What Should Governments Buy from the Private Sector —Assets or Services?*

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Abstract

Public–private partnerships (PPPs) are one of the fastest growing mechanisms for delivery of public services in both developing and developed economies. The defining feature of a PPP is that the government buys services whereas in a conventional arrangement the government buys or builds a physical asset. In this paper we provide a model that gives a clear and intuitive insight into the question of when a government should opt for a PPP and when it should stick with conventional procurement. An implication of the model is that comparisons of the conventional public model with PPPs suffer from sample selection bias. Keywords: Privatization, Public–Private Partnerships, Public Finance Initiative, Contracts, Procurement. JEL Classification: D82, H11, H57, L33.

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1 Introduction

Over the last thirty years governments around the world have made increasing use of the private sector in the delivery of services that were traditionally provided by the public sector. The primary wave of this privatization program was characterized by the full transfer of publicly owned enterprises to the private sector (often termed *full privatization*). Characteristically, these private sector operations tend to sell directly to the personal and corporate sectors. A large body of literature now strongly supports the view that such full transfers of ownership improve both efficiency and profitability.[1]

Now a second wave of privatization, developing mainly in the last fifteen years, is "beginning to sweep the world" (IMF (2004)). These transfers do not involve full privatization. Instead the government retains a central role in procurement and is usually the initial (and generally final) purchaser. However, the government purchases a service rather than physical assets. The assets are designed, built, and operated by the private sector. The terminology used by most international organizations (e.g. World Bank, IMF, United Nations) and governments for these arrangements is *public–private partnerships* (*PPPs*).[2]

The global growth of PPPs is impressive. In the period from 1990 to 2001 nearly 2,500 infrastructure projects in developing countries involved private participation, with a combined value of $750 billion (Harris (2003)). A large proportion of these were PPPs, although the impact differs between sectors. Oppenheimer and MacGregor (2004) estimate that between 1984 and 2002, 82% of all water projects and 92% of all transport projects were PPPs, but only 9% of energy and 3% of telecommunications projects involved PPPs. 49% of this investment has been in Latin America and 40% in East Asia.

Many OECD and other developed countries (e.g. Australia, Canada, Finland, Germany, Greece, Italy, Japan, Netherlands, Portugal, Spain, United Kingdom, and United States) and several transition countries (e.g. Czech Republic, Hungary, and Poland) have well-established PPP structures (see IMF (2004)). Furthermore, there is evidence that PPPs are developing particularly quickly at the sub-national level. Torres and Pina (2001) report that 30% of all services provided by the larger EU sub-national governments are delivered through PPPs.

[1] See, for example, the survey by Megginson and Netter (2001). Note, however, privatization transfers tend not to take place at market value, and this has implications for future pricing policy. See Grout, Jenkins, and Zalewska (2004).

[2] See Grout (1997) for an early discussion of the Public Finance Initiative (see also Grout and Stevens (2003)).

Although PPPs are particularly common in the delivery of infrastructure they are widespread in most public services. For instance, in many countries, including Canada and the UK, air traffic control is now privately owned and provided.[3] Government funding for science and technology research is increasingly based on PPPs (cf. Stiglitz and Wallsten (2000)). In 2001 there were 151 privately built and managed prisons in the US, providing incarceration services for a total capacity of 119,023 prisoners.[4] The US industry leader in the private management of public "contract" schools now manages and provides education services in 136 public schools attended by 75,000 students,[5] and so on.

The IMF defines a typical PPP as a *DBFO* (design-build-finance-operate) structure. Many different acronyms have been used to describe various PPP structures.[6] The central identifying feature of all these structures is that the same private sector firm or consortium builds the physical asset, operates the asset it has built and sells the service to the government. We take this as the defining feature of a PPP. PPPs contrast with conventional procurement models, i.e. those where the government buys or builds a physical asset and, in a separate arrangement, either operates the asset itself or contracts with a separate service provider to operate the asset and to supply the service to the government. The fundamental distinction is that in a PPP arrangement the government buys services whereas in a conventional arrangement the government buys a physical asset. In this paper we build a model that gives a clear and intuitive insight into the question of when a government should opt for a PPP and when it should stick with conventional procurement, and then draw inferences from the model.

A common, albeit far from universal, feature of PPPs is that the consortium building and operating the asset owns it during the operation (service provision) stage. It is well understood that, in the presence of incomplete contracts, ownership can affect incentives (cf. Hart and Moore (1990), and Hart (1995)). Generally, when non-contractible circumstances do arise, the owner of the asset can through contract renegotiation capture some of the profits of the individual that

[3]Source: Poole, R. W., Jr. and Butler, V. (2001) "How to Commercialize Air Traffic Control" Reason Public Policy Institute Policy Study (www.rppi.org/air.html).

[4]Source: Thomas, C. W. (2001) "Private Adult Correctional Facility Census" www.crim.ufl.edu/pcp/census/2001/. For a policy discussion of public–private partnerships in correctional facilities, cf. Larason Schneider (2000).

[5]Source: Edison Schools (www.edisonproject.com)

[6]For example, BOO (build-own-operate), BDO (build-develop-operate), DCMF (design-construct-manage-finance), BOOT (build-own-operate-transfer), BLOT (build-lease-operate-transfer), BTO (build-transfer-operate).

works with the asset and also pursue policies that may reduce operating cost but adversely affect quality. This hold-up problem frequently leads to underinvestment in asset-specific human capital or other specific investments.[7] This may not be true when the interaction is repeated, that is when reputation matters: cf. Halonen (2002). Adopting this incomplete contracts perspective, Hart, Schleifer, and Vishny (1997) and Hart (2003) identify when governments should own assets and when they should be owned by the private sector.

While ownership is clearly informative in understanding the public/private distinction we suggest that it is not the full story. One reason is that some PPP models involve the transfer of ownership of the asset to the public sector upon completion of the asset and then a lease back to the private sector consortium. The incomplete contracts approach cannot explain this phenomenon, or to be more precise, has to deal with these cases separately and treats them as if the government had built the asset itself or purchased it separately. Second, governments, when identifying the benefits of PPPs, tend to put little emphasis on ownership *per se* and emphasize the fact that whoever builds the asset has to live with the long run consequences (since they also will have to operate it for may years and their revenue comes through the service output).[8] Therefore, there are strong arguments for seeking an explanation of why and when PPPs exist that does not rest on ownership. This is not to say that ownership is unimportant, but that it does not explain the full picture. The model provided here focuses on the role of the procurement process and complements the incomplete contracts approach. What matters is that the same agent builds and operates the asset. Whether ownership is transferred from private to public sector after construction and then leased back does not matter.

The model, and the intuition for our main result, is roughly as follows.[9] There are two or three players - the government, builder and service provider (the last two are combined in a PPP). Each party has private information. At the build stage, the quality of the asset (i.e., how cheap it is to operate later) depends in part on the investment by the builder. Whether the builder has made the appropriate quality enhancing investment is private information to the builder. That is, there is a moral hazard problem at the build stage. If the government buys the asset or builds it itself it needs to create incentives at the build stage (through appropriate contract design) to ensure the

[7] See Grout (1984).

[8] That is, the risk of service delivery failure because of poor construction is passed to the private sector (see Dewatripont and Legros (2005)).

[9] We abstract from risk issues (for a discussion of risk see Grout (2003) and Grout and Zalewska (2005)).

quality enhancing investment is undertaken. When it comes to operate the asset the cost of doing so can be high or low and this is private information to the service provider. The government has to provide appropriate incentives to ensure that the service provider reveals the correct cost, i.e., there is an adverse selection problem at the service provision stage that creates information rent for the service provider. Finally, there is a one off set up cost associated with using the asset to provide the service. This cost is project specific and is initially private information to the government (but is revealed in equilibrium).

With conventional procurement the government has to separately incentivize the builder (to overcome the moral hazard problem) and apply a revelation mechanism for the service provider (to overcome the adverse selection problem). In contrast, in a PPP model the same company builds and then operates the asset to provide the service. Obviously, the information rent gained at the service delivery stage is greater the more often costs of delivery are low. So, providing the cost of quality enhancing investment at the build stage is sufficiently low, the consortium has an incentive to build the best asset it can since this maximizes information rent at the service provision stage. That is, to ensure the best asset is built the government does not have to pay additional incentive costs over and above the revelation mechanism it applies at the service provision stage. In this sense a PPP ensures the optimal quality enhancing investment at the build stage "for free". So a PPP is always the best policy whenever the quality enhancing investment cost at the build stage is low. Providing the cost of quality enhancing investment at the build stage is not too high the government will always be able to achieve the optimal investment decision at the build stage "for free". However, if the quality enhancing costs at the build stage become "large" the quality enhancing investment can no longer be induced "for free". With large quality enhancing costs the government can still ensure within a PPP that the correct build is made but only by increasing the payments it makes within the revelation mechanism. That is, to achieve the correct build the transfers within the "revelation mechanism" have to be set abnormally high. In particular, they are higher than would be necessary to achieve revelation if the cost structure could be taken as given. It follows that inducing the correct quality enhancing investment starts to become expensive. Although the government is "over-paying" for revelation, this will still be the best approach providing costs are not too high. However, a benefit of conventional procurement (i.e., two separate agents - builder and service provider) is that the separate incentives can be tailored specifically to each of the two tasks. So eventually, once the cost of incentivizing the PPP through a single revelation mechanism becomes too high, conventional procurement becomes superior.

We find that PPPs are the optimal mode of delivery when quality-enhancing investments at the build stage are relatively cheap and the set up costs at the service provision stage are low. In contrast, when these costs are high then conventional procurement is either optimal or at least as good as PPPs. The implication is that PPPs are chosen by governments precisely when service delivery and investments in quality enhancements are relatively cheap and rejected when they are not. PPPs exist when costs are low and conventional government provision when costs are high. But implementing a PPP when government costs are high will not lead to lower costs. This suggests that comparisons of the conventional public model with PPPs can suffer from sample selection bias. Conventional public provision should not be compared to PPPs but to a counterfactual scenario, viz, compared to the costs that would be delivered by a PPP in the high cost scenario. Without correction for project type, the PPPs may thus falsely appear more efficient and cost effective than public sector provision. This is a problem for cross section comparisons but should not be a problem for comparisons of activities that have been moved from the public to the private sector.[10]

The paper is organized as follows. Section 2 outlines the model.[11] Section 3 deals with the case where the set up costs for service delivery is low. This scenario is the most rich and hence this section contains the main body of our results. Section 4 (and Appendix A) completes the analysis by briefly addressing the case where the set up cost for service delivery is high. Section 5 gives brief conclusions. Appendix B provides a discussion of why potential collusion is not a problem in this model.

2 The Model

The government agency (G) seeks to provide a public service that requires a physical asset and service provision using that asset. In what we call the "conventional" model, G purchases the asset from a private builder (B), and the service is provided by a service provider (SP) using the asset (provided to it by G). In the "public–private partnership" model, G purchases the service and the provider of the service builds and owns the asset. This section outlines the cost structure, the information structure, the objectives of the parties, and the time structure.

[10] Unfortunately most examples of the latter concern full privatization.

[11] We show in appendix A that the government agency wants to disclose project characteristics if it has sufficiently favorable information, and does not disclose project characteristics if it has unfavorable information. Of course, not disclosing information in itself has some informational content, that is, our model describes a separating equilibrium.

2.1 Cost Structure

The cost structure has two components: the cost of building the asset, and the cost of providing the service. Both of these are project-specific.

2.1.1 *Costs of Service Provision*

The cost of service provision has two elements: A fixed set up cost, and a variable per unit cost.[12] The fixed service set up cost $\tilde{f}$ may be either low or high which, without loss of generality, we model as $\tilde{f} \in \{0, f\}$, with $\Pr\{\tilde{f} = 0\} = \pi$ and $\Pr\{\tilde{f} = f\} = 1 - \pi$.

The unit cost of service provision, $\tilde{\theta}$, depends on whether the asset is efficient or inefficient for its purpose, which is determined at the build stage. If the asset is efficient, $\tilde{\theta} = \theta_e$; if the asset is inefficient, $\tilde{\theta} = \theta_i$ with $\theta_i > \theta_e$. Denote $\Delta\theta \equiv \theta_i - \theta_e$.

2.1.2 *Costs of Design and Build*

The efficiency of the asset is determined at the build stage. The characteristics of the project are such that with probability p_0, the asset is efficient for its purpose regardless of the action of whoever builds the asset, that is $\tilde{\theta} = \theta_e$ for certain. With probability $(1 - p_1)$, the asset is inefficient, so that $\tilde{\theta} = \theta_i$ for certain. But with probability $(p_1 - p_0)$, the asset will be inefficient ($\tilde{\theta} = \theta_i$), unless whoever builds the asset makes an investment of cost c, in which case the asset will then be efficient ($\theta = \theta_e$). These probabilities, and the investment cost c, are common knowledge.

2.2 Information Structure

Knowledge about the cost components of service provision, and the design and build of assets is not available equally to all players. The service set up cost, $\tilde{f}$, is known privately to G, since it knows the nature of the project. For instance, G may know this cost because prior to privatization it may have provided the service itself. The service set up cost can become known to *SP*, but only if the requirements of the project are fully specified by G at the time of contracting.[13] G therefore

[12] We define the cost components of service provision as fixed (set up) and variable (unit) costs purely for expositional convenience. The central feature we need is that some components of cost are privately known to G, and some components are known to *SP*.

[13] We have in mind the idea that, for example, a specific project may have certain problems to be solved and, once the project is specified in detail, *SP* knows whether they will be costly to solve or not. We elaborate this intuition in section 2.2.3.

has to decide whether to share its information about $\tilde{f}$ or not. A contract that provides a precise specification of the project and thus reveals G's information we refer to as a "refined" contract. A contract that specifies general duties but where the details only become apparent after signing, i.e. one that does not reveal G's information, is called a "generic" contract. Intuitively, when G knows that the project it wants performed has a zero set up cost of service provision, it would like to reveal that information since that lowers the expected cost to G of service delivery. That is, if the project has zero service provision set up cost, G offers a refined contract. Therefore, if SP is offered a generic contract, in equilibrium this must be because the fixed set up cost of service provision is high. We prove this later.

2.2.1 *The Conventional Model*

As indicated, the conventional model has two stages: first, the design and build of the asset, and, second, service provision. We consider these in turn.

Service Provision Stage. The unit cost of service provision, $\tilde{\theta}$, depends on the efficiency of the asset (which is determined at the build stage). G does not observe the realization of $\tilde{\theta}$ directly. What SP knows about the efficiency of the asset at the time of signing the service provision contract depends on whether G offers a generic or a refined contract.

In particular, if G writes a refined contract with SP, she learns both the fixed service set up cost, $\tilde{f}$, as well as the variable cost, $\tilde{\theta}$. That is, a central assumption of the paper is that there is no mechanism that allows G to negotiate with SP in a manner that specifies in full detail the project characteristics, and hence reveals G's information, but does not convey information about the unit cost of service provision to SP.[14]

In contrast, if G writes a generic contract with SP, she learns nothing about the unit cost of the project. However, in equilibrium it can infer from the offer of a generic contract that the fixed set up cost of service provision must be high. In this case, G's and SP's information is symmetric.

Build Stage. Turning to the build stage, whether B chooses to invest c or not is not directly observable to G or SP.

When G contracts with B, it can offer a generic or a refined contract. If G offers a generic

[14]That is, G has control over whether to give SP pre-contractual private information. Similar information management issues are studied by Crémer and Khalil (1992) and Lewis and Sappington (1997).

contract that specifies only broad project requirements, then at the time of signing the contract B learns no new information. B of course knows the general probabilities with which an investment in efficiency improvements may be made, since this is common knowledge. Once construction has begun, B learns privately whether this investment of cost c needs in fact to be made.

On the other hand, if G specifies the project in detail by offering a refined contract to B, then she knows at the time of signing the contract whether investment is necessary to improve the efficiency of the asset. However, we show later that G can never do better than offering a generic build contract.

2.2.2 *The Public–Private Partnership Model*

In the public–private partnership model, G contracts with a private sector consortium (PC) for the delivery of the service, and the PC designs, builds, and owns the asset.

If G writes a refined contract with the PC, she learns all the project characteristics: whether the efficiency improving investment of cost c needs to be made, and G's information about the service set up cost, $\tilde{f}$.

If G offers a generic contract to the PC, the PC does not learn any specific information about the project directly, but in equilibrium the PC can infer that the service set up cost must be high. In particular, although the PC knows the general probabilities with which efficiency improvements may be made, with the generic contract it does not know whether the specific project will in fact allow investment into improving asset efficiency or not.

As in the conventional model, G cannot observe the unit cost, $\tilde{\theta}$, or whether the PC has chosen to invest c.

2.2.3 *Motivation*

To motivate the above information structure, consider the following example. The design and build of the asset has problems that need to be solved. B or PC may have encountered the problem previously and already solved it, requiring no additional cost to make the asset efficient. This is the sense in which we are thinking of the asset as already efficient with no investment cost necessary. On the other hand, the problem may not have been encountered before, in which case the asset can be made efficient, but only at a cost of c. Whether B or PC has encountered and solved the problem before is obviously information private to B or PC, and therefore G does not observe whether an investment cost is necessary to provide an efficient asset.

Furthermore, when G fully specifies the details of the project in a refined contract, hence revealing low set up costs, B or PC will know from the detailed description of the nature of the project whether there are previously encountered problems or problems that remain to be solved. Hence it is appropriate to assume that G will be unable to reveal the nature of the set up cost without also revealing whether an investment cost is necessary or not.

2.3 Objective Functions

The demand curve for the service is given by a continuous, and continuously differentiable function $q(\cdot)$, such that $q'(\cdot) < 0$, with inverse demand $q^{-1}(\cdot)$.[15] We denote $q_e = q(\theta_e)$, $q_i = q(\theta_i)$, and $\Delta q \equiv q_e - q_i$. Note that $q_e > q_i$. SP produces output q at a total cost of θq, for which G pays $kq(k)$, $k \in \{\theta_e, \theta_i\}$, depending on reported costs. In addition, SP may obtain a subsidy, s, from G.

All agents are risk neutral.

2.3.1 *The Government Agency's Objective*

G's objective is the maximization of net consumer surplus,

$$v(q(k)) - kq(k) - s - t,$$

where $v(\cdot)$ denotes gross consumer surplus

$$v(q) = \int_0^q q^{-1}(x)dx,$$

and t denotes other net transfers from G. Obviously $v'(\cdot) > 0$ and $v''(\cdot) < 0$.[16]

2.3.2 *The Service Provider's Objective*

SP maximizes expected monetary payoff, that is the expectation of

$$-\theta q(k) + kq(k) + s,$$

and has an outside utility level which we normalize to zero.

[15] Alternatively, q may be thought of as the quality of the service.

[16] Purely for presentational ease, we also make the assumption that G has no concern for SP's welfare. As long asSP's welfare in G's utility function is less than unity (for instance because of the shadow cost of taxation), our qualitative results remain unchanged.

2.3.3 *The Builder's Objective*

In the conventional model, G contracts with B, and the contract specifies a fixed fee, m, for building the asset, and damages d as an incentive to invest in asset efficiency. B's objective is therefore the maximization of expected profit, that is the expectation of $m - d - c$.

2.4 Timing

In summary, the structure and the timing of the model is the following:

1. G learns the set up cost of service provision, $\tilde{f}$, for its project and chooses whether to opt for the conventional model, or the public–private partnership model.
2. If the conventional model is chosen:
   - G chooses the type of contract (refined or generic) it will offer to each party.
   - G contracts with B over the building of the asset and writes a separate contract with SP.
   - B chooses whether to make the (unobservable) investment in asset quality.
   - Finally, SP announces (truthfully or by misrepresentation) whether the asset is efficient or not, delivers the service and payoffs are realized.
3. If the public–private partnership model is chosen:
   - G writes a contract (refined or generic) with PC.
   - PC chooses whether to make the unobservable investment in asset quality.
   - PC announces (truthfully or by misrepresentation) whether the asset is efficient or not. The service is delivered and payoffs are realized.

As indicated above, we study the model under the assumption (which we prove in appendix A) that the fixed set up cost, f, is large enough, to ensure a separating equilibrium. We first analyze the case in which G has a project that has a zero service set up cost ($\tilde{f} = 0$) in section 3. We study the outcome if G opts for the conventional asset purchase model, and then if G uses the public–private partnership model. Finally we compare these to decide the approach G should choose. This section contains the main results of the paper. In order to complete the study of this separating equilibrium, in section 4 we need to consider the case when G has a project with high set up cost of service provision ($\tilde{f} = f$) and we again go through the three stages. The final section 5 concludes the discussion. Appendix B contains additional material on the robustness of our results against collusion.

3 Equilibrium with Low Set Up Cost

In this section we study projects where the fixed set up cost of provision is low (i.e. normalized to zero). As argued previously (we prove this in appendix A), G will choose to offer a refined contract to SP or PC that specifies in detail the project characteristics. This allows G to share its information about the service set up cost (reducing the expected payment to SP or PC). A refined contract however also reveals to SP or PC pre-contractual private information about the unit cost of service provision (which allows SP or PC to extract information rent).

We first study incentives for investment in efficiency improvements to the asset in the conventional model. The incentive system required for B to make investments in improving the efficiency of an asset becomes more expensive to implement for G the more costly the required investment is. We obtain a limit on the most costly investment G is willing to implement. We then turn to the public–private partnership model and repeat the exercise. Again, we obtain an upper bound on the cost of efficiency-improving investments. Finally, we analyze G's choice between the two models of public service delivery. We find that there is a threshold of investment costs: below the threshold, G prefers to implement investments in efficiency improvements through the public–private partnership model, and above the threshold it prefers to implement investments through conventional public service provision. All results of this section are summarized in figure 1.

3.1 Conventional Provision

In the conventional model, G contracts with B to build an asset. B may be able to make an investment that will enhance the efficiency of the asset, in the sense that it decreases the unit cost of service provision. The intuition in the conventional model works as follows: Whether the investment has in fact been made is private information to B, and therefore the contract cannot be enforced on whether c is invested or not. However, G will provide incentives to SP to report truthfully on the cost outcome of B's effort so that, as in a standard moral hazard problem, incentives for B can be conditioned on the inferred outcome of B's effort. The contract with SP

is a refined contract, so that SP learns the cost of service provision, and the incentive contract with SP therefore is the standard adverse selection type. In equilibrium, SP reveals cost conditions truthfully (and, if the cost is low, extracts information rent). Having learned the unit cost, G can now enforce the incentives provided to B, as in a standard moral hazard problem in which the agent is rewarded for good news (the low cost outcome) and punished for bad news (the high cost outcome (cf. Milgrom (1981)). However, the more expensive the investment B is expected to make, the higher the cost of the contract G writes with B. There is a level of investment cost that is too costly to implement, and we identify that level.

Specifically, G writes a generic contract (m, d) with B, specifying money payments m to B, and damages of size d as the incentive to invest in asset efficiency.[17] Since it is a generic contract, B has no pre-contractual information about whether any efficiency improvements can in fact be made to the asset. B's payment is conditioned on the unit cost outcome reported by SP: B is rewarded for good news (reported low unit cost), and punished for bad news (reported high unit cost), as in Milgrom (1981). In our model, the cost outcome of B's action is not directly observable by G. In equilibrium, however, SP is given incentives to reveal the cost of service provision truthfully, and therefore litigation (contractually specified damages of size d) against B is successful whenever SP claims that unit service provision costs are high.[18] B therefore makes the investment whenever $d \geq c$. Competition for the building contract eliminates *ex ante* profits, so that the payment from G to B is

$$m = (p_1 - p_0)c + (1 - p_1)d$$

to satisfy B's participation constraint.

We now turn to SP to study the optimal refined service provision contract for a project with zero service set up costs. Since G offers a refined contract there is asymmetric information about the unit cost of service provision (SP learns whether the asset is efficient but G does not). The second-best optimal contract between agency and service provider under conditions of adverse selection is standard (cf. Baron and Myerson (1982)).[19] The revelation principle allows G to restrict attention,

[17]Risk neutrality of all agents implies obviously that G can do no better if it signs a refined contract: *ex ante*, G and B are indifferent between generic and refined contracts.

[18]Here it does not matter whether d is the actual or expected damage payment. If B loses with a fixed probability, d can be interpreted, without loss of generality, as the expected damage payment.

[19]Note, however, that here we reduce the number of G's instruments: it can only control the subsidy to SP; G's conjecture over cost is fixed to be $k(\theta) = \theta$, and correspondingly output is $q(\theta)$. We appeal to the idea that for

without loss of generality, to direct revelation mechanisms (in which SP reports, truthfully, on her type). When the distribution over $\tilde{\theta}$ is known to be $\{(\theta_e, p), (\theta_i, (1-p))\}$ (where p can be either p_0 or p_1, depending on whether B has or has not made the efficiency-improving investment), G designs a contract (schedule of subsidies) (s_e, s_i) for SP so as to

$$\max_{s_e, s_i} p\left[v(q_e) - q_e\theta_e - s_e\right] + (1-p)\left[v(q_i) - q_i\theta_i - s_i + d\right] \tag{1}$$

s.t.

$$s_e \geq q_i\theta_i - q_i\theta_e + s_i \tag{2}$$

$$s_i \geq q_e\theta_e - q_e\theta_i + s_e \tag{3}$$

$$s_e \geq 0 \tag{4}$$

$$s_i \geq 0 \tag{5}$$

Constraints (2) and (3) are the incentive compatibility constraints for the low and high cost type providers, and (4) and (5) are the individual rationality, or participation, constraints. Note that q_e and q_i are determined by θ and are not choice variables for G. We refer to a contract that satisfies constraints (2)–(5) as a "truth-telling" contract, since it induces truthful revelation of unit cost of service provision by SP.

As is standard, (2) and (5) are binding in equilibrium, and (3) and (4) are slack.

Second-best subsidies are characterized by

$$s_i = 0$$

and

$$s_e = q_i\Delta\theta.$$

Of course, $q_i\Delta\theta$ is the amount of information rent extracted by SP if the unit cost is low.

G's payoff from its relationship with SP is therefore

$$V_A(p, d) \equiv p\left[v(q_e) - q_e\theta_e - q_i\Delta\theta\right] + (1-p)\left[v(q_i) - q_i\theta_i + d\right].$$

efficiency reasons, G is required to price at marginal cost.

(Subscript A denotes the case where G buys assets, that is conventional service provision.)

G's *ex ante* payoff from writing a contract with B that gives B the right investment incentives, and a contract with SP that fulfills constraints (2)–(5) is

$$V_A(p_1, d) - (p_1 - p_0)c - (1 - p_1)d,$$

since B needs to be reimbursed for its expected investment cost, and for expected damage payments. G's *ex ante* payoff from writing an incentive contract that does not implement investment (and therefore requires zero damages in the build contract) is

$$V_A(p_0, 0) = p_0 \left[v(q_e) - q_e\theta_e - q_i\Delta\theta\right] + (1 - p_0)\left[v(q_i) - q_i\theta_i\right].$$

Since the contract with SP is second-best optimal, G would (*ex ante*) of course never want to write a service provision contract that does not obey constraints (2)–(5).

Comparison of these two payoffs yields the following: When G has purchased and owns the asset, it wants to induce investment up to an investment cost of

$$c^* = v(q_e) - v(q_i) - \Delta q\theta_e.$$

In hierarchical models such as this, the question of collusion naturally arises (cf. Tirole (1986)). We show in appendix B that in our model, collusion is no concern.

3.2 Public–Private Partnerships

The feature of the public–private partnership model is that G buys the service only. In this framework, the private sector consortium (PC) builds the asset and provides the service. The intuition is the following: as indicated above, G offers a refined contract, and PC therefore learns pre-contractual information about the characteristics of the project (the service set up cost and whether efficiency improvements need to be made at the build stage). The contract is the standard, second-best optimal (truth-telling), contract under adverse selection, and this contract allows PC to capture information rent whenever service provision cost is low. The incentive for PC to invest in efficient assets is therefore determined by the size of the information rent. G can therefore implement relatively cheap investments at no additional cost: the standard information rent required to implement truth-telling by PC is sufficient to implement optimal investment also. This is the standard argument from internalization of an externality. The more costly investments are, however, the more information rent G needs to leave to PC in order to achieve investment. G is willing to provide incentives to implement efficiency enhancing investment up to the point where increasing the information rent any further becomes too costly.

The refined contract with PC is a standard contracting problem under adverse selection. As before, when the distribution over $\tilde{\theta}$ is known to be $\{(\theta_e, p), (\theta_i, (1-p))\}$ (where p can be either p_0 or p_1, depending on whether the investment was carried out), G designs a refined contract (schedule of subsidies) (s_e, s_i) for PC so as to

$$\max_{s_e, s_i} p\left[v(q_e) - q_e\theta_e - s_e\right] + (1-p)\left[v(q_i) - q_i\theta_i - s_i\right] \tag{6}$$

subject to the usual incentive compatibility and individual rationality constraints (2)–(5). Again, of course, second-best subsidies are characterized by

$$s_i = 0$$

and

$$s_e = q_i\Delta\theta.$$

G's payoff given these subsidies is:

$$V_S(p) \equiv p\left[v(q_e) - q_e\theta_e - q_i\Delta\theta\right] + (1-p)\left[v(q_i) - q_i\theta_i\right].$$

(Subscript S denotes the case where G buys services only, i.e., the public–private partnership model.)

Since in this setting, subsidies (or, more precisely, the difference $s_e - s_i$) govern the incentive to make the efficiency enhancing investment, G may find it optimal to increase s_e beyond $s_e = q_i\Delta\theta$, if the loss from increased rent is outweighed by the gain in an increased probability of obtaining an efficient asset. Since (2) and (5) are binding in equilibrium, and (3) and (4) are slack, increasing s_e does not distort incentive compatibility, as long as

$$s_e \leq s_i + q_e\Delta\theta.$$

Since increasing s_i is costly for G and does not increase the investment incentive, we know that, in any refined PC contract, $s_i = 0$. The highest rent G can therefore give to PC, and still induce truth-telling about the efficiency of the asset is $s_e = q_e\Delta\theta$. Note that PC's individual rationality (participation) constraint is of course always satisfied, and no additional transfers are required. G's payoff from increasing information rent up to s_e^* is

$$V_S^I(p, s_e^*) \equiv p\left[v(q_e) - q_e\theta_e - s_e^*\right] + (1-p)\left[v(q_i) - q_i\theta_i\right].$$

(Superscript I refers to increased subsidy s_e, relative to the standard case.)

How far is G prepared to increase rent if that increase induces investment? G's payoff from increased rent s_e^* (if it induces investment) is $V_S^I(p_1, s_e^*)$. The payoff from writing the lowest-rent revealing contract (if that does not induce investment) is $V_S(p_0)$. If G can induce investment that way, it would therefore wish to increase the subsidy (information rent) to the low-cost PC up to

$$s_e^* = \frac{p_1 - p_0}{p_1}\left[v(q_e) - v(q_i)\right] - \frac{p_1 - p_0}{p_1}\left[q_e\theta_e - q_i\theta_i\right] + \frac{p_0}{p_1} q_i \Delta\theta.$$

The intuition for this result is simple: the information rent (which is paid with probability p_1) above the standard information rent $q_i\Delta\theta$ (which is paid with probability p_0), is worthwhile if it is less than, or equal to, the expected gain in net consumer surplus

$$(p_1 - p_0)\left[v(q_e) - v(q_i) - (q_e\theta_e - q_i\theta_i)\right].$$

We can now state our main proposition about investments in the PPP model:

Proposition 1 *If* G *chooses the public–private partnership model then* G *wants to implement investments up to an investment cost of*

$$c = \frac{p_1 - p_0}{p_1}\left[v(q_e) - v(q_i)\right] - \frac{p_1 - p_0}{p_1}\left[q_e\theta_e - q_i\theta_i\right] + \frac{p_0}{p_1} q_i \Delta\theta.$$

Proof. As a first step, we show that

$$q_i\Delta\theta \leq s_e^* \leq q_e\Delta\theta,$$

so that we know that the point to which G would wish to increase the subsidy to PC is (a) greater than the lowest rent that induces revelation and (b) less than the highest rent that still induces separation. It is straightforward that $q_i\Delta\theta \leq s_e^*$. We need to show that

$$v(q_e) - v(q_i) \geq \Delta q \theta_e.$$

Dividing by Δq, and letting $\Delta q \to 0$, we have

$$v'(q) \geq \theta_e,$$

which is true for all $q \in [\theta_e, \theta_i]$.

The proof that $s_e^* \leq q_e\Delta\theta$ is equally simple. We need to show that

$$\frac{p_1 - p_0}{p_1}\left[v(q_e) - v(q_i)\right] - \frac{p_1 - p_0}{p_1}\left[q_e\theta_e - q_i\theta_i\right] + \frac{p_0}{p_1} q_i \Delta\theta \leq q_e\Delta\theta$$

or

$$(p_1 - p_0)\left[v(q_e) - v(q_i)\right] + p_0 \Delta q \theta_e - p_1 \Delta q \theta_e - p_1 \Delta q \Delta \theta \leq 0$$

again, dividing by Δq and letting $\Delta q \to 0$, we obtain

$$v'(q) \leq \theta_e + \frac{p_1}{p_1 - p_0} \Delta \theta$$

which, since $\frac{p_1}{p_1 - p_0} > 1$, is true for all $q \in [q_i, q_e]$.

With this result we can now prove the proposition. Since we know that SP will invest if, and only if, $c \leq s_e$, and we know that G is willing to increase s_e up to

$$\frac{p_1 - p_0}{p_1}\left[v(q_e) - v(q_i)\right] - \frac{p_1 - p_0}{p_1}\left[q_e \theta_e - q_i \theta_i\right] + \frac{p_0}{p_1} q_i \Delta \theta,$$

the proposition follows. ■

3.3 Buying Assets or Buying Services?

We now have a complete description of implementable investments under conventional provision and PPPs. In this section, we turn to the question of which of these two models of service provision G will choose.

Consider first investments that can be induced both under conventional public service provision and under the PPP model. For investments that can be induced both when G buys the asset and when G buys services only (that is, for all investment costs $c \leq v(q_e) - v(q_i) - \Delta q \theta_e$), government purchase of the asset (when investment is induced) gives G an *ex ante* expected payoff of

$$V_A(p_1, d) - (p_1 - p_0)c - (1 - p_1)d,$$

since B needs to be reimbursed for the expected cost of investment and the expected damage payments. Buying only services gives G an *ex ante* payoff of

$$V_S^I(p_1, c) = p_1\left[v(q_e) - q_e \theta_e - c\right] + (1 - p_1)\left[v(q_i) - q_i \theta_i\right].$$

G chooses the structure that maximizes its *ex ante* expected payoff; that is, it chooses the public–private partnership model over conventional service delivery when[20]

$$V_S^I(p_1, \max\{c, q_i \Delta \theta\}) \geq V_A(p_1, d) - (p_1 - p_0)c - (1 - p_1)d.$$

[20]Recall that the subsidy to the low-cost SP needs to be at least $q_i \Delta \theta$ for revelation of cost conditions.

This is

$$c \geq \frac{p_1}{p_1 - p_0} \max\{c, q_i \Delta\theta\} - \frac{p_1}{p_1 - p_0} q_i \Delta\theta.$$

For all $c < q_i\Delta\theta$, G therefore prefers to buy services only. For $c \geq q_i\Delta\theta$, G prefers to buy services as long as $c < \frac{p_1}{p_0} q_i \Delta\theta$, and prefers to procure the asset itself if $c \geq \frac{p_1}{p_0} q_i \Delta\theta$.

The intuition for this result is simple: for very low values of the investment cost (up to $\frac{p_1}{p_0} q_i \Delta\theta$), G prefers to induce the investment just through the rent payment to PC (which needs to be paid to whoever provides the service anyhow in order to induce revelation). In this sense, G obtains investment essentially for free.

For $c \geq \frac{p_1}{p_0} q_i \Delta\theta$, G prefers to purchase the asset: investment in asset quality is, to G, less costly: when the asset is privately owned, G can induce investment only by paying PC the investment cost as part of the subsidy when (observed) cost is low, that is, with probability p_1. When G buys the asset, it only needs to reimburse B with the *ex ante* expected investment cost (that is, with probability $p_1 - p_0$).

For investments that can only be induced through the public–private partnership model, i.e. for all investment costs c such that

$$v(q_e) - v(q_i) - \Delta q \theta_e < c \leq \frac{p_1 - p_0}{p_1} [v(q_e) - v(q_i)] - \frac{p_1 - p_0}{p_1} [q_e\theta_e - q_i\theta_i] + \frac{p_0}{p_1} q_i \Delta\theta,$$

we know, by construction of s_e^*, that the public–private partnership model is optimal.

For investments that can only be induced through public purchasing of the asset, i.e. for all investment costs c such that

$$\frac{p_1 - p_0}{p_1} [v(q_e) - v(q_i)] - \frac{p_1 - p_0}{p_1} [q_e\theta_e - q_i\theta_i] + \frac{p_0}{p_1} q_i \Delta\theta < c < v(q_e) - v(q_i) - \Delta q \theta_e,$$

we know, by construction of c^* that up to $c^* = v(q_e) - v(q_i) - \Delta q \theta_e$ G prefers to implement investments, rather than not implement them, and G will therefore choose the conventional model.

We bring these results together in the following proposition:

Proposition 2 *For all c such that*

$$c < \frac{p_1}{p_0} q_i \Delta\theta$$

and

$$c \leq v(q_e) - v(q_i) - \Delta q \theta_e,$$

the public–private partnership model is optimal for G. *For all c such that*

$$c > \frac{p_1}{p_0} q_i \Delta\theta$$

and

$$c \leq v(q_e) - v(q_i) - \Delta q \theta_e,$$

it is optimal for G *to buy assets. For all c such that*

$$c > v(q_e) - v(q_i) - \Delta q \theta_e$$

but

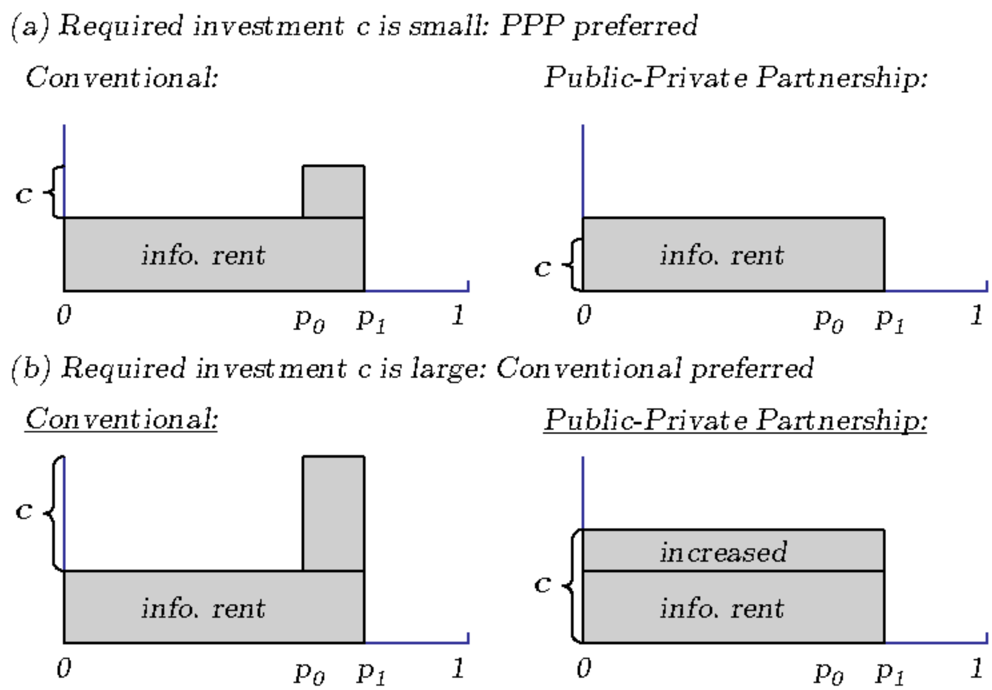
$$c \leq \frac{p_1 - p_0}{p_1} [v(q_e) - v(q_i)] - \frac{p_1 - p_0}{p_1} [q_e\theta_e - q_i\theta_i] + \frac{p_0}{p_1} q_i \Delta\theta,$$

the public–private partnership model is optimal.

Figure 1 provides a diagrammatic explanation of the difference between PPP and conventional procurement. Panel (a) of Figure 1 shows the situation when c is small. The left hand side depicts conventional procurement. Here G has to pay an information rent to SP and in addition, within the optimal build contract, G has to pay c times $(p_1 - p_0)$ to B to ensure that the quality enhancing investment is undertaken. The right hand side depicts the PPP situation. Here PC receives the information rent and has an incentive to undertake the quality enhancing investment since this maximizes the information rent. It is clear that PPP is the cheaper delivery mechanism. Panel (b) of Figure 1 shows the equivalent situation when c is large. The left hand side is similar to that in the top panel, except that c is larger so G must make larger payments to B. The right hand side depicts the PPP situation. Here G can still induce the PC to incur the quality enhancing investment but only by raising the transfer in the revelation mechanism to the level c. The problem is that the higher information rent is paid whenever costs are low. That is, the large transfer payment is paid not just when c is necessary to improve the asset (which occurs with probability $(p_1 - p_0)$) but whenever the cost is low (which occurs with probability p_1). The higher c or the closer p_0 is to p_1 then the more attractive is conventional provision.

Figure 2 provides a diagrammatic depiction of Proposition 2 (drawn on the assumption that $q_i\Delta\theta < v(q_e) - v(q_i) - \Delta q\theta_e$). p_0 is on the vertical axis and c is on the horizontal axis. Five regions, *(i)* to *(v)*, are identified. In region *(i)* c is so low that the minimum information rent is sufficient

Figure 1:

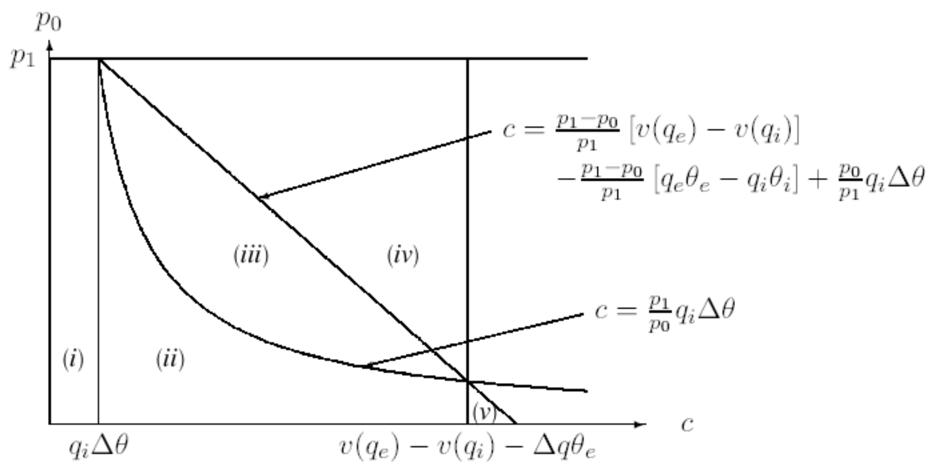


to ensure that the PPP delivers the quality enhancing investment. In region *(ii)* c is such that the payment in the incentive revelation scheme has to be raised above the minimum to ensure that the quality enhancing investment is undertaken in a PPP but the cost of doing this is sufficiently low that PPP is still optimal. In region *(iii)* the PPP can still deliver the quality enhancing investment but the cost is too large, i.e. conventional procurement is preferred. In region *(iv)* c is sufficiently large that the PPP cannot deliver the quality enhancing investment because a transfer set equal to c would be so large that the PC would not reveal the true cost. Again conventional delivery is optimal. In region *(v)* conventional methods are too expensive to deliver the quality enhancing investment but this can be achieved through a PPP. The figure shows clearly that, for a given p_0, PPPs are preferred when c is low.

4 Equilibrium With High Set Up Costs

The previous section has presented the main results of this paper. Since we study a separating equilibrium, we now need to complete the analysis with the case where G has a project with a set up cost f. In that case, G does not disclose project characteristics, and the question is therefore

Figure 2:



an entirely conventional contracting problem under imperfect, but symmetric information.

As indicated above (we prove this in appendix A), if f is sufficiently large, G will offer generic service provision contracts. Since we are studying separating equilibria, this will convey to SP or PC that the fixed cost is f, but it protects G from having to pay information rent. As in the previous section, we first study investment incentives in the conventional model. We then turn to the public–private partnership model and repeat the exercise. For both models of public service delivery we obtain the same upper bound on implementable investments at the build stage. Furthermore, we find that G is indifferent between both models of public service provision.

4.1 Conventional Provision

As appendix A shows, for sufficiently large fixed costs of service provision f, G writes a generic contract with SP. That is, in its relationship with SP, G seeks to

$$\max_{s_e, s_i} p\,[v(q_e) - q_e\theta_e - s_e] + (1-p)\,[v(q_i) - q_i\theta_i - s_i + d] - f \tag{7}$$

subject to the incentive compatibility constraints (2), (3), and the following individual rationality constraint:

$$ps_e + (1-p)s_i \geq 0. \tag{8}$$

(It reimburses cost, both fixed and variable, but can give transfers s_e and s_i that are nonpositive so as to give SP an expected rent of zero. Of course p is the probability that unit cost of service provision is low.)

It is straightforward that optimal subsidies are

$$s_e = (1-p)q_i\Delta\theta$$

and

$$s_i = -pq_i\Delta\theta,$$

and G's payoff from its relationship with SP is

$$V_A^E(p,d) \equiv p\left[v(q_e) - q_e\theta_e\right] + (1-p)\left[v(q_i) - q_i\theta_i + d\right] - f.$$

(Superscript E refers to a contract that satisfies the individual rationality constraint only in expectation, that is, a "generic" contract.)

Following the same line of argument as in the previous section, G's *ex ante* payoff from writing the incentive contract that implements investment c (and therefore a build contract with damages of size $d = c$ is necessary), is

$$V_A^E(p_1,d) - (p_1 - p_0)c - (1-p_1)d$$

(B needs to be reimbursed for its expected investment cost, and for expected damage payments). G's *ex ante* payoff from writing an incentive contract that does not implement investment (and therefore requires zero damages in the build contract) is

$$V_A^E(p_0,0) = p_0\left[v(q_e) - q_e\theta_e\right] + (1-p_0)\left[v(q_i) - q_i\theta_i\right] - f.$$

Comparison of these two payoffs tells us that G never wishes to implement investments above

$$c' = v(q_e) - v(q_i) + q_i\theta_i - q_e\theta_e.$$

Note that $c' > c^*$.

4.2 Public–Private Partnerships

When G signs a generic contract with a PC when a project has positive set up costs it seeks to

$$\max_{s_e,s_i} p\left[v(q_e) - q_e\theta_e - s_e\right] + (1-p)\left[v(q_i) - q_i\theta_i - s_i\right] - f - (p_1 - p_0)c \qquad (9)$$

subject to the incentive compatibility constraints (2), (3), and the following individual rationality constraint:

$$ps_e + (1-p)s_i \geq 0. \tag{10}$$

(It reimburses service provision cost, both f and θ, and expected investment cost, but can give transfers s_e and s_i that are nonpositive so as to give SP an expected rent of zero.)

Optimal subsidies are

$$s_e = (1-p)q_i\Delta\theta$$

and

$$s_i = -pq_i\Delta\theta,$$

and G's payoff is

$$V_S^E(p,c) \equiv p\left[v(q_e) - q_e\theta_e\right] + (1-p)\left[v(q_i) - q_i\theta_i\right] - f - (p_1 - p_0)c.$$

Note that higher investments can be induced by increasing s_e and decreasing s_i appropriately, such that $ps_e + (1-p)s_i = 0$. Of course this is *ex ante* costless to G.

G prefers to induce investment rather than not induce investment if

$$V_S^E(p_1, c) \geq V_S^E(p_0, 0),$$

that is, the most costly investment in efficiency improvement that can be implemented at the build stage is

$$c' = v(q_e) - v(q_i) + q_i\theta_i - q_e\theta_e,$$

which is of course just the same level of investment as in the conventional model.

4.3 Buying Assets or Buying Services?

When there are positive service set up costs G is willing to induce investments up to investment costs of

$$c' = v(q_e) - v(q_i) + q_i\theta_i - q_e\theta_e,$$

regardless of whether conventional or public–private partnership service provision was chosen. For implementable investments, we consider now the question of whether a government agency that knows it has a project with set up cost f prefers conventional service provision or public–private partnership service provision. If G purchases the asset G's *ex ante* payoff is

$$V_A^E(p_1, d) - (p_1 - p_0)c - (1 - p_1)d$$

(B needs to be compensated for expected investment cost and expected damage payments). Under the public–private partnership model G's *ex ante* payoff is

$$V_S^E(p_1, c).$$

Note that both payoffs are identical. That is, if the project has high set up cost then G is precisely indifferent between buying assets and buying services. This discussion is summarized in the following

Proposition 3 *When there is a positive set up cost of service provision,* G *wants to implement investment up to an investment cost of*

$$c' = v(q_e) - v(q_i) + q_i\theta_i - q_e\theta_e.$$

Furthermore, G *is indifferent between conventional public service provision (buying assets) and public–private partnership service provision (buying services).*

Proof. The proposition follows from the preceding discussion. ■

The intuition is that the offer of a generic contract reveals that the project has high set up costs. G obviously does better with a generic contract since it protects it from having to give information rent to SP and PC whereas a refined contract would also reveal that the project has high set-up costs but would expose G to a loss through information rent based on the level of efficiency. Since all parties sign generic contracts there is, in essence, no information asymmetry that requires costly incentive systems, and therefore no difference in expected returns to G. G therefore has no preference between the two models of public service delivery.

5 Conclusion

We have studied a government agency's ability to write contracts about public service delivery and/or asset procurement, when services are delivered using that asset. The government agency's ability to implement efficiency-enhancements by the asset builder is determined by whether the government agency chooses to buy, and own, the asset and contract on service delivery separately (the conventional mechanism), or whether the government agency contracts on service provision only (as in the case of the PPPs). We find that PPPs are the optimal mode of delivery when efficiency-enhancing investments at the build stage are relatively cheap and set up costs at the service provision stage are low. In contrast, when these costs are high then conventional procurement is either optimal or at least as good as PPPs. The implication is that PPPs are chosen by governments precisely when service delivery and investments in efficiency enhancements are relatively cheap and rejected when they are not cheap. This suggests that simple cross section comparisons of the conventional model of asset purchase and service contract, with the public-private partnership model could suffer from sample selection bias. Without correction for project type, the PPPs may thus appear more efficient and cost effective than public sector provision.

Finally, the paper clearly relates to the literature on "make-or-buy" (but now applied to government procurement) and we close with a few words on the relationship between the two. There are significant distinctions between our paper and the IO make-or-buy literature. The latter has usually assumed that the choice problem is the decision about whether to make or buy an asset, and has given us insights into the efficiency properties of various contractual forms through which assets can be acquired (cf., for instance, Bajari and Tadelis (2001)). As we do here, this literature usually assumes that contracts about asset procurement are complete, in the sense that all eventualities can be specified in the contract.[21] However, the make-or-buy literature has viewed the issue of asset procurement as largely divorced from the question of how governments contract over the provision of services using that asset. By contrast, we argue that we cannot separate the asset purchasing decision from the question of the provision of services using that asset. For instance, in the process of contracting over service provision, information about the asset may become known, and this information can be used in the procurement contract. Our model analyses the simultaneous choice of asset procurement and service delivery, as opposed to focusing on asset procurement.

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A Appendix: Existence of a Separating Equilibrium

Sections 3 and 4 focus on separating equilibria, that is, equilibria with the following characteristic: Whenever G has a project that it knows has zero service set up cost, it chooses to reveal this information to SP or PC by offering a refined contract. Offering a generic contract therefore implies that G has a project with positive service set up cost, f. The intuition for this result is simple: If G offers a project with positive service set up cost and SP or PC does not have information about the set up cost, G need only pay SP the expected cost (both fixed and variable) of service provision. That is, it can write a contract that induces truth-telling by SP or PC without leaving SP or PC information rent.[22] But if the service set up cost, f, is large, a government agency that has a project with zero service set up cost has an incentive to deviate from such a pooling equilibrium: if G can reveal that the service set up cost of its project is zero, it need not pay SP or PC for expected service set up costs at all. In our model, if G has a project with zero service set up cost, it can distinguish itself by offering a refined contract, and therefore bring about a separating equilibrium. However, revealing information about the set up cost is itself costly since a refined contract allows SP or PC to learn the variable cost of service provision θ also, and SP or PC can therefore extract information rent. If the set up cost of service provision is large enough, however, we obtain separation of types.

To complete the formal presentation we now show that there exists a level of the service set up cost, f^*, such that the equilibrium is a separating equilibrium for all f greater than f^* and discuss this assumption. This result is stated in the following proposition:

Proposition 4 *There exists a level of fixed cost of service provision f^* such that, if* G *has a project with zero service set up cost, it will always reveal that information to* SP *of* PC*. That is, a separating equilibrium exists.*

Proof of Proposition 4. It is obvious that if an agency has a project with high set up cost, it would always prefer to hide the information that its project has a high set up cost of service provision: Its *ex ante* payoff from revealing this information is

$$p_1(v(q_e) - q_e\theta_e) + (1 - p_1)(v(q_i) - q_i\theta_i) - f - (p_1 - p_0)c,$$

[22]Truthtelling contracts without pre-contractual information of this type are studied by Crémer and Khalil (1992).

and its payoff from not revealing this information (if this "lie" works, i.e. if this makes it indistinguishable from an agency with zero fixed cost of service provision) is

$$p_1(v(q_e) - q_e\theta_e) + (1 - p_1)(v(q_i) - q_i\theta_i) - (1 - \pi)f - (p_1 - p_0)c.$$

Therefore, G with the high set up cost project would never wish to deviate from a "pooling" equilibrium, that is one in which all contracts are generic.

Next, we study whether G with the zero service set up cost wishes to deviate from an equilibrium where all contracts are generic. In such an equilibrium, the 0-type agency has an *ex ante* payoff of

$$p_1(v(q_e) - q_e\theta_e) + (1 - p_1)(v(q_i) - q_i\theta_i) - (1 - \pi)f - (p_1 - p_0)c.$$

First, we analyze the case in which G with the zero service set up cost project prefers the public–private partnership route (that is, for all (c, p_0) such that

$$c < \frac{p_1}{p_0} q_i \Delta\theta$$

and

$$c \leq v(q_e) - v(q_i) - \Delta q \theta_e,$$

or for all (c, p_0) such that

$$c > v(q_e) - v(q_i) - \Delta q \theta_e$$

but

$$c \leq \frac{p_1 - p_0}{p_1} [v(q_e) - v(q_i)] - \frac{p_1 - p_0}{p_1} [q_e\theta_e - q_i\theta_i] + \frac{p_0}{p_1} q_i \Delta\theta,$$

as established in Proposition 2). If G with a zero service set up cost project signs a refined contract, its payoff is

$$p_1(v(q_e) - q_e\theta_e - \max\{c, q_i\Delta\theta\}) + (1 - p_1)(v(q_i) - q_i\theta_i).$$

It therefore prefers a refined contract if:

$$\begin{array}{rl} f > \frac{1}{1-\pi}(p_1 q_i \Delta\theta - (p_1 - p_0)c) & \text{for } c \leq q_i\Delta\theta \\ f > \frac{1}{1-\pi} p_0 c & \text{for } c > q_i\Delta\theta \end{array}.$$

Next, we analyze the case in which G with the zero service set up cost project prefers to buy the assets (that is, for all (c, p_0) such that

$$c > \frac{p_1}{p_0} q_i \Delta\theta$$

and

$$c \leq v(q_e) - v(q_i) - \Delta q \theta_e,$$

as established in Proposition 2). If G with the zero service set up cost project signs a refined contract its payoff is

$$p_1(v(q_e) - q_e\theta_e - q_i\Delta\theta) + (1 - p_1)(v(q_i) - q_i\theta_i) - (p_1 - p_0)c.$$

It therefore prefers a refined contract if

$$f > \frac{1}{1-\pi} p_1 q_i \Delta\theta.$$

The proposition therefore follows straightforwardly. ■

We have adopted a focus on separating equilibria since this provides a clean focus on when an agency wishes to use the public–private partnership model or when conventional service provision is optimal. Allowing for the service set up cost, f, to take on any (and conceivably small) values, gives us a large number of cases; for some combinations of c and f, non-existence of pure-strategy pooling or separating equilibria can be shown. While that exercise may contain some independent interest, in this paper our focus is on clarifying the incentive properties of different types of contracts a government agency can implement for two competing models of public service provision. Since we are therefore not interested in a complete description of all equilibria, in this paper we have studied the problem under the assumption that $f > f^*$.

B Appendix: "Collusion-Proofness"

In the conventional model of section 3, G offers SP a (refined) "truth-telling" contract, and if the unit cost realization is high, sues B for damages d. The concern is that after the build contract is signed, G may have the incentive to collude with SP. That is, G never pays SP the appropriate information rent, SP therefore reports (by misrepresentation) high cost always (and if cost is in fact low, makes positive profit), and G successfully sues B. This appendix argues that this collusion is not a concern.

Once the damage contract with B has been signed, the truth-telling contract that gives G payoff $V_A(p_1, d)$ may not be optimal from the point of view of G. For large enough damage payments, G may have an incentive to induce *SP* to misrepresent cost as high always, so that G can extract damage payments from B. In that case, the only binding constraints on G's maximization problem (1) are the participation constraints (4) and (5). That is, G offers *SP* subsidies $s_e = s_i = 0$. *SP* therefore reports high cost (θ_i) always and is reimbursed for its declared cost $q_i\theta_i$. This allows G to obtain damages d always and its payoff is therefore

$$V_A^M(d) \equiv v(q_i) - q_i\theta_i + d.$$

(Superscript M indicates misrepresentation.)

For completeness, we briefly show that G would never want to implement a refined misrepresentation contract in which *SP* misrepresents the cost as being low always. This is formalized by the following

Lemma 5 *For* G*, a refined misrepresentation contract in which* SP *always reports high cost dominates a refined misrepresentation contract in which* SP *always reports low cost.*

Proof. We need to prove that

$$v(q_i) - q_i\theta_i + d \geq v(q_e) - q_e\theta_e - q_e\Delta\theta.$$

(We prove this by showing that

$$v(q_i) - q_i\theta_i \geq v(q_e) - q_e\theta_e - q_e\Delta\theta.$$

Since $d \geq 0$, this proves the lemma.) This implies, and is implied by,

$$v(q_e) - v(q_i) \leq \Delta q\theta_i.$$

Dividing both sides by Δq and taking limits as $\Delta q \to 0$, we have

$$v'(q) \leq \theta_i.$$

Recall that $v'(q) = q^{-1}(q)$, which is less than (or equal to) θ_i for all feasible values of q. ■

We now take a step back to study which investments in asset quality will be implemented. In order to induce investment by B, G needs to specify damages in the build contract of $d \geq c$,[23]

[23]Suppose that it is known that the truth-telling contract with the service provider will be written. The builder knows that if state of nature 2 occurs (the only state of nature in which the investment is relevant) implementing the investment will cost c but avoid damages d. Therefore, it will invest when $d \geq c$.

and it needs to implement the truth-telling contract with *SP*. If both conditions are satisfied, G's payoff from the point of contracting with *SP* forward is $V_A^T(p_1, d)$, and investments up to a cost of $c \leq d$ will be made by B. If G implements a refined misrepresentation contract, no investment will be made by B (B is successfully sued for damages regardless of whether or not it invests c). First, we have the following

Lemma 6 *If* $d = 0$*,* G *prefers the refined truth-telling contract to a refined misrepresentation contract.*

Proof. We need to prove that

$$p(v(q_e) - q_e\theta_e - q_i\Delta\theta) + (1-p)(v(q_i) - q_i\theta_i) \geq v(q_i) - q_i\theta_i.$$

We therefore need to show that

$$v(q_e) - q_e\theta_e - q_i\Delta\theta \geq v(q_i) - q_i\theta_i.$$

By convexity of $v(q(\theta)) - q(\theta)\theta$ in θ, the result follows. ■

As the expected damage payment d increases from zero, since both payoffs $V_A^T(p, d)$ and $V_A^M(d)$ are linear in d (but increase at different rates), there exists some d^* such that for all $d < d^*$, $V_A(p_1, d) > V_A^M(d)$, and for all $d > d^*$, $V_A(p_1, d) < V_A^M(d)$. In fact,

$$d^* = v(q_e) - v(q_i) - \Delta q\theta_e.$$

Investments that cost more than $c = d^*$ cannot be implemented since the damage payment required as an incentive would provoke collusion between G and *SP*. However, since $d^* = c^*$, the collusion incentive only arises for investments that are so costly that G does not want to see them implemented anyway. Collusion therefore is not a concern in our model.