\max} < \mathscr{I}$. Then $m = \mathscr{I}$. For if $m > \mathscr{I}$, all states are low demand, and the concessionaire's participation constraint holds with slack, which cannot be optimal. And if $m < \mathscr{I}$, the concessionaire's participation constraint cannot be satisfied, because revenue in all demand states is smaller than $\mathscr{I}$. It follows that $m = \mathscr{I}$ while now M is irrelevant. Thus, the optimal contract subsidizes the concessionaire in all demand states to ensure that total revenue is equal to the cost of the project.

We refer to a project with $v_{\min} \geq \mathscr{I}$ as a high demand *project*, while one with $v_{\max} < \mathscr{I}$ is a low demand project, and summarize these results in the following proposition.

Proposition 3 (Optimal contract for high and low demand projects) *The optimal contract for high and low demand projects specifies that $R(v)+S(v) = \mathscr{I}$ for all v. Given demand realization v, the government collects $v-\mathscr{I}$ in each state if the project is high demand, while it pays a subsidy of $\mathscr{I}-v$ in each state if the project is low demand.*

The economics of Proposition 3 should be apparent. The social cost of transferring an additional dollar to the concessionaire is λ in all states when a project is high demand, and full insurance immediately follows. In a low demand project the social cost of transferring an additional dollar to

[97] The formal proof is similar to that of Proposition 1. Also note that from $m < M$ it follows that no subsidies are paid out for all feasible values of m, and therefore this threshold is irrelevant to pin down the optimal contract.

the concessionaire is higher (i.e., $(1+\lambda)(1+\zeta)-1$), but is also the same across states and therefore full insurance is optimal as well.

As we can see from Figure 1, the structure of the optimal contract is different for projects such that $v_{\min} < \mathscr{I} \leq v_{\max}$, for a contract that gives full insurance to the concessionaire ($m = M = \mathscr{I}$) is no longer optimal. To see this, consider decreasing m to $\mathscr{I} - \Delta m$, and using the funds to increase M to $\mathscr{I} + \Delta M$. Lowering the minimum revenue guarantee frees up resources $F(\mathscr{I})\Delta m$ in expected value, and this can be used to finance an increase in M of $F(\mathscr{I})\Delta m/(1-F(\mathscr{I}))$.[98] Society is made better off in the process, since each dollar saved in guarantees is $1+\bar{\zeta} > 1$ times more valuable than a dollar of foregone user fee revenue. Thus it follows from (19a) that the planner's objective function improves by $(1+\lambda)\zeta F(\mathscr{I})\Delta m$. Increased risk reduces the concessionaire's expected utility by an expression on the order of $(\Delta m)^2$. It follows that the optimal values of m and M satisfy $m < \mathscr{I} < M$.

C.3.5 Comparative statics

Comparative statics for high and low demand projects are straightforward. When $\mathscr{I}$ rises, the planner must transfer more revenue to the concessionaire. On the other hand, changes in $\bar{\zeta}$ or in the concessionaire's degree of risk aversion have no effect on the optimal contract.

By contrast, as we show in EFG (2008), in an intermediate demand project both an increase in $\bar{\zeta}$ or a fall in the concessionaire's degree of risk aversion increases the wedge between the minimum revenue guarantee m and the revenue cap M. Moreover, the risk premium demanded by a concessionaire with decreasing absolute risk aversion grows with $\mathscr{I}$, but does not change if absolute risk aversion is constant.

C.3.6 An application: Minimum income guarantees and revenue sharing

Minimum income guarantees are routine in many types of PPPs. However, most real world contracts have a fixed term and therefore do not follow the prescriptions laid out here. These contracts would be closer to the optimal contract if their durations were longer in low demand states, when guarantees are paid out. Thus, real world contracts pay excessive guarantees in low demand states.

Real world profit and revenue sharing agreements also do not coincide with the revenue cap that characterizes the optimal contract. When governments impose profit sharing arrangements, they split revenues in excess of a given threshold with the concessionaire in fixed proportions. By contrast, Proposition 3 suggests assigning all the revenue in excess of a given threshold to the government—the windfall profits tax rate should be 100%.

More generally, the rationale behind real-world guarantees and revenue sharing schemes is to reduce the risk borne by the concessionaire. By contrast, the rationale behind the optimal contract in Proposition 3 is to optimally trade off insurance on one hand, and the use of user fees and subsidies on the other. This is why the concession lasts indefinitely when subsidies (i.e., guarantees) are granted; the term is variable in high demand states; and the concessionaire's revenue in high demand states is higher than in low demand states.

C.4 Implementation

The informational requirements needed to implement the optimal contract might seem formidable, but somewhat surprisingly, this is not the case. We show next how to implement the optimal con-

[98] Since this is an intermediate demand project, $0 < F(I) < 1$.

tract with a competitive auction when the planner knows neither $\mathscr{I}$ nor firms' risk aversion.

C.4.1 High and low demand projects

Consider first a high demand project. Then an auction where the bidding variable is the total present value of user fee revenues (PVR) collected by the concessionaire, β, implements the optimal contract. This follows from noting that rents will be dissipated in a competitive auction, so that β will satisfy:

$$\int u(\beta - \mathscr{I}) f(v) dv = u(0). \tag{24}$$

Hence the winning bid will be $\beta = \mathscr{I}$, which corresponds to the optimal contract derived in the preceding section. Denote by $T(v)$ the time it takes for user fee revenue accumulated in state v to attain $\mathscr{I}$. The concession term is shorter when demand is high, that is, when $T(v)$ is small.[99] The concessionaire bears no risk because users pay him the same amount in all states of nature.[100] Furthermore, the planner can implement the optimal contract using a PVR auction even if she does not know $\mathscr{I}$, the density $f(v)$ or the concessionaire's degree of risk aversion. All the planner needs to know is that the project can finance itself in all states of demand, that is, that $v_{\min} \geq \mathscr{I}$.[101] Furthermore, moving from a fixed term contract to the optimal contract can lead to substantial welfare gains.[102]

Consider next a low demand project. A PVR auction will implement the optimal contract in this case as well, as long as the government subsidizes the difference between the winning bid and the present value of user fees collected. In this case firms end up bidding on a minimum income guarantee and the winning bid ensures a total revenue of $\mathscr{I}$. Informational requirements are modest again, since the planner only needs to know that $v_{\max} < \mathscr{I}$, and be able to verify revenue in each state. Note that the concession lasts forever in this case. We summarize both cases reviewed so far as follows:

Proposition 4 (High and low demand projects) *The optimal contract can be implemented with a PVR auction, or a simple extensions thereof, for both high and low demand projects. Furthermore, bidders reveal $\mathscr{I}$ in the auction and there is no need to know f or u.* ∎

Application: Evaluating least subsidy auctions Low demand projects are sometimes awarded to the firm that makes a bid for the smallest subsidy. That is, the government sets a fixed concession term T and a user fee p, and firms bid the subsidy they require to build, operate and maintain the project.

Assume that cumulative user fee revenue accrued by time t in state v is equal to $\gamma(t,v)v$, with γ strictly increasing in t, and $\lim_{t\to\infty}\gamma(t,v) = 1$. Assuming a competitive auction, so that ex-ante rents are dissipated, the winning bid S then satisfies:

$$\int u\left(\gamma(T,v)v + S - \mathscr{I}\right) f(v) dv = u(0),$$

[99] As noted in footnote 96, this requires that demand grows at the same rate in all states.

[100] Uncertainty in $\mathscr{I}$ which may be important in some projects, cannot be eliminated with a variable term contract.

[101] This case is considered in EFG (2001).

[102] Depending on the degree of risk aversion and revenue uncertainty, EFG (2001) find welfare gains between 16 and 64% of the upfront investment.

which means that the concessionaire will be forced to bear risk.[103] It follows that

$$S > \mathscr{I} - \int \gamma(T, v) v f(v) dv,$$

and since $\gamma(T, v) \leq 1$ we conclude that

$$S > \mathscr{I} - \mu_v,$$

where μ_v is the mean of $f(v)$.

By contrast, with a PVR auction the equilibrium outcome satisfies $S(v) = \mathscr{I} - v$ and expected expenditures are equal to:

$$\mathrm{E}[S] = \mathscr{I} - \mu_v.$$

With a minimum subsidy auction the subsidy is the same in all states of demand, which forces the concessionaire to bear risk. By contrast, the optimal contract features state-contingent subsidies that ensure that the concessionaire bears no risk. This leads to the somewhat counterintuitive result that the average subsidy paid out with a PVR auction is lower than the winning bid in a lowest-subsidy auction. The concessionaire is forced to bear risk in the latter case, therefore demanding higher revenue on average, and a higher subsidy.

Proposition 5 (Sub-optimality of least subsidy auctions) *A least-subsidy auction of a fixed-term concession is not optimal. Furthermore, for low demand projects this auction does not minimize the average subsidy paid out by the government.*

C.4.2 The general case

Next we consider the case where the planner does not know if the project is high, intermediate or low demand. We also assume that the planner does not know firms' risk aversion, but does know the probability density $f(v)$.[104] We show next how to implement the optimal contract with a simple scoring auction.

Proposition 6 (Optimality of the two-threshold auction) *The following two-threshold, scoring auction implements the optimal contract:*

- *The government announces the probability density of expected discounted user fee revenue flow from the project, $f(v)$, and the parameter $\bar{\zeta}$ that summarizes the wedge between the shadow cost of public funds and subsidies.*
- *Firms bid on the minimum revenue guarantee, m, and the cap on their user fee revenue, M.*
- *The firm that bids the lowest value of the scoring function*

$$W(M, m) = M(1 - F(M)) + \int_0^M v f(v) dv + (1 + \bar{\zeta}) \int_0^m (m - v) f(v) dv \tag{25}$$

wins the concession.

[103] Note that $\lim_{t\to\infty} \gamma(t, v) = 1$ and $v_{\min} < v_{\max}$ imply that $\gamma(T, v) v$ has to vary with v.

[104] The government should be as informed about demand as third parties, because it either provides the service directly or it must compare the PPP with unbundled provision. Furthermore, substantial public planning is needed to design most PPP projects, and this requires an assessment of demand.

Proof Since all firms are identical, the winning bid of the competitive auction minimizes the scoring function subject to firms' participation constraints. And since the scoring function is equal to the planner's objective function, where we use the fact that the optimal contract is characterized by thresholds m and M, it follows that the winning bid maximizes the planner's objective function subject to the firm's participation constraint, thereby solving the planner's problem. ∎

What is the intuition underlying this result? Note first that the planner's objective function does not require knowledge of $\mathscr{I}$. The objective function only depends on the probability distribution of the present value of revenue that the project can generate and the distortions associated with government expenditures, as summarized by $\bar{\zeta}$. By awarding the PPP to the bidder that maximizes his objective function, and assuming competitive bidding, the planner induces the concessionaire to solve society's problem without knowing the cost of the project or the firms' degree of risk aversion.

In the case of a high demand project, the two-threshold auction is equivalent to a PVR auction. If all states have high demand, any bid with $M = \mathscr{I}$ and $m \leq \mathscr{I}$ will win the auction. No subsidies are paid out and the concession term is shorter if demand is higher. Similarly, in the case of a low demand project, a bid with $m = \mathscr{I}$ and $M \geq \mathscr{I}$ wins the concession, since this time the upper threshold is irrelevant. In this case the two-threshold auction reduces to the extension of the PVR auction described above. However, the two-threshold auction is more general than a PVR auction, as it can be used for intermediate demand projects or, more importantly, for projects where the planner does not know whether the project is low, intermediate or high demand.