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Building and Managing Facilities for Public Services

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Abstract
We model alternative institutional arrangements for building and managing facilities for provision of public services, including the use of the Private Finance Initiative (PFI), by exploring the effects on innovative investment activity by providers. The desirability of bundling the building and management operations is analyzed, and it is considered whether it is optimal to allocate ownership to the public or the private sector. We also examine how the case for PFI is affected by the (voluntary or automatic) transfer of ownership from the private to the public sector when the contract expires. Asset specificity and service-demand risk play critical roles.

Keywords: private finance initiative (PFI), public-private partnerships, integration versus separation, residual value, incomplete contracts.

JEL Classification: D23, H11, L33

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1 Introduction

The provision of public services is often organized through contracting out by governments to private profit-maximizing firms. Recently, however, governments in Western Europe and North America have developed new forms of public-private partnership (PPP) for public service provision (Rosenau, 2000). A form of PPP that has attracted particular attention is the Private Finance Initiative (PFI) developed in the UK (Grout, 1997; HM Treasury, 2000). PFI contracts cover most forms of public service provision, including health, education, defence, prisons and roads. HM Treasury (2003) estimates[1] that, over the period 1998-9 to 2003-4, private sector investment in public services through PFI was between 10 and 13.5 per cent of total investment in public infrastructure, with 451 PFI projects completing construction, including 34 hospitals and 119 other health schemes, and 239 new and refurbished schools.

There are two major differences between PFI and previous arrangements. First, PFI typically involves the bundling of the design, building, finance, and operation of the project, which are contracted out to a consortium of private firms for a long period of time, usually 25-30 years. The consortium includes a construction company and a facility management company and is responsible for all aspects of services. Second, a system of output specifications is used: the government specifies the service it wants, and some basic standards, but it leaves the consortium with control rights over how to deliver the service. The consortium has responsibility for the infrastructure facility during the contract period, during which it may implement innovative approaches to service delivery and it may use the facility for additional income-generating activities - provided the basic standards of service provision are not violated. However, there is no specific rule as to what happens to facilities at the end of the contract, although, in practice, in the few contracts that have been completed, in the cases of schools, hospitals and prisons, the facilities have been returned to the public sector, whilst for accommodation and general IT systems, they have been kept by the private sector

[1] HM Treasury will publish a document with updated figures by the end of 2005.

(HM Treasury, 2002, 2004).

PFI contrasts sharply with the way public services have traditionally been procured. Under traditional procurement (TP) the different stages of an infrastructure project are contracted out separately to different private firms and an input specification approach is followed, with the government keeping ownership of the facility both throughout the contract period and after the contract ends (HM Treasury, 1998).

The primary motivations for PFI schemes are to allow the consortium to exploit synergies between different stages of a project, and to incentivize the consortium to come up with innovative approaches to service delivery (Daniels and Trebilcock, 2000; IPPR, 2001).[2] Yet, evidence on the performance of PFI, relative to that under TP, is mixed. On the one hand, a greater proportion of projects is being delivered on time and within budget than under TP (National Audit Office, 2003b). In PFI prisons, for example, innovative solutions have been incorporated that had not featured previously, and there is evidence that greater benefits and lower costs are being achieved (National Audit Office, 1997, 2003b). On the other hand, the quality and cost of some early PFI schools have been worse than under TP (Audit Commission, 2003).

In this paper we analyze the factors underlying these stylized facts.[3] First, we study the desirability of the two defining characteristics of the PFI model: whether it is optimal to bundle the different stages of production and whether control rights should be given to the private firm(s). Second, we focus on an important practical concern for public infrastructure projects involving long-term private investments: the role of the residual value the facility, and of ownership of the facility once the contract expires.[4] We consider a model in which there are three stages to a project. The first is

[2] Specifically, HM Treasury (2003) states that '[t]he public sector defines the service to be delivered, but it is for the private sector partner to decide how to deliver it, drawing on its own *innovation* and experience. This provides the private sector with an incentive to develop innovative ways to meet requirements, and allows the public sector to harness the efficiency that can come from contestability, helping improve standards across the public sector.' (Emphasis in original)

[3] This is a much revised version of Bennett and Iossa (2002).

[4] Although the source of finance for the project is an important element of PFI, the analysis of finance is beyond the scope of this paper. See Sussex (2001) for discussion of how the private finance element might be excluded from PFI in the health sector.

the 'building' of a facility (we interpret this stage to include design), while the second is the 'management' of public service provision using the facility. The government delegates these two functions to the private sector, and, because the functions require specialized skills, two distinct firms carry out the tasks. We compare the case of unbundling, where the government contracts with the two firms separately, with the case of bundling, where the government writes a single contract with a consortium of the two firms. For bundling and unbundling, we consider both private and public ownership. Private ownership with bundling is interpreted as PFI; public ownership with unbundling is interpreted as TP. The third stage in our model relates to what happens to ownership at the end of the contract period.

To reflect the emphasis given to innovation under PFI, we model investments by the firms as the undertaking of research into innovative approaches to carrying out their respective tasks. Such investments are noncontractible *ex ante* but verifiable *ex post*: whilst it is not possible to contract *ex ante* on the delivery of an innovation, once a potential innovation has been discovered, its implementation is verifiable. If implemented, an innovation may affect social benefit, management/maintenance cost, and residual value. We assume that, due to contractual incompleteness, ownership rights result in control rights: the owner of the facility during the contract period has the power to decide (and veto) whether any given innovative activity can be implemented.

Thus, under private ownership, provided that basic standards are not violated, the owner (a firm or consortium) has the power to implement an innovative approach unilaterally. In contrast, under public ownership, renegotiation between the firm/consortium and the authority must take place before an innovation may be implemented. This modelling strategy seems to reflect existing evidence on the different nature of renegotiation under TP and PFI. House of Commons (2003) cites a census that compares the extent of renegotiation of the contract price under these two arrangements. Under TP, in 73% of construction projects the final price exceeded that agreed at contract. Under PFI, the corresponding figure was only 22%, and where there had been a price increase this had mainly been due to changes that had been led by the government department,

not the contractor. Such price increases related to further work or facilities that had not been part of the original specification, or to changes to the function of a building.[5]

Our first result is to show that synergies between the stages of the project do indeed play a critical role, although they do not necessarily work in favor of PFI. A building innovation that increases the social benefit from a project may be associated with either reduced cost at the management stage (we call this a positive externality) or increased cost at the management stage (we call this a negative externality). For example, the design of a prison with better sight-lines for staff that improve security (i.e., social benefit) may yield the positive externality that the required number of security guards is reduced. In this case, bundling is always optimal, for it allows internalization of the positive externality. However, an innovative design of a hospital, using recently-developed materials, may lead to improved lighting and air quality, and therefore better clinical outcomes, but may have the negative externality of increased maintenance costs. In this case unbundling may become optimal, making a consortium undesirable. This is because, in a world where contracts are incomplete, the hold-up problem may lead to underinvestment even under the preferred ownership structure. To attenuate the underinvestment problem, it may become optimal to induce the firms not to internalize the negative externality (a second-best result) since internalization would depress incentives further.

Our next set of results relates to the issue of optimal ownership and thus control rights. The intuition follows Hart Shleifer and Vishny (1997). Under private ownership, the firm/consortium has ownership and control rights. Therefore, if there are private gains from implementing the innovation, it will implement the innovation without any further inducement. In this case a promise by the government to reward the firm/consortium for the increase in social benefit following the innovation would not be credible. Realizing this, the investor will disregard the effect on social benefit

[5] In practice renegotiation sometimes occurs under PFI, for example when the consortium refinances the project. However, this is not in the spirit of PFI. As stated by the Audit Commission (n.d.), "[p]urchasers should recognize the need for incentives to encourage contractors to innovate. They should also appreciate that it is generally counter-productive to insist that all benefits are taken by the purchaser under these circumstances."

when it decides on its investment. In contrast, when control rights are left with the government, the firm/consortium has no power to implement the innovation unless renegotiation occurs. But, through renegotiation, it will internalize some of the benefits that its innovation brings to the government, and give up a share of the private benefits that the innovation brings to itself. In our context this implies that, with a positive externality, control rights should lie with the firm/consortium if the cost and residual value effects dominate the social benefit effect, and with the government in the reverse case. In contrast, with a negative externality, provided the cost effect is relatively small, a large residual value effect favors ownership by firm 1, and a large social benefit effect favors ownership by the government.

Innovation during the contract period is also related to how the facility will be used after the contract expires. In practice, with PFI, the facility is in some cases retained by the consortium at the end of the contract period, but in others it is transferred back to the public sector, mostly automatically. In our analysis, assuming a positive externality, these arrangements do not affect the rationale for bundling. Furthermore, the prospect of a possible transfer of ownership to the public sector - if this can be achieved by voluntary negotiation, and the payment of agreed compensation - improves the consortium's investment incentives. But, given the unverifiability of investments and residual value, an automatic transfer clause in the PFI contract is necessarily inoptimal because it blunts these incentives. We explore these issues by assuming that when the initial contract is agreed, there is uncertainty concerning the relative sizes of the 'public residual value' (the residual value if the facility is used in the public sector when the contract ends) and the 'private residual value' (the facility being used in the private sector).

Our analysis leads to specific results concerning the factors favoring the use of PFI. It is more likely to be optimal to use PFI if the externality is (more strongly) positive, if the effect of innovation on social benefit is relatively small, and if the effect on residual value is relatively large. Also, PFI is more likely to be optimal the more probable it is that the private residual value will be higher than the public residual value, and the

lower the specificity of the facility for public, rather than private, use at the end of the contract. These results are generally consistent with empirical evidence on PFI, which we cite where relevant below.

Several recent contributions apply the theory of incomplete contracts to the contracting out of public services. Hart, Shleifer and Vishny (1997) compare contracting out with in-house provision to a single private firm. They show that when there is contracting out the private firm will reduce costs excessively, at the expense of quality, whereas with in-house provision there are blunted incentives for both cost reduction and quality improvements.[6] Besley and Ghatak (2001) study the optimal provision of public goods and show that ownership of a public good should lie with the party that values more highly the benefit that the public good generates. Neither of these papers discusses bundling, but Hart (2003) finds that bundling is desirable if the quality of the service can be well specified in the initial contract, whereas the quality of the building cannot. In contrast to our analysis, he assumes that investments are never verifiable (so renegotiation never takes place) and in his model it does not matter who owns the facility at the end of the contract.[7] King and Pitchford (2001) also discuss bundling and consider the possibility of spillovers onto the value of other facilities. However, they model public and private ownership as distinct sets of rules that affect managerial discretion, and so no bargaining ever takes place. An alternative, complete-contract, approach to PFI is taken by Bentz, Grout and Halonen (2001). They show that the government will wish to buy services (as in PFI) rather than facilities (as in TP) if the building and service delivery costs are low. None of the papers cited here analyzes explicitly the role of residual value.

Section 2 outlines the model, and Section 3 analyses the level of investments under alternative regimes. Section 4 compares different ownership structures first for a

[6] See also Schmidt (2000) for an extension of this model to the case of joint ownership by the state and the private investor.

[7] An incomplete-contract model is also formulated by Bös and De Fraja (2002) to analyze the provision of health care for which quality is unverifiable. In their analysis a hospital both builds and manages a facility, i.e., there is bundling. They focus on the effects of investment by the health care authority in 'contingency plans,' which give it the option to purchase care from outside providers.

positive and then for a negative externality, while Section 5 explores issues relating to residual value. Section 6 concludes.

2 The Model

We consider a setting where a governmental agency such as a ministry or a local authority (hereafter, 'the government') delegates to private firms the building and management of a facility (or 'facility ') that will be used to supply a public service. To take into account the possibility that each stage of production requires specialized skills, we allow for the existence of two private firms: firm 1 is specialized in building, while firm 2 manages the facility once it is built. The building and management functions will be said to be 'bundled' if the two firms are organized as a consortium that contracts and operates as a single unit. The functions are 'unbundled' if the two firms operate independently and the government contracts separately with each of them.

Initially, a contract is agreed which includes a specification of basic standards that must be (at least) met in the building and management stages. The satisfaction of these basic standards is assumed to be observable and verifiable. However, at the beginning of each stage of the project, building and management, the firm concerned may make an observable but unverifiable investment, researching innovative approaches to performing its task. Let a denote the level (and cost) of investment made by firm 1 at the beginning of the building stage and let e denote the level (and cost) of investment made by firm 2 at the beginning of the management stage ($a, e \geq 0$). We assume that each innovation, if implemented, affects the social benefit that is generated by the production of the public service once the facility is built and run. Also, as we shall specify below, the building innovation a may affect costs in the management stage and the residual value of the facility .

Neither innovation can be contracted upon *ex ante*, for it is not possible to specify in advance the delivery of a specific innovation. However, this uncertainty is resolved after the investment in research is made. We assume that the implementation of

any innovation requires the approval of the owner of the facility; thus, if there are positive gains from implementing an innovation, renegotiation between the owner and the investor will occur at this stage. However, if the investor is the owner, it always implements an innovation that would yield it a positive gain; that is, the investor cannot commit not to implement the innovation.[8]

Parties are risk-neutral and have rational expectations about the renegotiation process when they make their investments; that is, they can make correct calculations about the expected returns from any action. All variables may be interpreted in expected terms and are assumed to be discounted appropriately.

The timing of the game can be summarized as follows. In period 0, the ownership structure is chosen. Also, the government specifies the basic standards and the prices that it will pay to firms 1 and 2, respectively, or to the consortium of firms 1 and 2, for satisfying these standards. Period 1 is the building stage, at the beginning of which firm 1 can undertake research to improve on the contracted design of the facility. Conditional upon the approval of the owner, negotiation may take place to allow the innovation to be incorporated into the building of the facility. Period 2 is the management stage, at the beginning of which research can be carried out by firm 2 to find ways to improve on the contracted level of service. Again, negotiation may take place to allow the innovation to be implemented in the supply of the service. When period 2 ends, the contractual relationship between the firms and the government ends. We assume for now that in period 3 the owner of the facility can freely decide on its future use; this assumption is dropped in Section 5.[9,10]

[8] A similar assumption is made by Maskin (2003). See also Manzini and Ponzati (2005).

[9] Although what we call period 3 may, in practice, occur tens of years after the initiation of the project, there is evidence, that, even allowing for appropriate discounting, residual value often plays a critical role. For example, the contractor Jarvis has stated that its return on PFIs in building and maintaining schools is high primarily because of the (expected) residual value (*Financial Times*, 13.9.00). Similarly, see *Financial Times*, 1.3.00, on the role of residual value in the building of a community centre in Dudley, West Midlands.

[10] We disregard option-to-buy contracts (see Nöldeke and Schmidt, 1998) which, as shown by Edlin and Hermalin (2000), are not robust to renegotiation.

The social benefits generated by the facility at the management stage are[11]

$$B\left(a,e\right)=B_0+u(a)+v(e), \tag{1}$$

where B_0 is a positive constant, $v'(e)$, $u'(a)>0$; $v''(e),u''(a)\leq 0$; $v(0)=u(0)=0; v'(0)=u'(0)=\infty$; and $v'(\infty)=u'(\infty)=0$. Both a and e affect social benefits positively. $u'(a)>0$ implies that an increase in the quality of the facility increases the benefits from the provision of the service. A well-constructed prison may facilitate the rehabilitation of inmates. $v'(e)>0$ implies that an innovation in management increases the benefits from the provision of the service. For example, a well-maintained school may facilitate educational attainments.

The costs at the building stage are

$$I\left(a\right)=I_0+a,$$

where I_0 is a positive constant.[12] However, we also allow for the possibility that the investment undertaken during the building stage affects the cost of managing the facility, which is

$$C\left(a,e\right)=C_0-\gamma c(a)-d(e)+e, \tag{2}$$

where C_0 is a positive constant; $c'(a)>0$, $c(0)=0$; and γ is a shift parameter whose value is either 1 or -1. If $\gamma=1$, there is a positive externality across stages. This occurs, for example, when an improvement in the building quality of a facility makes it cheaper to maintain. If $\gamma=-1$ there is a negative externality across stages. This may be representative of a situation where higher quality of the building requires greater maintenance costs, or where a path-breaking design may have a high risk of breakdown. We assume that $c'(0)=\infty$, $c'(\infty)=0$, $c''(a)\leq 0$, if $\gamma=1$; and $c'(0)=0$, $c'(\infty)=\infty$,

[11] The innovations $\{a,e\}$ only affect B if they are implemented. However, in our solutions they actually are implemented and so, for simplicity, we write B as a function of $\{a,e\}$. A similar comment applies to the residual value function and the externality in the management cost function specified below.

[12] We follow Hart, Shleifer and Vishny (1997) in assuming that after a firm has incurred an investment cost in researching an innovation there is no additional cost in implementing the innovation. Our broad conclusions would survive if we dropped this assumption. See Besley and Ghatak (2001) for a model in which implementation costs play a significant role.

$c''(a) \geq 0$, if $\gamma = -1$. $d(e)$ is the reduction in management costs (including maintenance costs) from implementation of innovation e; $d'(0) = \infty$, $d'(\infty) = 0$, $d''(e) \leq 0$,

Consider now the residual value R of the facility . We assume until Section 5 that this is independent of the use of the facility in period 3, so that

$$R = R_0 + t(a), \tag{3}$$

where $R_0 \geq 0$, $t'(a) > 0$, $t''(a) < 0$, $t(0) = 0$, $t'(0) = \infty$, and $t'(\infty) = 0$. An investment a that improves the quality of the facility will increase its residual value.

$B(.)$, $R(.)$, $C(.)$ and $K(.)$ are observable but uncontractible. Each private firm is assumed to maximize its profits, including value generated at the end of the contract if it owns the facility. The government maximizes the social benefits $B(.)$ net of the payments to the firms plus the residual value of the facility if it is the owner. In this setting, the first-best levels of investments (e^*, a^*) maximize $B(a, e) + R(a, e) - K(a) - C(a, e)$. Hence, they satisfy

$$u'(a^*) + t'(a^*) + \gamma c'(a^*) = 1, \tag{4}$$

$$v'(e^*) + d'(e^*) = 1, \tag{5}$$

with $a^*, e^* > 0$.

We discuss four alternative ownership structures for the facility.[13] The first three involve private ownership: respectively, by firm 1, by firm 2, and by a consortium (firms 1 and 2 being integrated). We shall refer to ownership by the consortium as PFI. The fourth type of ownership is by the government. This divides into two cases: the two firms may operate separately (we refer to this case as 'traditional procurement' (TP)) or they may be organized as a consortium. We compare these ownership structures in the presence, first, of a positive externality, and then of a negative externality. We use subscripts on $\{a, e\}$ to denote values taken under a particular ownership structure (for example, a_2 is the value of a when firm 2 owns the facility).

[13] Throughout, when we refer to the 'optimal' ownership structure, we mean the one, out of the four specified here, that leads to the highest value of the government's objective function.

3 Investments under alternative regimes

We derive the first-order conditions for investments first for private ownership and then for public ownership. For private ownership there are three cases, with ownership by firm 1, firm 2, or the consortium (PFI). For public ownership there are two cases - without bundling (traditional procurement) and with bundling.

3.1 Private ownership

Ownership by Firm 1. Suppose that firm 1 owns the facility and consider the building stage. Since firm 1 has control rights, it will implement the innovation whenever it receives private gains from doing so. In this case it will not internalize any positive effect that its innovation brings to firm 2 or to the government, since any threat of not implementing the innovation, unless it receives some of the external benefits it generates, is not credible. Hence, it chooses a level of investment $a = a_1$ that solves

$$t'(a_1) = 1 \tag{6}$$

In the management stage, however, since firm 2 gains directly from the implementation of the innovation, renegotiation takes place between the two firms. Thus, firm 2 will choose the level of investment $e = e_1$ that solves

$$\frac{1}{2}d'(e_1) = 1 \tag{7}$$

Ownership by Firm 2. The case where firm 2 is the owner is symmetric to the one where firm 1 is the owner: renegotiation between firm 1 and 2 will occur over the choice of a, while e will be implemented unilaterally. Hence, firm 1 sets $a = a_2$ to solve

$$\frac{1}{2}\left[t'(a_2) + \gamma c'\left(a_2\right)\right] = 1; \tag{8}$$

and it sets $e = e_2$ to solve

$$d'(e_1) = 1. \tag{9}$$

Ownership by the Consortium (PFI). Suppose that the two firms operate as a consortium, which owns the facility. In this case the investors are, together, the owner

in both the building and management stage, and renegotiation never occurs. Since the consortium has control rights for the facility, as well as residual claimancy over its residual value, it will implement both the building and management innovations. Thus, the levels of a and e are a_I and e_I respectively, which solve

$$t'(a_I) + \gamma c'(a_I) = 1, \tag{10}$$

$$d'(e_I) = 1. \tag{11}$$

3.2 Public Ownership

Suppose instead that the government has control rights over the facility, in which case innovations cannot be implemented without the government's consent. Thus, unlike with PFI, the government has a say on input specifications. Since the investor is never the owner, renegotiation between the government and the investor will always have to occur for an innovation to be implemented. This implies that, contrary to the case of private ownership, social benefits are now (in part) internalized.

Bundling. Assume first that the two firms are in a consortium. Since there are positive benefits for the government from the implementation of the innovations, both in terms of social benefits and in terms of higher residual value, Nash bargaining between the government and the consortium occurs. Hence, the levels of a and e under public ownership are a_{GI} and e_{GI} respectively, which solve

$$\frac{1}{2}\left[t'(a_{GI}) + u'(a_{GI}) + \gamma c'\left(a_{GI}\right)\right] = 1, \tag{12}$$

$$\frac{1}{2}\left[v'(e_{GI}) + d'(e_{GI})\right] = 1. \tag{13}$$

Although the firm takes into account the effect of its investments on both the residual value and social benefits, it does so only partially, for the gains must be split with the government. Because the firm is integrated, it takes into account (partially) the externality across stages.

Unbundling (Traditional Procurement). Suppose the two firms operate independently and the government is the owner. We refer to this as traditional pro-

curement (TP).[14] To achieve implementation, the government enters a separate Nash bargain with each firm. Therefore, in the Nash bargain between firm 1 and the government, the externality across the building and management stages will not be taken into account. The firms set $a = a_{GS}$ and $e = e_{GS}$, where

$$\frac{1}{2}\left[u'(a_{GS}) + t'(a_{GS})\right] = 1, \tag{14}$$

$$\frac{1}{2}\left[v'(e_{GS}) + d'(e_{GS})\right] = 1. \tag{15}$$

From (13) and (15), $e_{GI} = e_{GS}$: unbundling has no effect on e. However, from (12) and (14), it does affect the choice of a: only under bundling is the externality across stages internalized.

4 Optimal investment

4.1 Positive Externality ($\gamma = 1$)

In this section we compare the various ownership arrangements in terms of $\{a, e\}$ in the case where $\gamma = 1$: (implementation of) a greater investment a at the building stage leads to a fall in the cost of providing the service at the management stage.

Our first proposition is obtained by comparing the first-order conditions for the choices of a and e.

Proposition 1 *In the presence of a positive externality ($\gamma = 1$) (i) bundling is always optimal; (ii) if $c'(a)+t'(a) > u'(a)$ PFI is optimal for a; if $d'(e) > v'(e)$ PFI, is optimal for e. If the inequalities are reversed, public ownership with bundling is optimal.*

Part (i) of the proposition states that, if ownership is private, the PFI model of ownership by the consortium always dominates ownership by either firm 1 or firm 2, while, if ownership is public, it is always better for the government to contract with a consortium than with separate firms. Intuition follows from the fact that in

[14] The term 'traditional procurement' may also be used to cover in-house provision, but we do not consider such provision here.

all ownership structures there exists an underinvestment problem. Consequently, it is always optimal to induce the internalization of the positive externality across stages of production, and this calls for bundling of building and management. Thus, the choice of the optimal ownership structure reduces to a choice between ownership by the government, which contracts with a consortium, and ownership by the consortium (PFI), and so we confine our discussion to these two arrangements.

Now consider part (ii), first for the choice of a. Intuitively, when the consortium owns the facility, it foresees gains from future use (or sale) of the facility and from the future reduction of operating costs. Thus, it internalizes fully the effect of a on R and C, though it does not take into account the effects of its choices on B. When the government owns the facility, however, the consortium cannot implement the innovation in the event of disagreement, and so renegotiation between the consortium and the government takes place. As a result of Nash bargaining, the consortium will share the benefits from the innovation with the government. Thus, it loses half of the effects of the innovation on residual value and of the positive externality in the management stage, while it gains half of the effects on social benefit.

Therefore, if the effect of the building innovation on residual value and the cost of operating the facility dominates that on social benefit, PFI leads to higher investment in the building stage. The greater the effect of the investment on the residual value of the facility or on the externality across the two stages of the project, or the smaller the effect of the investment on social benefit, the stronger the case for PFI with respect to the choice of a. If, however, the effect of the building innovation on social benefit dominates that on private residual value and on the cost of operating the facility, public ownership leads to the greater building investment. In this case, the absence of ownership for the firm works as a commitment to renegotiate, and renegotiation is optimal for a.

Similar considerations apply for the choice of e, except that there is no parallel to the externality term $c'(a)$. Thus, if the effect of the management innovation on costs dominates that on social benefit, PFI is preferred to public ownership in terms of its ef-

fect on investment in the building stage, and *vice versa*. Hence, even if PFI is associated with the higher level of a, because of a strong positive externality, it does not follow that it is necessarily preferred to public ownership, for the investment in management innovation under PFI may nonetheless be less than under public ownership.

Our results are generally consistent with existing evidence on how PFI is working, compared to previous arrangements. According to a report commissioned by the Treasury Taskforce (Arthur Andersen and LSE, 2000), the average estimated saving on a sample of PFI projects has been 17%, compared to traditional procurement.[15] In particular, PFI appears to have worked well for roads and prisons, generating substantial cost saving and leading to new design and management innovations, though it is has worked less well for schools and hospitals.

Consider the case of prisons. 80% of running costs are staff costs, particularly those associated with the need to ensure compliance with security standards. Thus, an innovative design that has a significant impact on the number of guards that are required can bring major cost savings; that is, we can expect there to be a strong positive externality $c'(a)$ across stages, favoring PFI. Indeed, as reported by National Audit Office (1997, 2003b), PFI prisons have incorporated innovative design solutions that had not have featured previously in the UK. For example, PFI prisons have been designed with the use of fewer buildings and a smaller perimeter, helping to reduce the level of staffing needed to ensure security. There was also evidence of more efficient design, reducing the cost of construction, and enabling construction to terminate ahead of schedule. One such innovation was in the precasting of off-site modular houseblocks, which were then assembled on site to provide the basic structure. The Prison Service considers the houseblocks to be well-lit and spacious, and provide to good sight lines. Other innovations include the use of an appointment system for prison visits (reducing the space needed for the visitors' room), and the replacement of kitchen facilities with

[15] This comparison is made with the 'Public Sector Comparator,' which is used during the preliminary stage of a PFI project to provide an estimate of what the project cost would have been had TP been used. It should be emphasized however, that projected savings are sensitive to risk transfer valuations, which accounted for 60% of forecast cost savings.

a catering service based on the delivery of cooked/chilled foods to the prison site. The Prison Service has estimated that these improvements in design reduced overall project costs by approximately 30%.

For highway projects, HM Treasury (n.d.) reports that the life-cycle approach to costs under PFI is working well, by encouraging long-term thinking on facility provision, maintenance and renewal, and overcoming the conventional divide between the various interests. There is evidence of innovative design, for example in the use of high modulus roadbases and stone mastic asphalt, which, compared to traditional designs, has the advantages of greater noise-reduction, and reduced traffic disruption from maintenance, as well as lower building, raw-material, and time costs.

For projects such as roads and prisons, the design and build of the facility will generally be the primary determinant of management costs and of social benefits. In terms of Proposition 1, part (ii), this means that even if the second inequality is the reverse of that shown (i.e., $d'(e) > v'(e)$), and so favors public ownership, this will have a small welfare effect compared to the advantage of PFI that works through the first inequality, that is, through the welfare effect of the innovation at the building stage. However, in other cases, such as specialized IT provision, where the appropriate use of the facility involves continuous adaptation, this argument is less likely to hold, and so public ownership may be preferred. In practice, PFI projects in IT have been widely criticized. For example, National Audit Office (2003a) concludes that the £400m Libra project to provide IT systems for magistrates' courts has not enabled the courts to manage their workloads properly.

5 Negative Externality

We now consider the case in which $\gamma = -1$; that is, implementation of a greater investment a at the building stage leads to a rise in the cost of providing the service at the management stage. We focus on the choice of a, since the choice of e is not affected by the type of the externality at the building stage.

Because the externality is negative, we now have that $a_1 > a_I, a_2$ (using (6), (8) and (10)), while $a_{GS} > a_{GI}$ (from (12) and (14)). Intuitively, if firm 1 owns the facility it ignores the externality when choosing a. In contrast, if firm 2 is the owner, the bargain between the two firms causes firm 1 to internalize partially the negative externality, and so to set a at a lower level. Similarly, if the consortium owns the facility, it internalizes the negative externality, restricting the level of a. If there is public ownership, internalization of the externality only occurs when the firms are in a consortium. The significance of this case is that it depicts a situation in which unbundling is optimal, and, provided the negative externality is not too strong, relatively simple conclusions can then be obtained.

Lemma 1 *If* $c'(a^*) \leq \min[1, u'(a^*)]$, *unbundling is optimal for* a. *Specifically, (i) if* $t'(a) < u'(a)$, *public ownership with unbundling (TP) is optimal for* a; *but (ii) if* $t'(a) > u'(a)$, *ownership by firm 1 is optimal for* a.

Proof. Assume $\gamma = -1$. First, note that $a^* > a_2, a_I, a_{GI}$. To see this, let $H_2(a) \equiv \frac{1}{2}[t'(a) - c'(a)] - 1$, so that, from (8), $H_2(a_2) = 0$. From (4), $H_2(a^*) = -\frac{1}{2}[u'(a^*) + 1] < 0$. Since $H_2(a)$ is decreasing in a, it follows that $a^* > a_2$. Similarly, let $H_I(a) \equiv t'(a) - c'(a) - 1$. From (4), $H_I(a^*) = -u'(a^*) < 0$, which, given (10), implies $a^* > a_I$. Comparison of (4) and (12) yields $a^* > a_{GI}$.

Second, note that under the condition $c'(a^*) \leq \{1, u'(a^*)\}$, we also have $a^* > a_{GS}, a_1$, so that there is under-investment under each ownership structure. Indeed let $H_1(a) \equiv t'(a) - 1$. From (4), $H_1(a^*) = c'(a^*) - u'(a^*)$. Given (6), $H_1(a^*) < 0$ implies $a_1 < a^*$. To see this, let $H_{GS}(a) \equiv u'(a) + t'(a) - 2$. From (4), $H_{GS}(a^*) = c'(a^*) - 1$. Given (14), $H_{GS}(a^*) < 0$ implies $a_{GS} < a^*$.

Finally, following the same procedure, we note that $a_1 > a_I, a_2$, while from (12) and (14), $a_{GS} > a_{GI}$. Thus, in determining which arrangement yields the highest level of a, we need only compare a_1 with a_{GS}. Since $H_1(a) \equiv t'(a) - 1$, from (14), $H_1(a_{GS}) = (t'(a_{GS}) - u'(a_{GS}))/2$. From (6), $H_1(a_1) = 0$, so that, when $t'(a) < u'(a)$ we have $a_{GS} > a_1$ and *vice versa*. ■

This lemma can be understood intuitively by noticing that, in our second-best world, none of the ownership structures allows full internalization of the positive effects of a on B and R, and, therefore, given that the externality is not too strong, underinvestment results in all cases. To attenuate the underinvestment problem it is optimal not to induce the internalization of the negative externality on C. This can be achieved by not giving ownership to the firm that suffers the negative externality, thereby ruling out ownership by either firm 2 or the consortium. The same reasoning indicates the desirability of separating the building and the management functions under public ownership, so that firm 1 will not take into account the effect of a on cost at the management stage. If the residual value effect is relatively strong ($t'(a) > u'(a)$), then so is the incentive of firm 1 to invest, and ownership by firm 1 is optimal. But if $t'(a) > u'(a)$, public ownership with unbundling (that is, TP), which in effect gives a commitment to renegotiate, is preferred.

In this context, consider the building of schools under PFI. A report by the Audit Commission (see *PPP Focus, Education 2*, 2004) notes that PFI schools have shown little evidence of design innovation, having, for example, audible and visual intrusion into teaching, and poor acoustic and air quality, compared to TP schools; and it is suggested that this had direct negative links to pupil behavior and educational achievement. We cannot be sure that this was the result of the internalization of a negative externality, with consortia being unwilling to develop more innovative solutions because they expected these would result in higher management and maintenance costs; but this example is at least consistent with our analysis.

A reinterpretation of our framework also enables us to comment on how the time horizon for a project affects the optimal type of ownership when there is a weak negative externality. We normalize time units in terms of the length of period 1, the building stage. Suppose the management stage is n units of time in length. Interpret $B(a, e)$ and $C(a, e)$ as the present values of the flows of benefits and management costs, respectively, over n. For simplicity, suppose that the investments a and e are each one-off decisions, the cost of each being incurred once. Thus, benefit per unit of time and management

cost per unit of time are each constant across the n units of time. Similarly, interpret $R(a)$ in present value terms. We then obtain the following.

Proposition 2 *Let $c'(a^*) < \min[1, u'(a^*)]$. If the number n of units of time over which the service is to be provided is greater for a given project, the relative case for public, rather than private, ownership improves.*

The rationale for this result is twofold. First, when n is greater, the present value $R(a)$ is smaller, for given a. Consequently, the present value of the effect $t'(a)$ on residual value is smaller. We have seen in Propositions 1 and 2 that small values of these effects favor public ownership. Second, if n is greater, benefits are obtained over a longer time period. Therefore, the effects $u'(a)$ and $v'(e)$, where each is now interpreted as the present value of a stream over n units of time, are greater. From Proposition 2, this also favors public ownership.[16]

If, alternatively, $c'(a^*) > \min[1, u'(a^*)]$, the negative externality being relatively large, clear-cut results are not obtained. Both a_1 and a_{GS} are greater than a^*; that is, the non-internalization of the negative externality which occurs under ownership by firm 1 and under traditional procurement leads to overinvestment. Then, whether bundling or unbundling is optimal depends on the relative sizes of the effects on welfare of the overinvestment that occurs under unbundling, and of the underinvestment that occurs under bundling.

6 Residual Value

We now consider how the results are affected if ownership may change when the contract expires. Under TP it is the custom to keep the facility in public hands at the end of the contract. Under PFI, however, as stated in HM Treasury (2002, 2004), at end of the contract, facilities for which there is a clear long-term public sector demand, or

[16] A corresponding, unconditional, proposition does not hold for positive externalities. Consider Proposition 1. A rise in n reduces $t'(a)$ and increases $u'(a)$, but it also increases $c'(a)$. Thus, the implications for whether $u'(a) < t'(a) + c'(a)$ are unclear.

no practical alternative use, should return to the public sector, typically by automatic transfer. But for generic facilities with an alternative use outside the public sector and no clear long-term public sector need, it is advised that ownership be retained by the private sector. Examples given by HM Treasury of the former types of facility include schools, hospitals, prisons, specialist IT systems, and office accommodation that is specific to the public sector client, while examples given of the latter include office accommodation and land use where there is demand from other users, and general IT systems.

To explore this issue, we now assume that the residual value of the facility depends on whether in period 3 its use is public or private. In particular, we consider the case in which, in the absence of exogenous shocks, the facility has a greater value if used for public than for private purposes. We assume, however, that, before the end of period 2, a shock may occur such that the facility will not be needed for public purposes in period 3. The shock may, for example, be a change in sentencing policy for prisons, or the availability of a technological improvement in health care. In the event of such a shock, the facility will have no public value in period 3, that is, after the service contract with the private sector provider has expired. Specifically, we assume that, *ex ante*, with probability p, the residual value of the facility if it is used for public purposes in period 3 - the 'public residual value' - will be R, as given by equation (3), while, with probability $1-p$, the public residual value will be zero.

The 'private residual value' of the facility in period 3 is its residual value if ownership resides with a private sector agent in period 3. We assume that there are no other firms or consortia in the economy who can use the facility more efficiently than the firms and consortium that we have modelled above. The private residual value is assumed to be $r \equiv \theta R$, where, for simplicity, r is certain, with $\theta \in (0,1)$. Thus, although public sector plans may change such that the facility is no longer needed for public sector use, the facility has some value in the private sector, providing the same or a related service. A high value of θ may reflect a low degree of specificity of the facility for the original use. For example, a leisure facility that is not required by the public sector may be easily

converted into an up-market private facility. In contrast, a low value of θ represents a facility such as a specialist public sector IT system, which would have a relatively small market value.

Consider the game that is played between periods 2 and 3 - that is, once a and e have been exerted and the service provision contract has expired. Suppose that there has been private ownership during the contract period (by firm 1, firm 2, or the consortium). Then, with probability p, since $\theta < 1$, the owner will sell the facility to the government. We assume that in this case the firm and the government engage in Nash Bargaining, where θR is the outside option of the owner. Using the outside-option principle, we have that the owner obtains $max\left[\frac{1}{2}R(a), \theta R(a)\right]$, with the outside option binding if $\theta \geq \frac{1}{2}$, but not otherwise. With probability $1-p$, the facility has no public value and the owner will use it for private purposes, so as to obtain θR. Thus, a private agent that owns the facility in periods 1 and 2 will, in period 3, receive the expected gain R_F, where

$$R_F(a, p, \theta) = [R_0 + t(a)] \left[p \max(\frac{1}{2}, \theta) + (1-p)\,\theta \right], \tag{16}$$

with the derivative with respect to a given by

$$\begin{aligned} R'_F &= \left[\frac{1}{2}p + (1-p)\,\theta\right] t'(a) \text{ if } \theta < \frac{1}{2}\,; \\ R'_F &= \theta t'(a), \text{ if } \theta \geq \frac{1}{2}. \end{aligned} \tag{17}$$

If, instead, the facility is owned by the government in periods 1 and 2, then, with probability p the government keeps the facility (since $\theta < 1$). With probability $1-p$, the public residual value of the facility is zero, in which case the facility is sold to the private sector. In order to stimulate investment a as much as possible,[17] the facility should be sold to the private investor (firm 1 or the consortium, depending on which one had control rights during periods 1 and 2), rather than some outside party, and it should have been specified in the contract at period 0 that the investor will be given

[17] Instead of (4), the first-best value of a is now given by $u'(a^*) + [p + (1-p)\theta]\, t'(a^*) + \gamma c'(a^*) = 1$. It is still found that each ownership arrangement leads to underinvestment.

first option if a sale should take place. When the government sells the facility, we assume again Nash bargaining; and since the public residual value is zero, the outside option for the government is now zero, the government getting $\frac{1}{2}\theta R$. Hence, in period 3, the government's expected gain is R_G, where

$$R_G(a,p,\theta) = [R_0 + t(a)]\left[p + (1-p)\frac{1}{2}\theta\right], \tag{18}$$

and the derivative with respect to a is given by

$$R'_G = \left(p + (1-p)\frac{\theta}{2}\right)t'(a). \tag{19}$$

Consider how the above modifies our earlier results, focusing on the case of a positive externality. Amending the first-order conditions for investment a, it is found that bundling is still optimal (the intuitive argument is unaffected). We therefore limit our discussion to the comparison between PFI ($a = a_I$) and public ownership with bundling ($a = a_{GI}$). Instead of (8), the first-order condition for a under PFI becomes

$$R'_F(a_I) + c'(a_I) = 1, \tag{20}$$

where $R'_F(a_I)$ is given by (17). Instead of (12), the first-order condition for a under public ownership with bundling is

$$\frac{1}{2}\left\{R'_G(a_{GI}) + (1-p)\frac{\theta}{2}t'(a_{GI}) + u'(a_{GI}) + c'\left(a_{GI}\right)\right\} = 1, \tag{21}$$

where $R'_G(a_{GI})$ is given by (19).

In comparing (20) and (21), the role of the c' and u' is the same as in Proposition 1, but now, using (17) and (19), we have more complicated coefficients for t'. From (20) and (21), we are interested in the value of $\Delta R(a,p,\theta) \equiv R'_F - \frac{1}{2}R'_G - (1-p)\frac{\theta}{4}t'(a)$, and, from (17) and (19), this is given by

$$\Delta R(a,p,\theta) = \begin{cases} (1-p)\frac{\theta}{2}t'(a) \geq 0 & \text{for } \theta < \frac{1}{2}; \\ \frac{1}{2}\left[\theta - p(1-\theta)\right]t'(a) \geq 0 & \text{for } \theta \geq \frac{1}{2}. \end{cases} \tag{22}$$

Using (22), we obtain the following parallel to the relevant parts of Proposition 1.

Proposition 3 *Assume a positive externality, and that ownership may change when the contract expires. Then (i) bundling remains optimal and (ii) if* $c'(a)+\Delta R(a,p,\theta) > u'(a)$*, PFI is optimal for* a*.*

Before turning to the intuition, using (17) and (19), we obtain the following corollary.

Corollary 1 *With a positive externality, PFI is more likely to be optimal for* a *the lower is* p *and* $u'(a)$*, and the higher are* θ *and* $t'(a)$*.*

As in Proposition 1, Corollary 1 states that PFI is more likely to be optimal for a the lower is the social-benefit effect $u'(a)$ and the higher is the residual-value effect $t'(a)$. The intuition is unchanged. Corollary 1 also states that PFI is more likely to be optimal for a the lower the probability that the facility is needed in period 3 for providing public services (the lower is p) and the lower the degree of specificity of the facility (the higher is θ). The intuition is as follows, first for θ, and then for p.

When PFI is used, the consortium has control rights and ownership of the facility. If it keeps the facility, which occurs with probability $1-p$, it receives the entire increment to the private residual value θR resulting from investment a. If it sells the facility to the government, which occurs with probability p, it obtains $max[\theta R, \frac{1}{2}R]$. Now suppose instead that the government has control rights and ownership of the facility. In this case, with probability $1-p$, the consortium buys the facility, but since bargaining occurs, it only obtains $\frac{1}{2}\theta R$; and with probability p the government keeps the facility, the consortium obtaining none of the residual value. Thus, an increase in θ has a greater impact on the incentive to invest under PFI than under TP, making PFI more likely to be optimal for a the higher is θ.

Now consider the role of p. If the government owns the facility *ex ante*, investment incentives are weakened by the government's appropriation, through bargaining, of some of the effect of a on the residual value. But suppose the consortium owns the asset *ex ante*. If p were zero, the facility would always go to the consortium at the end

of the contract, and there would be no attenuation of incentives through bargaining with the government. However, when $p > 0$, bargaining also occurs under ownership by the consortium: with probability p, the consortium sells the facility to the government. Hence, a rise in p entails an increase in the probability that bargaining will take away from the consortium some of the residual-value effect of a. As this probability increases, the case for ownership by the consortium becomes weaker.

Our framework also allows us to examine whether an automatic transfer of ownership between periods 2 and 3 is welfare-enhancing. Again, we focus on PFI and public ownership with bundling. Under PFI, if the facility is to be transferred to the public sector automatically at the beginning of period 3, then, from the viewpoint of the beginning of period 1, the public residual value will be $R(a)$ with probability p, and zero with probability $1-p$. We assume that there are no social/political prohibitions on the subsequent sale of the facility by the public sector to the consortium. Sale will then be mutually advantageous if the public residual value turns out to be zero, in which case the consortium will buy the facility for the price $\frac{1}{2}\theta R(a)$, and its net gain will be the remaining half of $\theta R(a)$. If, instead, the public residual value turns out to be $R(a)$, the consortium will not buy the facility, and so it will not gain a share of $R(a)$. Hence, at the beginning of period 1, if the contract specifies automatic transfer of the facility to the public sector at the beginning of period 3, the expected benefit to the consortium from the residual value of the facility is $(1-p).\frac{1}{2}\theta R(a)+p.0 = \frac{1}{2}(1-p)\theta R(a)$. However, if, instead of automatic transfer, there is merely an option of transfer, the consortium's expected benefit is $R_F(a,p,\theta)$, as given by(16), which, given (3), exceeds $\frac{1}{2}(1-p)\theta R(a)$. Because of the effect on investment incentives, this yields our next result.

Lemma 2 *Under PFI, automatic transfer of ownership to the public sector at the end of the contract is welfare reducing.*

When PFI is used, the consortium has control rights during the contract period, but, as we have noted, for many facilities, the UK government's preferred option is nonetheless for there to be automatic transfer of ownership back to the public sector

at the end of the contract. The above lemma indicates that if this preference is to be enforced, the argument for using PFI is weakened, for the anticipation of automatic transfer diminishes the consortium's incentive to invest (the value of $R'_F(a)$ in Proposition 3 is reduced). Nonetheless, for $\theta < 1/2$, the case for using PFI would be strengthened if the option were left open of a voluntarily negotiated transfer of ownership to the public sector. The dependence of the price the consortium would receive for the facility on investment a would raise its incentive to invest, enhancing welfare under PFI.[18]

There are, however, other considerations, beyond the scope of our analysis, which can offer some rationale for automatic transfer. In practice, negotiation at the end of the contract period may be lengthy and create uncertainties, and perhaps disruption, in service provision. Also, if it turns out that the public sector urgently needs to continue the provision of the public service using the facility, negotiation, rather than automatic transfer, may give the consortium the chance to hold the government to ransom.[19] Recognition that this possibility may occur can raise the consortium's incentive to invest, although distributional considerations may make this outcome unattractive.

7 Concluding Comments

In this paper we have studied the desirability of bundling the building and management of facilities used for the provision of public services; we have considered the appropriate ownership of these facilities; and we have focused on the role of the residual value of the facilities. We have paid particular attention to the case for PFI, and we have related our analysis to the evidence available.

When there is a positive externality across the stages of production, bundling, with

[18] However, results may change if we assume that a has a negative impact on the private market value of the facility, though it still increases residual public value. This is likely to occur for facilities that have a little market value and for which the design is very specific to the delivery of the public service. See Rajan and Zingales (1998).

[19] The government may have a higher discount rate than the consortium, adversely affecting the terms it would obtain in a repeated-offers bargaining game.

the firms organized as a consortium, is always optimal since it induces the internalization of the externality. This is consistent with the motivation commonly given for PFI contracts, which views the integration between the different phases of the provision of a public service as a device to promote investment. We have also shown, however, that, with a positive externality, ownership of facilities by the consortium (the PFI model) is not necessarily optimal: under some conditions it is preferable for the government to have ownership. Furthermore, if the externality is negative, the case for bundling is weakened, and, if the externality is weak, either public and or private ownership, with unbundled provision, is preferred. PFI is more likely to be preferred (a) the more positive (or less negative) is the externality; (b) the stronger the effects that innovations in building and management have on the residual market value of facilities; and (c) the weaker the effect that innovations have on the benefit from provision of the public service. With a weak negative externality, if the period over which the service is to be provided is lengthened, public provision is favored relative to private provision.

Provisions for ownership of facilities when the public service contract has expired also have an important role to play. In particular, assuming a positive externality, under PFI, automatic transfer of facilities back to the public sector reduces *ex ante* investment incentives, thereby weakening the case for using PFI. If, instead, it is specified initially that the PFI consortium will keep ownership at the end of the contract, the option to negotiate a mutually beneficial transfer of ownership to the public sector strengthens its investment incentives, and therefore also the case for PFI. Thus, the case for PFI is stronger for services for which there is no political or social prohibition on long-term private ownership of the facilities concerned.

Our analysis has been based on the assumption that investments are verifiable. But suppose, instead, that they are unverifiable, as assumed by Hart (2003), in which case there can be no bargaining over implementation of innovations. Then a private provider can only be driven by concern for its own profit. In the revised model, the only innovation that will occur will be the building innovation a if firm 1 is the owner, the management innovation e if firm 2 is the owner, or both a and e if there is PFI; under

public ownership there will be no investment. Hence, if the externality is positive, the case for PFI is strengthened: PFI dominates each other arrangement.

A development of our analysis would be to take into account distinctions between different types of services. In particular, government reports have distinguished between core services, such as prison security or school classroom teaching, and ancillary services, such as cleaning and facility maintenance in prisons or schools (see, e.g., House of Commons, 2001). It is suggested that PFI works better where it provides both types of service (as in prisons), but less well when it is restricted to ancillary services (as in schools). This issue could be analyzed by incorporating into our model a public sector service agent that may provide the core service, and by allowing for possible synergies between core and ancillary service provision.[20]

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[20] Further development of our framework might also model explicitly the relationship between the members of the consortium. Additionally, asymmetric information about costs and about the likelihood of changes in public sector preferences might be allowed for. And distributional considerations might be introduced: we have ignored in the present paper that side payments that induce the implementation of an innovation may leave the public sector short of funds to pay for other public services for which there is an urgent need.

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