Building and Managing Facilities for Public Services*

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First Version: January 2002
This version: April 2004

Abstract

We model public-private partnerships in building and managing facilities for the provision of public services. In particular, we analyze both the desirability of bundling the building and management operations, and the optimal allocation of ownership between the public sector and private firms. When a positive externality exists across stages of production, bundling is optimal; but unbundling may be preferred when the externality is negative. Whether public ownership is preferred to private ownership depends on the extent and sign of the externality, the market value of the facility and the effect of the firms' investments on social benefits. The main advantage of public ownership is that it works as a commitment device for the government to share social benefits with the investor.

JEL Classification: H11, L33.

Keywords: private finance initiative (PFI), public-private partnership, integration versus separation and incomplete contracts.

*We are grateful for very helpful comments by Svetlana Andrianova, Antoine Faure-Grimaud, Paul Grout, Patrick Legros, Paola Manzini, Mariano Selvaggi and Al Slivinski. We would also thank participants at the Royal Economic Society Conference, Warwick, April 2002, and the International Institute of Public Finance Congress, Helsinki, August 2002, for comments on earlier versions. Financial support from the ESRC under grant R/000/22/3811 is gratefully acknowledged.

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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). In particular, in the UK it has become common, under the Private Finance Initiative (PFI), to contract out the design, building, finance and operation of an infrastructure project to a consortium of private firms (Grout, 1997; HM Treasury, 2000). This approach contrasts sharply with the way public services have traditionally been procured, with the public sector financing and designing the project itself, contracting with a private firm to build the facility, and then either operating the facility in-house or contracting out the operation to another firm (HM Treasury, 1998).

As reported by the HM Treasury (2003), PFI contracts cover most forms of public service provision, including health, education, defence, prisons and roads. Over the period 1998-9 to 2003-4 the estimated private sector investment in public services through PFI was between 10 and 13.5 per cent of total investment in public infrastructure. A total of 451 PFI projects have now completed construction, delivering over 600 new public facilities including 34 hospitals and 119 other health schemes, and 239 new and refurbished schools.

In this paper we study the desirability of some aspects of the PFI model: whether it is optimal to bundle the different stages of production and whether

control rights should be left to the private firm(s).[1] We consider a stylized setting in which there are two stages to a project, the 'building' of a facility and then the 'management' of public service provision using the facility. The government delegates these two functions to private firms. Because the functions require specialized skills, two distinct firms carry out the tasks. We analyze whether it is optimal for the government to contract with the two firms separately (unbundling) or whether it is preferable to write a single contract with a consortium of the two firms (bundling). We assume that, due to contractual incompleteness, ownership rights result in control rights: the owner of the facility has the power to decide (and veto) whether any given innovative activity can be implemented. This approach emphasizes the distinction between PFI and traditional procurement. Under public ownership (traditional procurement) the government owns the facility, and specifies the inputs to be used for the provision of the public service, i.e., it has control rights over how the service should be delivered. Under PFI it only specifies the output; the consortium of private firms is the owner of the asset and has control rights.

One of the main arguments used to justify PFI projects is that bundling allows the exploitation of synergies between the different phases of a project, inducing more innovative and cost-effective designs (Daniels and Trebilcock, 2000; IPPR, 2001). We discuss this argument and show that, indeed, such synergies play a critical role, but do not necessarily work in favour of PFI. In particular, suppose

[1] 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.

that innovation in the building stage reduces cost at the management stage (we call this a positive externality) as well as increasing social benefit. In this case, bundling is always optimal, for it allows internalization of the positive externality. Instead, if the innovation in the building stage increases cost at the management stage (we call this a negative externality), though it still increases social benefit, unbundling may become optimal, making consortia 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.

Consider now the issue of optimal ownership. In the incomplete-contract framework developed by Grossman and Hart (1986), Hart and Moore (1990) and Hart (1995) we know that giving ownership to the investing party protects the investor from having the gains from investment expropriated. This is apparently one of the motivations for the PFI approach. However, De Meza and Lockwood (1998) and Chiu (1998) show that this result depends critically on how the no-trade payoffs are interpreted. When no-trade payoffs are outside options, ownership can reduce incentives to invest. Also, Rajan and Zingales (1998) show that if investment reduces the investor's no-trade payoff, the associated weakening of incentives may mean that another party should be the owner.

However, we identify a different reason why it may be optimal for the non-investing party to own the asset. Consider for example the case of a positive

externality. If there is private ownership, the consortium will be willing and able to implement the innovation without any further inducement. In this case a promise by the government to reward the investor (the consortium) for the increase in social benefit following the innovation would not be credible. Realizing this, the investor will not take into account the effect on social benefit when it decides on its investment. In contrast, public ownership leaves the investor with no power to implement the innovation unless renegotiation occurs. Hence, public ownership works as a commitment device for the government to share its benefit with the investor. This argument extends to all cases where there are direct private benefits for the investor from the implementation of the innovation.

Hence, with a positive externality, private ownership by a consortium, as in PFI, has the advantage of inducing full internalization both of the externality and of the effect of investment on residual value. Instead, public ownership has the advantage that it leads to renegotiation that, amongst other things, induces the partial internalization of the effect of investment on social benefit. Depending on the relative significance of these effects in the social welfare function, public ownership may therefore be optimal. A higher positive externality and a greater effect on residual value favour private ownership, while higher social benefits favour public ownership.

With a negative externality across stages of production, the externality will not be induced if there is either ownership by the firm involved only in the building stage, or, provided the two firms act independently, ownership by the government. Furthermore, it is optimal not to induce the internalization of the externality if

the externality is weak, for in this case under all ownerships structures there is underinvestment. Then, if investments have a relatively large effect on social benefits, public ownership as under traditional procurement is optimal. However, when the externality is strong so that not inducing its internalization can result in over-investments, almost all ownerships structures can be optimal.

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 reduction.[2] 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 (2002) 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 asset at the end of the contract.[3] King and Pitchford (2001) also discuss bundling and consider the possibility of spillovers onto the value of other assets. However, they

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

[3]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.

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 assets (as in traditional procurement) 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. Section 3 discusses the bargaining procedure used in the paper. Section 3 analyses the level of investments under alternative regimes. Section 4 and 5 compare different ownership structures in the case of positive and negative externalities, respectively. Section 6 concludes and draws some policy implications.

2 The Model

We consider a setting where a governmental agency such as a ministry or a local authority (hereafter referred to as 'the government') delegates to private firms the building and management of a facility (or 'asset') 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 form 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. Whether the basic standards are then met by the firms 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 in excess of the basic standard. 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 of these innovations, if implemented, affects both the residual value of the asset and 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.

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.[4] 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

[4]In practice, however, as noted by the National Audit Office (2001), it is sometimes found that a government department prevents a private contractor (the owner of the asset) from implementing an innovative design. In effect, this results in a hybrid form of ownership not considered in this paper.

expected returns from any action. All variables may be interpreted in expected terms and are assumed to be discounted appropriately.

The residual value of the asset is given by[5]

$$R(a,e) = R_0 + t(a) + r(e), \tag{1}$$

where R_0 is a positive constant, $t'(a)$, $r'(e) > 0$; $t''(a)$, $r''(e) \leq 0$; $t(0) = r(0) = 0$; $t'(0) = r'(0) = \infty$; and $t'(\infty) = r'(\infty) = 0$. a may be interpreted as an investment devoted to improving the quality of the building, say by developing ways of using recently available resistant materials; e may be interpreted as an investment in asset-maintenance activities.[6]

The social benefits generated by the facility at the management stage are

$$B\,(a,e) = B_0 + v(e) + u(a), \tag{2}$$

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 $v'(\infty) = u'(\infty) = 0$. Note that both e and a affect social benefits positively: an increase in the quality of the asset or in maintenance activities increases the benefits from the provision of the service (a well-constructed or well-maintained prison may facilitate the rehabilitation of inmates).

The costs at the building stage are

$$K\,(a) = K_0 + a,$$

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

[6]In an earlier version of this paper, Bennett and Iossa (2002), we assumed that, for any given $\{a, e\}$, the residual value would be greater for the government than for a private firm. However, this had no significant effect on the results.

where K_0 is a positive constant.[7] However, we also allow for the possibility that the investment undertaken during the building stage affects the cost of managing the facility, which is

$$C(a, e) = C_0 - \gamma c(a) + e, \tag{3}$$

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.[8] 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 easier 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: $c'(0) = \infty$,$c'(\infty) = 0$, $c''(a) \leq 0$, if $\gamma = 1$; and $c'(0) = 0$, $c'(\infty) = \infty$, $c''(a) \geq 0$, if $\gamma = -1$.

$B(.)$, $R(.)$, $C(.)$ and $K(.)$ are observable but unverifiable. Each private firm is assumed to maximize its profits, including value generated at the end of the contract by its asset ownership, if any. The government maximizes the social benefits $B(\cdot)$ net of the payments to the firms, including the residual value of the asset if it is the owner.

In this setting, the first-best levels of investments (e^*, a^*) maximize $B(a, e) +$

[7] 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 role.

[8] The additional case of $\gamma = 0$ (no externality) is considered in n. 15.

$R(a,e) - K(a) - C(a,e)$. Hence, they solve

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

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

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

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, P and p, that it will pay to firms 1 and 2, respectively, 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. In period 3 the owner of the facility can freely decide on its future use.[9,10]

We discuss four alternative ownership structures for the facility.[11] The first

[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.

[11] 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.

three involve private ownership: 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') 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 (e.g., a_2 is the value of a when firm 2 owns the asset).

3 Bargaining, Ownership and Externalities

In this section we discuss the bargaining procedure that is used in the paper. To ease the understanding of the results in the next sections, we also explain here the implications of our bargaining approach for investment incentives in the presence of externalities under different ownership structures.

Suppose there are two parties, an investor (I) and a stakeholder (S), and that I has an idea for an innovation, which would modify the way an asset is used. The parties' respective direct payoffs are $i, s > 0$ (note that $s > 0$ implies that the investment by I generates a positive externality for S) if the innovation is implemented, and zero otherwise. The investor is indispensable for the implementation of the innovation, but ownership of the asset also matters: the innovation can only be implemented with the consent of the owner. Two cases must be considered, depending on whether I or S is the owner.

Suppose first that I is the owner. In this case, I has the power to decide whether the innovation is implemented. Thus, it can always obtain its direct payoff i by implementing the innovation without consulting S (i.e., I has an outside option of i). If I implements, S obtains s: the choice by I creates a positive externality for S. The crucial issue here is whether I will be able to extract some of S's stake, s.

We assume that I cannot commit not to implement the innovation in the event of disagreement with S. That is, if S closes all channels of communication with I so as to stop bargaining permanently, I will implement the innovation. Thus S has an outside option of s.[12] It then follows that, when I is the owner, the only feasible payoffs are precisely i and s (i.e. both outside options bind in equilibrium), and I is not able to extract any of S's stake, s.

Now suppose that S is the owner. In this case, neither I nor S can implement the innovation by itself (i.e., the outside options of the two parties are $(0,0)$). I cannot do so because it does not have property rights and S cannot do so because it does not have the skills. Therefore, we are back to a more standard bargaining situation. Renegotiation between I and S will occur and we assume that it takes the form of Nash bargaining: I and S obtain $\frac{1}{2}(i+s)$ each.

We now compare the two alternative ownership structures. If $i > s$, ownership makes the investor better off (since $i > \frac{1}{2}(i+s)$) and increases its incentive to invest. Instead, if $i < s$, ownership makes the investor worse off (since $\frac{1}{2}(i+s) <$

[12]The assumption that S can commit to stop bargaining with I is also made by Maskin (2003). For an in depth analysis of bargaining with a stakeholder see also Manzini and Ponzati (2002).

i) and decreases its incentive to invest. By acquiring property rights over the asset, I acquires the right to implement the innovation regardless of whether negotiation with S occurs. Such a right decreases the incentives for S to arrive at an agreement with I and thus weakens I's bargaining power.

Finally, consider the case where $s < 0$ (i.e., the externality is negative) and $i + s > 0$. Then, if I is the owner it can always obtain $i > 0$ by implementing the innovation immediately, in which case S suffers the loss s. Since S cannot veto the implementation and since the amount S is willing to pay I for not implementing the innovation $(-s)$ is insufficient for I (since $i > -s$), no agreement can be found. I implements the innovation and obtains i . If instead S is the owner, it can and will veto the implementation unless renegotiation occurs. Both players have now an outside option of zero. Since $i + s > 0$ implementation is optimal and bargaining occurs, yielding $\frac{1}{2}(i + s)$ each. Since $i > \frac{1}{2}(i + s)$, we conclude that when $s < 0$ and $i + s > 0$, the negative externality is not internalized and so ownership by the investor yields a higher investment.

In the following sections we use this bargaining procedure to discuss the optimality of bundling the different stages of production and the optimal ownership structure in the presence of positive and negative externalities.

4 Investments under alternative regimes

4.1 Private Ownership

- **Ownership by Firm 1**

Suppose that firm 1 owns the facility. Thus, the investor (firm 1) is the owner

in the building stage, but not in the management stage (where the investor is firm 2). Following the discussion in the previous section, this implies that renegotiation will occur for the implementation of e but not of a.

Consider the building stage. Since firm 1 has control rights, and as it will receive the residual value, which, from (1), is increasing in a, it will implement the innovation. Let s_1 denote the side-payment firm 1 will have to make to firm 2 to induce firm 2 to implement its innovation e.[13] Profit maximization by firm 1 therefore entails

$$\max_a \quad P - (K_0 + a) + R_0 + t(a) + r(e) - s_1.$$

Hence, it chooses a level of investment $a = a_1$ that solves

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

Compared to the first-best, firm 1 does not take into account the effect of a on either social benefits $B(a, e)$ or firm 2's costs $C(a, e)$.

Now consider the management stage. Since the owner (firm 1) gains directly from the implementation of the innovation, renegotiation takes place. Given Nash bargaining with equal shares, firm 1 makes firm 2 the side payment $s_1 = \frac{1}{2}r(e)$, and so the profit-maximization problem for firm 2 is

$$\max_e \quad p - C(a_1, e) + \frac{1}{2}r(e).$$

Given (3), it follows that at the beginning of period 2, firm 2 will choose the level

[13] We shall see below that s_1 is independent of a. It therefore does not affect firm 1's f.o.c. for profit maximization.

of investment $e = e_1$ that solves

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

Under-investment occurs (relative to the first best) since the firm does not fully internalize the effect of e on the residual value, nor does it take into account the effect on social benefits.

- **Ownership by Firm 2**

The case where firm 2 is the owner is symmetric to the one where firm 1 is the owner: renegotiation will occur with respect to the choice of a but not of e.

When firm 2 owns the facility, firm 1 has no incentive to implement innovation a. However, firm 2 wishes the innovation to be implemented because of its effects on the future value of the asset and on the costs of operating the facility. We therefore assume that the two firms will negotiate and agree to share the benefits $t(a) + \gamma c(a)$ from the innovation equally. Hence, firm 1 sets $a = a_2$ to solve

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

Firm 2 will receive the residual value, which is increasing in e, and it implements the management innovation. Parallel to (6), it sets $e = e_2$ to solve

$$r'(e_2) = 1. \tag{9}$$

- **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 power, as well as residual claimancy over the asset 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

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

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

Comparison of (10) and (11) with (4) and (5) reveals that, as in the ownership already discussed, there is no internalization of the effects of investments on social benefit. However, as a consortium, the firms take into account fully the effect of the investments both on the residual value and on the externality across stages.

4.2 Public Ownership

Suppose now that the government has control rights over the asset, in which case innovations cannot be implemented without the government's agreement. Thus, unlike in 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

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

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

Note that under-investment still occurs. Although in this case 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. Also, note that 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 procurement. 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

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

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

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.

5 Positive Externality

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.

With a positive externality, all ownership structures lead to underinvestment compared to the first-best, while, from (6)-(11), $a_I > a_1, a_2$ and $e_I = e_2 > e_1$. In light of this, we obtain the following lemma.

Lemma 1 *With a positive externality, bundling is always optimal.*

If ownership is private, then the PFI model of ownership by the consortium always dominates ownership by either firm 1 or firm 2. 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 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.

Given Lemma 1, the choice of the optimal ownership structure reduces to the choice between ownership by the government, which contracts with a consortium, and ownership by the consortium (PFI). The Proposition below is obtained by comparing the first-order conditions for the choices of a and e.

Proposition 1 *With a positive externality, if* $u'(a) < t'(a) + c'(a)$ *and* $v'(e) < r'(e)$*, PFI is optimal; but if both inequalities are reversed, public ownership with*

bundling is optimal.

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 e and a on R, though it will 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 social benefit dominates that on private residual value and the cost of operating the facility, public ownership leads to higher investment in the building stage. It will also lead to a greater investment in the management stage if the effect of the management innovation on social benefit dominates that on private residual value. This is a case where absence of ownership for the firm works as a commitment to renegotiate, and renegotiation is optimal.

Instead, if the effect of the building innovation on social benefit is dominated by that on the private residual value and on the cost of operating the facility, then consortium ownership is preferable for both e and a.

In the remaining cases, where for one innovation the effects on the residual value and the cost of managing the facility dominate, while for the other it is

the social benefit effect that is greater, each of the two ownership structures will encourage one type of investment but depress the other. Hence, it is the relative importance of the two investments in the welfare function that will be critical in determining which ownership structure is optimal.

6 Negative Externality

We now consider the case in which $\gamma = -1$; i.e., 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.

The sign of the externality has no implications for the choice of e: we still have that $e_I = e_2 > e_1$ and $e_{GI} = e_{GS}$. However, with regard to choice of a, 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 asset 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 asset, 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.

A complication caused by the negative externality is that some of the ownership structures may lead to a level of a that exceeds the first-best level a^*. As shown in the next lemma, whilst it is always the case that $a^* > a_2, a_I, a_{GI}$, it may occur that either a_{GS} or a_1 or both are greater than a^*. We shall therefore

distinguish between two cases. In the first one, which we label 'weak negative externality,' the externality is moderate and in each case considered, $a < a^*$. In the second case, labelled 'strong negative externality,' under some institutional arrangements $a > a^*$.

Lemma 2 *(i)* $a^* > a_2, a_I, a_{GI}$. *(ii) (a) Weak negative externality: if* $c'(a^*) < \min[1, u'(a^*)]$, *then* $a^* \geq a_{GS}, a_1$; *(b) strong negative externality: if* $c'(a^*) > \max[1, u'(a^*)]$, *then* $a_{GS}, a_1 > a^*$.

Proof. Assume $\gamma = -1$. (i) 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, in light of (10), implies $a^* > a_I$. Comparison of (4) and (12) yields $a^* > a_{GI}$.

(ii) Let $H_1(a) \equiv t'(a) - 1$. From (4), $H_1(a^*) = c'(a^*) - u'(a^*)$. In light of (6), $H_1(a^*) > (<) 0$ implies $a_1 > (<) a^*$. Similarly, let $H_{GS}(a) \equiv u'(a) + t'(a) - 2$. From (4), $H_{GS}(a^*) = c'(a^*) - 1$. In light of (14), $H_{GS}(a^*) > (<) 0$ implies $a_{GS} > (<) a^*$.

■

In the subsections below we shall first discuss the case of a weak negative externality where $c'(a^*) < \min[1, u'(a^*)]$, and therefore $a^* > a_{GS}, a_{GI}, a_1, a_2, a_I$: under all ownership structures there is underinvestment. We shall then consider a strong negative externality, focusing our attention on the case where $c'(a^*) > \max[1, u'(a^*)]$ implying that $a_{GS}, a_1 > a^* > a_2, a_I$.[14]

[14]This discussion can easily be extended to the case where either a_{GS} or a_1 are above a^*.

6.1 The weak negative externality case

Suppose that $c'(a^*) < \min[1, u'(a^*)]$ so that under all institutional arrangements there is underinvestment (from Lemma 2). This leads immediately to the following lemma.

Lemma 3 *In the presence of a weak negative externality, with public ownership it is optimal for the government to contract with separate firms rather than a consortium. With private ownership, ownership by firm 1 is optimal for the choice of a.*

Proof. The first sentence in the Lemma follows by noticing that under public ownership $a_{GS} > a_{GI}$ (from (12) and (14)) and $e_{GS} = e_{GI}$ (from (13)and (15)). The second sentence is an immediate consequence of Lemma 2, and in particular of the fact that $a^* > a_1 > a_2, a_I$. ■

Before turning to the intuition, we also compare private with public ownership. Using the first-order conditions of the various cases, we obtain the following proposition.

Proposition 2 *In the presence of a weak negative externality, a sufficient condition for traditional procurement to be optimal is that $u'(a) > t'(a)$ and $v'(e) > r'(e)$.*

The results above show, amongst other things, the possibility that, with a negative externality, unbundling of the building and management functions constitutes the optimal choice for a. Proposition 2 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, when the externality is weak, underinvestment results in all cases. It follows that in order to attenuate the underinvestment problem it may be optimal not to induce the internalization of the negative externality on $C(.)$. As discussed in Section 3, this can be achieved by not giving ownership to the firm that suffers the negative externality, which rules 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 the cost at the management stage.

Clearly, the optimal ownership structure for the choice of a does not necessarily coincide with the optimal ownership structure with respect to e. Proposition 2 is obtained by comparing traditional procurement with ownership by firm 1 and by the consortium. The type of private ownership that yields the highest level of a is ownership by firm 1. Comparison of (6) with (14) yields the first inequality in the proposition. The type of private ownership that yields the highest level of e is ownership by the consortium (or by firm 2). Comparison of (11) with (15) yields the second inequality. Thus we obtain the result that if the marginal effects of a and e on social benefit are relatively large compared to the effects on the residual value of the asset, traditional procurement is optimal.[15]

[15]If there is no externality, the values of a are found by setting $\gamma = 0$ in the various first-order conditions set out in Section 4. PFI is found to be the best form of private ownership, but, with public ownership, bundling and unbundling yield the same results. The sufficient condition given in Proposition 2, for public ownership to be optimal when $\gamma = -1$, also holds when $\gamma = 0$.

Finally, a reinterpretation of our framework enables us to comment on how the time horizon for a project affects the optimal type of ownership when there are weak negative externalities. 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. Assume that there is discounting and 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 $R(a, e)$ in present value terms. We then obtain the following.

Proposition 3 *In the presence of a weak negative externality, if the number n of units of time over which the service is to be provided is greater, 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 of $R(a, e)$ is smaller, for given $\{a, e\}$. Consequently, the present values of the effects $t'(a)$ and $r'(e)$ on residual value are smaller. We have seen in Proposition 2 that small values of these effects favour 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 favours public ownership.[16]

[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.

6.2 The strong negative externality case

Suppose now that the negative externality is strong, as defined by Lemma 2. Since e is not affected by the strength of the externality, we again focus on the choice of a. While it is still the case that $a^* > a_I, a_2, a_{GI}$, it now happens that 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.

We then obtain the following lemma.

Lemma 4 *With a strong negative externality, (i) if* $u'(a) > t'(a)$ *either ownership by firm 1 or government ownership with bundling is optimal; (ii) if* $t'(a) > u'(a) > t'(a) - c'(a)$*, either traditional procurement or government ownership with bundling is optimal; and if* $t'(a) - c'(a) > u'(a)$ *either traditional procurement or PFI is optimal.*

Proof. Using the various first-order conditions in conjunction with Lemma 2, the level of a under each institutional arrangements can be ranked, as follows: (i) if $u'(a) > t'(a)$, then $a_{GS} > a_1 > a^* > a_{GI} > a_I > a_2$; (ii) if $t'(a) > u'(a) > t'(a) - c'(a)$, then $a_1 > a_{GS} > a^* > a_{GI} > a_I > a_2$; (iii) and if $t'(a) - c'(a) > u'(a)$, then $a_1 > a_{GS} > a^* > a_I > a_{GI} > a_2$. The optimal arrangement is one of the two levels of a adjacent to a^* in this ranking. ■

Whether bundling or unbundling is optimal in the presence of a strong negative externality depends on the welfare effect of the overinvestment that occurs under unbundling, compared to the welfare effect of the underinvestment that

occurs under bundling. Now, bundling can be the optimal arrangement even with negative externalities. We find that relatively large effects on social benefit favour ownership by firm 1 or government ownership with bundling. Intermediate values of the effects on social benefit favour government ownership, with or without bundling; whilst low values of the effects on social benefit favour either traditional procurement or PFI. Note that bundling may be optimal both when $u'(a)$ is relatively large (when there is government ownership) and when $u'(a)$ is relatively small (with PFI).[17]

7 Conclusion and Policy Implications

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 shown that when there is a positive externality across the stages of production, bundling, with 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 show, however, that, with a positive externality, ownership of the asset by the consortium (the PFI model) is not necessarily optimal: under some conditions it is preferable for the government to own the asset. Furthermore, if the externality is negative, the case for bundling is weakened: with both public and private ownership unbundled provision may then be preferable. With a weak negative

[17]An equivalent to Proposition 3 does not hold when the negative externality is strong.

externality, if there is public ownership, unbundling is always preferable, while if the period over which the service is to be provided is lengthened, public provision is favoured relative to private provision. With a strong negative externality, results are less clear-cut, with, for example, bundling possibly being preferable.

If we exclude the case of a strong negative externality, 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 the facility; and (c) the weaker the effect that innovations have on the benefit from provision of the public service. If the externality is weakly negative, private ownership is more likely to be preferred if the period of service provision is shorter.

In the U.S. prison sector there is a widespread bundling of building and management functions (see Schneider, 2000). This is in line with our predictions, for the design of a prison can have a great effect on the cost of providing an adequate level of security; that is, there appears to be a strong positive externality. Nonetheless, given that a prison may have little residual market value, it does not necessarily follow that PFI, rather than public ownership (with bundling) should be used. In the case of education, however, if we accept the argument made by IPPR (2001) that the link between the design of schools and pupil educational outcomes has not been clearly shown, our analysis tends to support the use of PFI for the provision of physical assets. The argument is reinforced if residual value is significant.

Our analysis has different implications when safety is a major issue, as, for

example in the building of railway infrastructure. A high level of investment at the building stage in the incorporation of new safety features may lead to substantial social benefits. However, this investment may have a negative externality, for it may be necessary to employ relatively expensive, skilled labour to operate these safety features. We have seen that under these conditions the case for PFI tends to be weak (when the externality is weak) or unclear (when the externality is strong); traditional procurement may be preferred. When safety is not a major consideration or can be easily monitored, for example, for roads and bridges, the case for PFI is stronger.

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