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What Should the State Buy?

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Abstract
This paper is concerned with what the state buys and in particular the decision to shift from conventional government purchase and ownership of assets toward public-private partnerships, i.e. purchase of final services, leaving the private sector supplier to design, build and own the assets. The approach emphasizes the information and contractual nature of the problem, rather than residual control. Buying services rather than assets creates different incentive structures. The central theme of the paper is how these incentives encourage efficient service delivery. We identify when the government will buy services rather than assets and amongst other results we find that the government will strictly wish to buy services when costs of delivery and build are low. This suggests that certain cross section studies of public-private partnerships versus more conventional service provision may be subject to a sample selection bias.

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1 Introduction

In the last thirty years there has been a major shift toward the use of the private sector in the delivery of services where the primary purchaser is the government. This has conventionally taken the form of the use of private contractors to operate public assets. Examples of the use of private contractors to collect refuse, clean hospitals, and run prisons are now common throughout the world. Although the widespread use of private contractors may be something new, this model of service delivery itself is relatively conventional. The major government purchase decision is still the purchase of the asset. However, government agencies are now increasingly contracting to purchase services and are leaving the design, build and ownership of the physical assets to those who commit to deliver the services. This shift in what the state chooses to buy from the private sector, away from assets and toward final services, is the focus of this paper.

The empirical privatization literature (cf., for instance, the survey by Megginson and Netter (2001)), now strongly supports the view that privately owned firms operate more efficiently, and more profitably, than publicly owned enterprises. The complete transfer of firms from public to private ownership, however, is only one way in which private sector incentives can be introduced into the public sector. In this paper, we address this latter issue: We study the appropriate role of the private sector in the provision of public services; that is, services for which a government agency is the primary purchaser. The government agency chooses between two models of service delivery. One, which we call the "conventional" delivery of services, requires contracting with a private builder to design and build an asset and separately with a service provider to work on the government-owned asset. The other, which involves the writing of a single contract with a private finance consortium (PFC) for the delivery of services, thus leaving the design, build, and ownership of the asset to the consortium. This second model of service delivery is frequently referred to as the "public–private partnership" model (cf., for instance, Vaillancourt Rosenau (2000)).

The central theme of this paper is the incentive for the efficient delivery of public services that arises within these two different models. In particular, our focus is on the relationship between what the state buys and the incentives to build assets that are efficient, and that therefore allow efficient service delivery.

The choice of government agencies to buy services without also purchasing and owning the associated assets, despite its controversial nature, is increasingly widespread, both in the US and the UK. In 2001, there were 151 privately built and managed prisons in the US, providing incar-

ceration services for a total capacity of 119,023 prisoners.[1] 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.[2] The US Air Force recently solicited bids for private flight schools to provide aircraft and initial flight training for US Air Force cadets.[3] In many countries, including Canada and the UK, air traffic control is now privately owned and provided.[4] Government funding for science and technology research is increasingly based on public–private partnerships (cf. Stiglitz and Wallsten (2000)), and so on. The extent of the superiority of private delivery is a hotly debated issue but one of the strongest arguments made for it is that it is frequently shown to be cost effective; the superiority coming from better incentives. Indeed in the classic incomplete contracts framework of Hart, Schleifer, and Vishny (1997), the incentives to reduce cost can become "too strong" if one cannot pre-commit on quality. A central result of our model is that the government agency will have stronger preferences to buy services (that is, choose the public–private partnership model of public service provision) rather than physical assets (that is, choose the conventional model) precisely when the cost of delivery of these services, including the build element, is low. That is, public–private partnerships are the appropriate model where costs are low, rather than the public–private partnerships leading to lower cost. One implication is that this may affect the interpretation of cost evidence: if there is no control for project characteristics, cross section studies of public–private partnerships versus conventionally delivered public services may be subject to sample selection bias. That is, public–private partnerships, with the associated private asset ownership, may appear overly efficient.

The model is roughly as follows. Provision of the service requires the building of an asset, and service delivery using that asset. At the build stage, investment by whoever builds the asset can improve the efficiency of the asset for its purpose. Making the asset more efficient lowers the service delivery cost, but the procuring government agency cannot observe either the builder's investment effort or the resulting cost of service delivery. The government agency therefore needs to create incentives through appropriate contract design. In the conventional model, the government agency

[1] 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).

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

[3] Source: Aircraft Owners and Pilots Association (2001) "Air Force Training Contract Angers Bidders" *AOPA Pilot* March 2001.

[4] Source: Poole, R. W., Jr. and Butler, V. (2001) "How to Commercialize Air Traffic Control" *Reason Public Policy Institute Policy Study* 278 (*www.rppi.org/air.html*).

has to provide incentives separately to the builder and the service provider, but this allows the government agency to provide incentives separately for the two tasks, asset building and service delivery. In the public–private partnership model, the government agency can provide incentives for efficient service provision only to the public finance consortium (PFC) and therefore cannot differentiate between build and delivery tasks, but only one agent needs to be incentivized. If the investment required to improve the efficiency of the asset at the build stage is relatively small, the public–private partnership model allows implementation of an incentive scheme relatively more cheaply, and the government agency will therefore choose public–private partnerships for such projects. If the investment necessary to improve asset efficiency is large, the conventional model of public service delivery provides incentives to implement that investment more cheaply, and the government agency will choose conventional provision for those projects.

The paper is organized as follows. In the remainder of this section, we link our paper to some of the literature. Section 2 presents the model. As indicated above, we study the cost to the government agency of providing contractual incentives for efficient service provision. A natural assumption is that the government agency has private information about some of the cost characteristics of service provision. If the government agency shares its information with the service provider or PFC, it also discloses project characteristics that allow the service provider or PFC to obtain information rent in the relationship with the government agency. 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. Section 3 deals with the case where the government agency has favorable information and therefore discloses project characteristics to the service provider or PFC. The service provider or PFC therefore obtains private information. We study the cost to the government agency of providing incentives for the private sector to invest in efficient public services, first in the conventional model, and then in the public–private partnership model. We then compare the two models to establish which model achieves efficiency more cheaply. This section contains the main body of our results. In order to establish the separating equilibrium, we also need to study the case where the government agency has unfavorable information about the project. Section 4 therefore completes the analysis by briefly addressing that case. Since the government agency has unfavorable information about the project, the service provider or PFC

obtains no private information. Again, we study incentives in the conventional and public–private partnership models, and make cost comparisons between the two. The final section 5 concludes. Additional material on the potential for collusion can be found in appendix B.

1.1 Relation to the Literature

Our paper provides a new perspective on the old "make-or-buy" decision in government procurement. This literature has usually assumed that the government's choice problem is the decision about whether to make or buy an asset, and the literature has given us insights into the efficiency properties of various contractual forms through which governments can acquire assets (cf., for instance, Bajari and Tadelis (2000)). This literature also usually assumes that contracts about asset procurement are complete, in the sense that all eventualities can be specified in the contract.[5] In this paper, we also adopt a complete contracts approach. 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 often we cannot separate the asset purchasing decision from the question of the provision of services using the 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. We therefore study not only the choice of asset procurement contracts, but the simultaneous choice of asset procurement, and service delivery.

The literature on contractual incompleteness (cf. Hart and Moore (1990), and Hart (1995)) assumes that complete contracts cannot be written, and it therefore studies very generally the question of ownership allocation, and the incentives that result from ownership of an asset. In that literature, incentives (for instance, incentives for investment in cost reduction) are governed by the asset owner's residual control rights when non-contractible circumstances arise. Generally, when non-contractible circumstances do arise, the owner of the asset can capture some of the profits of the individual that works with the asset through contract renegotiation. This hold-up problem frequently leads to underinvestment in asset-specific human capital or other specific investments.[6] The theory predicts that such specific investment incentives are generally stronger for the asset owner.

[5] For instance, cf. the textbook treatment of the procurement problem in Laffont and Tirole (1993).

[6] See Grout (1984). This may not be true when the interaction is repeated, that is when reputation matters: cf. Halonen (forthcoming).

Adopting an incomplete contracts perspective, Hart, Schleifer, and Vishny (1997) study the question of cost reduction in the provision of public services. Roughly, their argument is as follows. When contracts are incomplete, the asset owner can extract some of the returns to cost-reducing investment from the agent working with the asset. When an asset is owned by the government, incentives to invest in quality improvement and cost reduction are therefore typically weaker (since the service provider needs to negotiate with the government about each quality or cost innovation) than when the asset is owned by the private service provider. Hart, Schleifer, and Vishny (1997) envision cost reduction as necessarily reducing service quality. Since the private owner is not concerned with the negative effect of cost reduction on service quality, private ownership implements greater cost savings, but service quality tends to be too low.

In this paper, we adopt a complete contracts approach, and shift the focus of discussion away from the residual control rights arising from *ownership* toward the incentives created by the *purchase* of assets and services by the government agency. We emphasize that in order to have ownership of an asset, the asset must have been purchased first. If information is not symmetrically available at the time of the purchase decision, there is scope for contractual incentives to matter. We focus on incentives for cost-reducing (that is, efficiency-enhancing) investments in the asset that is used to deliver a public service. We believe that a central feature of the choice between what we call conventional and public–private partnership service provision is the choice between different contractual mechanisms for the purchase of service delivery and/or asset building (that is, a choice between which contracts can be written), and these mechanisms have implications for the implementability of efficiency-enhancing investments. We find that for certain types of projects, letting the service provider procure and own the asset results in greater investment in efficiency-enhancements to the asset. We show that an important ingredient is what information is available to the contracting parties at the point when asset procurement and service provision contracts are negotiated.

2 The Model

The government agency seeks to provide a public service that requires a physical asset and service provision using that asset. In what we call the "conventional" model, the government agency purchases the asset from a private builder, and the service is provided by a private service provider using the asset (provided to it by the government agency). In the "public–private partnership" model the government agency purchases the service and the provider of the service builds and owns

the asset.

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 depend on the characteristics of the specific project.

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.[7] 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 public service provision, and the design and build of assets is not available equally to all players. We now specify the information structure of the model, and how information may be shared.

The service set up cost, $\tilde{f}$, is known privately to the government agency, since it knows the nature of the project. For instance, the government agency may know this cost because prior to

[7] We present the two cost components of service provision as fixed (set up) and variable (unit) costs purely for expositional convenience. All we need for our model is that some components of cost are privately known to the government agency, and some components are known to whoever provides the service.

privatization it may have provided the service itself. The service set up cost can become known to whoever provides the service, but only if the requirements of the project are fully specified by the government agency at the time of contracting.[8] The government agency therefore 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 the government agency'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 the government agency's information, is called a "generic" contract. Intuitively, when the government agency 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 the government agency of service delivery. That is, if the project has zero service provision set up cost, the government agency offers a refined contract. Therefore, if the service provider 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.

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

In particular, if the government agency writes a refined contract with the service provider, the service provider 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 the government agency to negotiate with the service provider in a manner that specifies in full detail the project characteristics, and hence reveals the government agency's information, but does not convey information about the unit cost of service provision to the service provider.[9]

[8] 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, whoever provides the service knows whether they will be costly to solve or not. We elaborate this intuition in section 2.2.3.

[9] That is, the government agency has control over whether to give the service provider pre-contractual private infor-

In contrast, if the government agency writes a generic contract with the service provider, the service provider 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, the government agency's and the service provider's information is symmetric.

Build Stage. Turning to the build stage, whether the builder chooses to invest c or not is not directly observable to the government agency or the service provider.

When the government agency contracts with the builder, it can offer a generic or a refined contract. If the government agency offers a generic contract that specifies only broad project requirements, then at the time of signing the contract the builder learns no new information. The builder 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, the builder learns privately whether this investment of cost c needs in fact to be made.

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

2.2.2 The Public–Private Partnership Model

In the public–private partnership model, the government agency contracts with a public finance consortium (PFC) for the delivery of the service, and the PFC designs, builds, and owns the asset.

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

If the government offers a generic contract to the PFC, the PFC does not learn any specific information about the project directly, but in equilibrium the PFC can infer that the service set up cost must be high. In particular, although the PFC 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.

mation. Similar information management issues are studied by Crémer and Khalil (1992) and Lewis and Sappington (1997).

As in the conventional model, the government agency cannot observe the unit cost, $\tilde{\theta}$, or whether the PFC 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. The builder or PFC 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 the builder or PFC has encountered and solved the problem before is obviously information private to the builder or PFC, and therefore the government agency does not observe whether an investment cost is necessary to provide an efficient asset.

Furthermore, when the government agency fully specifies the details of the project in a refined contract, hence revealing low set up costs, the builder or PFC 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 the government 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 Service Demand and 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 $q^{-1}(\cdot)$.[10] We denote $q_e = q(\theta_e)$, $q_i = q(\theta_i)$, and $\Delta q \equiv q_e - q_i$. Note that $q_e > q_i$. Whoever provides the service produces output q at a total cost of θq, for which the government agency pays $kq(k)$, $k \in \{\theta_e, \theta_i\}$, depending on reported costs. In addition, whoever provides the service may obtain a subsidy, s, from the government agency.

All agents are risk neutral.

2.3.1 The Government Agency's Objective

The government agency's objective is the maximization of net consumer surplus,

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

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

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

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

and t denotes other net transfers from the government agency. Obviously $v'(\cdot) > 0$ and $v''(\cdot) < 0$.[11]

2.3.2 The Service Provider's Objective

The service provider 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.

2.3.3 The Builder's Objective

In the conventional model, the government agency contracts with the builder, and the contract specifies a fixed fee, m, for building the asset, and damages d as an incentive to invest in asset efficiency. The builder'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. The government agency 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:

   - The government agency chooses the type of contract (refined or generic) it will offer to each party.
   - The government agency contracts with a builder over the building of the asset and writes a separate contract with the service provider.
   - The builder chooses whether to make the (unobservable) investment in asset quality.

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

- Finally, the service provider 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:

   - The government agency writes a contract (refined or generic) with the private finance consortium (PFC).
   - The PFC chooses whether to make the unobservable investment in asset quality.
   - The PFC 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 the government agency has a project that has a zero service set up cost ($\tilde{f} = 0$) in section 3. We study the outcome if the government agency opts for the conventional asset purchase model, and then if the government agency uses the public–private partnership model. Finally we compare these to decide the approach the government agency 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 the government agency 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 Projects with no Service Set Up Cost

In this section we study public projects with no fixed set up cost of public service provision. As argued previously (we prove this in appendix A), the government agency will choose to offer a refined contract to the service provider or PFC that specifies in detail the project characteristics. This allows the government agency to share its information about the service set up cost (reducing the expected payment to the service provider or PFC). A refined contract however also reveals to the service provider or PFC pre-contractual private information about the unit cost of service provision (which allows the service provider or PFC 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 the builder to make investments in improving the efficiency of an asset becomes more expensive to implement for the government agency the more costly the required investment is. We obtain a limit on the most costly investment the government agency 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 the procuring government agency's choice between the two models of public service delivery. We find that there is a threshold of investment costs: below the threshold, the government agency 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, the procuring government agency contracts with a builder to build an asset. The builder 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 the builder, and therefore the contract cannot be enforced on whether c is invested or not. However, the government agency will provide incentives to the service provider to report truthfully on the cost outcome of the builder's effort so that, as in a standard moral hazard problem, incentives for the builder can be conditioned on the inferred outcome of the builder's effort. The contract with the service provider is a refined contract, so that the service provider learns the cost of service provision, and the incentive contract with the service provider therefore is the standard adverse selection type. In equilibrium, the service provider reveals cost conditions truthfully (and, if the cost is low, extracts information rent). Having learned the unit cost, the government agency can now enforce the incentives provided to the builder, 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 the builder is expected to make, the higher the cost of the contract the government agency writes with the builder. There is a level of investment cost that is too costly to implement, and we identify that level.

Specifically, the government agency writes a generic contract (m, d) with the builder, specifying money payments m to the builder, and damages of size d as the incentive to invest in asset efficiency.[12] Since it is a generic contract, the builder has no pre-contractual information about whether any efficiency improvements can in fact be made to the asset. The builder's payment is conditioned on the unit cost outcome reported by the service provider: the builder 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 the builder's action is not directly observable by the government agency. In equilibrium, however, the service provider is given incentives to reveal the cost of service provision truthfully, and therefore litigation (contractually specified damages of size d) against the builder is successful whenever the service provider claims that unit service provision costs are high.[13] The builder therefore makes the investment whenever $d \geq c$. Competition for the building contract eliminates *ex ante* profits, so that the payment from the government agency to the builder is

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

to satisfy the builder's participation constraint.

We now turn to the service provider to study the optimal refined service provision contract for a project with zero service set up costs. Since the government agency offers a refined contract there is asymmetric information about the unit cost of service provision (the service provider learns whether the asset is efficient but the government agency does not). The second-best optimal contract between agency and service provider under conditions of adverse selection is standard (cf. Baron and Myerson (1982)).[14] The revelation principle allows the government agency to restrict attention, without loss of generality, to direct revelation mechanisms (in which the service provider 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 the builder has or has not made the efficiency-improving investment), the government agency designs a contract (schedule of subsidies) (s_e, s_i)

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

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

[14] Note, however, that here we reduce the number of the government agency's instruments: it can only control the subsidy to the service provider; the agency's conjecture over cost is fixed to be $k(\theta) = \theta$, and correspondingly output is $q(\theta)$. We appeal to the idea that for efficiency reasons, the government agency is required to price at marginal cost.

for the service provider 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 the government agency. 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 the service provider.

As is standard, we have the following lemma:

Lemma 1 *(2) and (5) are binding in equilibrium, and (3) and (4) are slack.*

The proof for this "constraint reduction theorem" is standard and therefore omitted here.

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 the service provider if the unit cost is low.

The government agency's payoff from its relationship with the service provider is therefore

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

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

The government agency's *ex ante* payoff from writing a contract with the builder that gives the builder the right investment incentives, and a contract with the service provider that fulfills constraints (2)–(5) is

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

since the builder needs to be reimbursed for its expected investment cost, and for expected damage payments. The government agency'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 the service provider is second-best optimal, the government agency 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 result, illustrated in figure 1:

Proposition 2 *When the government agency has purchased and owns the asset, it wants to induce investment up to an investment cost of*

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

Proof. The proposition follows from the argument in the text. ■

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 the government agency buys the service only. In this framework, the public finance consortium (PFC) builds the asset and provides the service. The intuition is the following: as indicated above, the government agency offers a refined contract, and the PFC 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 the PFC to capture information rent whenever service provision cost is low. The incentive for the PFC to invest in efficient assets is therefore determined by the size of the information rent. The government agency can therefore implement relatively cheap investments at no additional cost: the standard information rent required to implement truth-telling by the PFC 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 the government agency needs to leave to the PFC in order to achieve investment. The government agency 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 the PFC 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), the government agency designs a refined contract (schedule of subsidies) (s_e, s_i) for the PFC 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

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

The government agency'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 the government agency 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, the government agency 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 the government agency and does not increase the investment incentive, we know that, in any refined PFC contract, $s_i = 0$. The highest rent the government agency can therefore give to the PFC, and still induce truth-telling about the efficiency of the asset is $s_e = q_e \Delta\theta$. Note that the PFC's individual rationality (participation) constraint is of course always satisfied, and no additional transfers are required. The government agency'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 the government agency prepared to increase rent if that increase induces investment? The government agency'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 the government agency can induce investment that way, it would therefore wish to increase the subsidy (information rent) to the low-cost PFC 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

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

In the following lemma we prove that

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

so that we know that the point to which the government agency would wish to increase the subsidy to the PFC is (a) greater than the lowest rent that induces revelation and (b) less than the highest rent that still induces separation. The following lemma proves this:

Lemma 3 *$q_i\Delta\theta \leq s_e^* \leq q_e\Delta\theta$.*

Proof. 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

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

or

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

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 $q \in [q_i, q_e]$. ■

The preceding discussion prompts our next result:

Proposition 4 *If the government agency chooses the public–private partnership model then the government agency wants to implement investments up to an investment cost of*

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

Proof. Since we know that the service provider will invest if, and only if, $c \leq s_e$, and we know that the government agency is willing to increase s_e up to

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

the proposition follows. ■

Again, figure 1 illustrates.

3.3 Buying Assets or Buying Services?

We now have a complete description of implementable investments under conventional provision and public–private partnerships. In this section, we turn to the question of which of these two models of service provision the government agency will choose.

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

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

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

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

The government agency chooses the structure that maximizes its *ex ante* expected payoff; that is, it chooses the public–private partnership model over conventional service delivery when[15]

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

This of course is just

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

For all $c < q_i\Delta\theta$, the government agency therefore prefers to buy services only. For $c \geq q_i\Delta\theta$, the government agency 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 $\frac{p_1}{p_0} q_i\Delta\theta$), the government agency prefers to induce the investment just through the rent payment to the PFC (which needs to be paid to the service provider anyhow in order to induce revelation). In this sense, the government agency obtains investment essentially for free.

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

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

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 $c^* = v(q_e) - v(q_i) - \Delta q \theta_e$ the government agency prefers to implement investments, rather than not implement them, and the government agency will therefore choose the conventional model.

We summarize the preceding discussion in the following proposition:

Proposition 5 *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 the government agency. 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 the government agency to buy assets. For all c such that

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

but

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

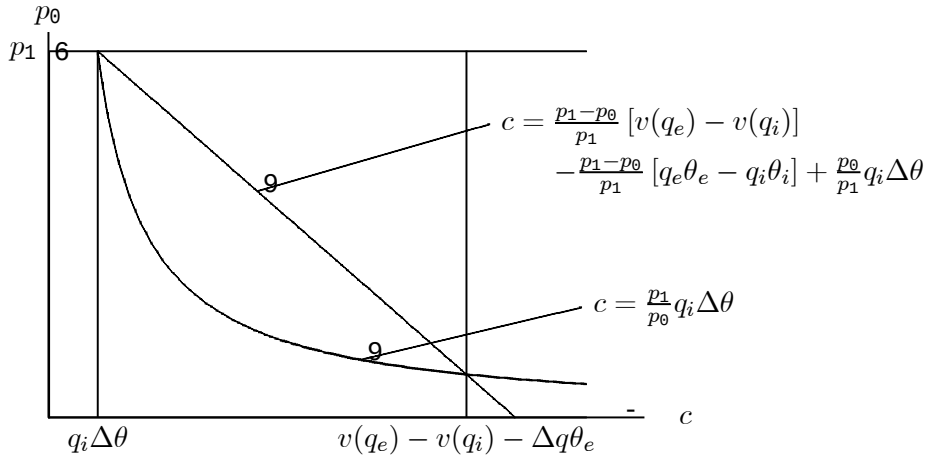
the public–private partnership model is optimal.

Proof. The proposition follows from the preceding discussion. ■

Proposition 5 is summarized in figure 1, below. The figure is drawn on the assumption that

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

Figure 1: investments under conventional and public–private partnership service provision



The proposition states that, as is intuitive, for small required investments, and for investments that improve asset quality dramatically ($\frac{p_1}{p_0}$ is large), the public–private partnership model is optimal. This is straightforward. Consider small investment costs (or equivalently, very effective investments) first: The government agency would rather provide investment incentives through the cheaper way of the information rent to the PFC through the public–private partnership route. This is less costly for the government agency since the PFC needs to obtain rent anyway in order to reveal cost conditions to the government agency. For small investment costs, this (standard) rent is sufficient for the PFC to want to invest in asset efficiency. If the government agency were to purchase the asset in the conventional model, it would need to pay the builder separately for the expected investment cost, which is more costly. Next, for intermediate levels of cost (up to the point at which the conventional agency purchase model can no longer induce investment), government agency purchase of assets is optimal. These levels of investment costs are those for which it is cheaper for the government agency to provide investment incentives directly: the government agency needs to reimburse the builder's expected cost (i.e. cost which arises with probability $p_1 - p_0$

only), whereas the subsidy to the PFC is paid whenever cost is low (that is, with probability p_1). Finally, when investment can not be induced through the government agency purchasing the asset, but it can be induced through public–private partnerships, the government agency prefers the public–private partnership model.

4 Projects with Positive Service 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 the government agency has a project with a set up cost f. In that case, the government agency does not disclose project characteristics, and the question is therefore an entirely conventional contracting problem under imperfect, but symmetric information.

As indicated above (we prove this in appendix A), if f is sufficiently large, the government agency will offer generic service provision contracts. Since we are studying separating equilibria, this will convey to the service provider or PFC that the fixed cost is f, but it protects the government agency 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 the procuring government agency 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, the government agency writes a generic contract with the service provider. That is, in its relationship with the service provider, the government agency seeks to

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

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 the service provider 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 the government agency's payoff from its relationship with the service provider 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, the government agency'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

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

(the builder needs to be reimbursed for its expected investment cost, and for expected damage payments). The government agency'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 the government agency 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 the government agency signs a generic contract with a PFC when a project has positive set up costs it seeks to

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

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 the service provider an expected rent of zero.)

Optimal subsidies are

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

and

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

and the government agency'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 the government agency.

The government agency 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 the government agency 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 the government agency purchases the asset the government agency's *ex ante* payoff is

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

(the builder needs to be compensated for expected investment cost and expected damage payments). Under the public–private partnership model the government agency'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 the government agency is precisely indifferent between buying assets and buying services. This discussion is summarized in the following

Proposition 6 *When there is a positive set up cost of service provision, the government agency 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, the government agency 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. The government agency obviously does better with a generic contract since it protects it from having to give information rent to the service provider and the PFC whereas a refined contract would also reveal that the project has high set-up costs but would expose the government agency

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 the government agency. The government agency 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 investment in 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 public–private partnership model), and the PFC designs, builds, and owns the asset. Furthermore, these mechanisms differ with respect to the cost at which investments that increase asset efficiency can be implemented.

We find that, when set up costs of service delivery are low, and for intermediate levels of investments required to make the asset efficient for service, the conventional route is chosen: the state should buy assets, not services. However, when efficiency-enhancing investments are relatively cheap, or if it is very likely that the opportunity for the asset builder to make these investments arises, public-private partnerships will be chosen as a mechanism for public service provision: in this case, the state should buy services, not assets.

The striking implication of our model is that public-private partnerships are chosen precisely when service delivery and investments in efficiency enhancements are relatively 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 public–private partnership model (with its associated private ownership) may thus appear more efficient and cost effective than it actually is.

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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 the government agency has a project that it knows has zero service set up cost, it chooses to reveal this information to the service provider or PFC by offering a refined contract. Offering a generic contract therefore implies that the government agency has a project with positive service set up cost, f. The intuition for this result is simple: If the government agency offers a project with positive service set up cost and the service provider or PFC does not have information about the set up cost, the government agency need only pay the service provider the expected cost (both fixed and variable) of service provision. That is, it can write a contract that induces truth-telling by the service provider or PFC without leaving the service provider or PFC information rent.[16] 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 the government agency can reveal that the service set up cost of its project is zero, it need not pay the service provider or PFC for expected service set up costs at all. In our model, if the government agency 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 the service provider or PFC to learn the variable cost of service provision θ also, and the service provider or PFC 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 7 *There exists a level of fixed cost of service provision f^* such that, if the government agency has a project with zero service set up cost, it will always reveal that information to the service provider of PFC. That is, a separating equilibrium exists.*

Proof of Proposition 7. 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

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

[16] 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, the government agency 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 the government agency 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 the government agency 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 5). If the government agency 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:

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

Next, we analyze the case in which the government agency 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 5). If the government agency 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, the government agency offers the service provider a (refined) "truth-telling" contract, and if the unit cost realization is high, sues the builder for damages d. The concern is that after the build contract is signed, the government agency may have the incentive to collude with the service provider. That is, the government agency never pays the service provider the appropriate information rent, the service provider therefore reports (by misrepresentation) high

cost always (and if cost is in fact low, makes positive profit), and the government agency successfully sues the builder. This appendix argues that this collusion is not a concern.

Once the damage contract with the builder has been signed, the truth-telling contract that gives the government agency payoff $V_A(p_1, d)$ may not be optimal from the point of view of the government agency. For large enough damage payments, the government agency may have an incentive to induce the service provider to misrepresent cost as high always, so that the government agency can extract damage payments from the builder. In that case, the only binding constraints on the government agency's maximization problem (1) are the participation constraints (4) and (5). That is, the government agency offers the service provider subsidies $s_e = s_i = 0$. The service provider therefore reports high cost (θ_i) always and is reimbursed for its declared cost $q_i\theta_i$. This allows the government agency 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 the government agency would never want to implement a refined misrepresentation contract in which the service provider misrepresents the cost as being low always. This is formalized by the following

Lemma 8 *For the government agency, a refined misrepresentation contract in which the service provider always reports high cost dominates a refined misrepresentation contract in which the service provider 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 the builder, the government agency needs to specify damages in the build contract of $d \geq c$,[17] and it needs to implement the truth-telling contract with the service provider. If both conditions are satisfied, the government agency's payoff from the point of contracting with the service provider forward is $V_A^T(p_1, d)$, and investments up to a cost of $c \leq d$ will be made by the builder. If the government agency implements a refined misrepresentation contract, no investment will be made by the builder (the builder is successfully sued for damages regardless of whether or not it invests c). First, we have the following

Lemma 9 *If $d = 0$, the government agency 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 the government agency and the service provider. However, since $d^* = c^*$, the collusion incentive only arises for investments that are so costly that the government agency does not want to see them implemented anyway (by proposition 2). Collusion therefore is not a concern in our model.

[17] 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 $d \geq c$.