Building and Managing Facilities for Public Services

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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 …rms. When a positive externality exists across stages of production, bundling is always optimal; but unbundling tends to be preferred when the externality is negative. Whether public ownership is preferred to private ownership depends on the extent of the externality, the market value of the facility and the e¤ect of the …rms' investments on social bene…ts.

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1 Introduction

The provision of many public services is organized through contracting out by the government of some infrastructure functions to private pro…t-maximizing …rms. Under traditional procurement, the public sector …nances and designs the project itself, contracts with a private …rm to build the facility, and then either operates the facility in-house or contracts out the operation to another …rm (HM Treasury, 1998). Recently, however, governments in Western Europe and North America have developed new forms of public-private partnership 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, …nance and operation of an infrastructure project to a consortium of …rms (Grout, 1997; HM Treasury, 2000). The formation of a consortium may allow the exploitation of synergies between the di¤erent phases of a project, inducing more innovative and cost-e¤ective designs (Daniels and Trebilcock, 2000; IPPR, 2001).

In this paper we study the desirability of the PFI model and the (second-best) optimal allocation of ownership between the government and the …rms with which it contracts. 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.[1] The government delegates these two functions to private …rms. Because the functions require specialized skills, two distinct …rms carry out the tasks. We analyze whether it is optimal for the government to contract with the two …rms separately ('unbundling') or whether it is preferable for the government to write a single contract with a consortium of the two …rms ('bundling'). We also analyze the optimal allocation of ownership of the facility. 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.[2]

We show that a critical role is played by externalities across the di¤erent stages of production. In particular, in the presence of a positive external-

[1] Thus, we disregard entirely the source of …nance for the project. However, as we are focusing on the potential synergies between the building and management stages, the source of …nance may not be a signi…cant factor. See Sussex (2001) for discussion of how the private …nance element might be excluded from PFI in the health sector.

[2] Other applications of the theory of incomplete contracts to the contracting out of public services include Hart, Shleifer and Vishny (1997) and Besley and Ghatak (2001). Hart et al. consider the scope for con‡ict between cost reduction and quality improvement when there is a single private …rm. They compare contracting out with in-house provision. Besley and Ghatak show that the ownership of a public good should lie with the party that values its services more highly, irrespective of the relative importance of the parties' investments. However, neither of these papers deals with the issue of bundling and ownership. A recent contribution to the literature on PFI by Bentz, Grout and Halonen (2001) is complementary to the incomplete contract approach, emphasizing the informational and contractual nature of the problem. An implication of their model is that the government will wish to buy services (as in PFI) rather than assets (as in conventional procurement) if the building and service delivery costs are low.

ity, bundling is always optimal, for it allows internalization of the positive effect that the investment activities in the building stage generate on the management of the facility. Hence, the formation of consortia is preferred to contracting with separate firms. Whether the ownership of the facility should be with the consortium, as in PFI, or the government, is shown to depend on the market value of the asset, the extent of the externality across stages and the social benefits generated by the asset. Ownership by the consortium induces its members to internalize more of the effect of their choices on both the residual value of the asset and the externality across the stages, but less of the effect on social benefits. Hence, depending on the relative significance of these effects in the welfare function, either consortium ownership or public ownership can be optimal. These results also hold in the absence of an externality.

The case of negative externality can lead to quite different results. In particular, unbundling may become optimal, making consortia undesirable. This result can be understood by noticing that 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 a negative externality since this could depress incentives further. Thus, it may be optimal either to give ownership rights to the …rm involved only in the building stage or, provided the two …rms act independently, to the government.

The rest of the paper is organized as follows. Section 2 outlines the model. Section 3 discusses the case of positive externalities between the di¤erent phases of production and compares di¤erent ownership structures; it also covers the case of no externalities. Section 4 studies the negative externality case, while Section 5 concludes and draws some policy implications.

2 The Model

We consider a setting where the government delegates to private …rms the building and management of a facility (or 'asset') which is 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 …rms: …rm 1 is specialized in building, while …rm 2 manages the facility once it is built. The building and management functions will be said to be 'bundled' if the two …rms form a consortium and operate as a single unit. The functions are 'unbundled' if the two …rms operate independently and the government contracts separately with each of them.

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 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. 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 and any renegotiation occurs. We shall assume that 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 discounted appropriately.

The residual value of the asset is given by[3]

$$R^i(a, e) = \mu^i[R_0 + t(a) + r(e)], \qquad i = G, F,$$

where R_0 is a positive constant, $t'(a), r'(e) > 0$ and $t''(a), r''(e) \leq 0$. 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.

The parameter μ^i is used to allow for the possibility that, when the management stage is over (at the end of the period of service provision specified in the contract) the residual value of the asset will depend on the use to which it is put. The residual value that the government assigns to the asset, linked to the possibility of continuing to use it for the provision of the public service, is $R^G(a, e)$. If, instead, the asset is used by private firms in the post-contractual period, its (market) value is $R^F(a, e)$. We assume that $\mu^G \geq \mu^F$, so that $R^G(a, e) > R^F(a, e)$.[4] This assumption is justified on the grounds

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

[4] A setting in which the reverse inequality may hold is considered by Edlin and Hermalin (2000).

that most of the facilities that are built in order to provide public services would need some restructuring in order to be valuable for the provision of alternative services. Consider the case of a prison. It would be costly to the private sector to convert the prison into a hotel and, given restrictions on prison location, it could be expensive to the government to move the accommodation of the inmates elsewhere. We further assume that $R^i(a;e)$ is observable but not veri…able.[5]

The social bene…ts generated by the facility at the management stage are

$$B(a;e) = B_0 + v(e) + u(a)$$

where B_0 is a positive constant, $v'(e); u'(a) > 0$ and $v''(e); u''(a) \leq 0$: Note that both e and a a¤ect social bene…ts positively: an increase in the quality of the asset or in maintenance activities increases the bene…ts from the provision of the service (a well-constructed or well-maintained prison may facilitate the rehabilitation of inmates).

[5] The unveri…ability of asset values implies that no pro…t-sharing contract can be enforced.

The costs at the building stage are

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

where K_0 is a positive constant.[6] However, we also allow for the possibility that the investment undertaken during the building stage affects the cost of managing the facility, which is

$$C(a; e) = C_0 + c(a) + e \tag{1}$$

where C_0 is a positive constant. We consider two cases. First, $c'(a) \leq 0$ and $c''(a) \leq 0$; that is, there exists a positive (or zero) externality between stages. This occurs, for example, when an improvement in the building quality brings about a reduction in maintenance activities. In the second case, $c'(a) > 0$ and $c''(a) \geq 0$; that is, there exists a negative externality across stages. This may be representative of a situation where a higher quality of the building requires greater maintenance costs.

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

We assume that $B(\cdot)$; $C(\cdot)$ and $K(\cdot)$ are observable but unverifiable. The allocation of property rights on the asset therefore has a twofold effect. First, it affects the allocation of control rights, for it is assumed that the implementation of any innovation requires the owner's approval. Second, the allocation of property rights may determine whether or not the asset will be sold once the contract expires.[7] Indeed, allowing for different asset values, depending on the use of the asset, implies that if the owner is not the one who values the asset most, then sale will occur.

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, or will be, the owner.

In this setting, the first-best levels of investments $(e^*; a^*)$ maximize $B(a; e) + R^G(a; e) - K(a) - C(a; e)$. Hence, they solve

$$v'(e^*) + \mu^G r'(e^*) = 1 \quad (2)$$

$$u'(a^*) + \mu^G t'(a^*) - c'(a^*) = 1 \quad (3)$$

[7] 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.

We assume that $e^{*} > 0$ and $a^{*} > 0$.

The timing of the game can be summarized as follows. In period 0, the ownership structure is chosen and the government specifies basic standards that must be met in the design of the facility and the provision of the service. These basic standards are observable and verifiable. Also, the price P that the government will pay to firm 1 for building the facility to the basic standard and the price p that it will pay to firm 2 for providing the service at the basic standard are specified. At the beginning of the building stage (period 1), firm 1 can undertake research to improve upon the contracted design of the facility. Conditional upon the approval of the owner, renegotiation of contract terms may take place to allow the innovation to be incorporated in the building of the facility. Similarly, at the beginning of the management stage (period 2), research can be carried out by firm 2 to find ways to improve upon the contracted level of service. Again, renegotiation of contract terms 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.[8]

[8] 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,

We start by discussing four alternative ownership structures for the facility.[9] The first 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 be operating separately 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.

3 Positive Externality

Assume that $c'(a) \leq 0$ and $c''(a) \leq 0$. Hence, (implementation of) a greater investment a at the building stage leads to a fall (or no change) in the cost of providing the service at the management stage.

Throughout, 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

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.

[9] 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.

the asset).

3.1 Private Ownership

Since $\theta^G \geq \theta^F$; at the end of period 2 the asset has a (weakly) greater value for the government than for the private market. We therefore assume that if a private firm owns the asset it will negotiate with the government. We see no reason to suppose that one party has all the bargaining power, and so we assume they will split the gains from trade equally.[10] This implies that the firm owning the asset receives

$$R^F(a;e) + \frac{1}{2}[R^G(a;e) - R^F(a;e)] = \frac{1}{2}\left(\theta^G + \theta^F\right)[R_0 + t(a) + r(e)], \qquad (4)$$

while the government receives

$$R^G(a;e) - \left\{R^F(a;e) + \frac{1}{2}[R^G(a;e) - R^F(a;e)]\right\} = \frac{1}{2}\left(\theta^G - \theta^F\right)[R_0 + t(a) + r(e)]. \qquad (5)$$

[10] Indeed, option-to-buy contracts like those suggested by Nöldeke and Schmidt (1998) are not robust to renegotiation.

3.1.1 Ownership to Firm 1

Suppose that firm 1 owns the facility.[11] Consider the building stage. Since firm 1 has control rights, and as, from (4), it expects future benefits $\frac{1}{2}\left(\theta^G + \theta^F\right)[R_0 + t(a) + r(e)]$ from the sale of the asset to the government, 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.[12] Profit-maximization by firm 1 therefore entails

$$\max_a \quad P - (K_0 + a) + \frac{1}{2}\left(\theta^G + \theta^F\right)[R_0 + r(e) + t(a)] - s_1,$$

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

$$\frac{1}{2}\left(\theta^G + \theta^F\right)t'(a_1) = 1. \tag{6}$$

Compared to the first-best, under-investment occurs for three reasons: the firm does not fully internalize the effect of a on the residual value (since $\theta^F \le \theta^G$; then $\frac{1}{2}\left(\theta^G + \theta^F\right) \le \theta^G$); and it does not take into account the

[11] In our framework the case of ownership to firm 1 is equivalent to the case of joint ownership between the government and firm 1 if we view the partners in a joint venture as each having veto power.

[12] 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.

effect of a on either social benefits $B(a; e)$ or firm 2's costs $C(a; e)$:

Now consider the management stage. Since ownership of the asset is in the hands of firm 1, firm 2 cannot implement the management innovation without the approval of firm 1. It follows that the default payoff of firm 2 in this case is $p - C(a_1; e)$. However, since there are gains from the implementation of the innovation (indeed the implementation of e has a positive effect on the payoff of firm 1, for it increases the residual value of the asset) it is reasonable to expect the firms to realize them through negotiation. We shall again assume that bargaining yields Nash outcomes, namely, through equal sharing of $\frac{1}{2}\left(\theta^G + \theta^F\right) r(e)$, the effect of the innovation e on the part of the residual value accruing to the firm 1. Hence, firm 1 makes firm 2 the side payment $s_1 = \frac{1}{4}\left(\theta^G + \theta^F\right) r(e)$, the profit-maximization problem for firm 2 being

$$\max_e \; p - C(a_1; e) + \frac{1}{4}\left(\theta^G + \theta^F\right) r(e).$$

Given (1), it follows that at the beginning of period 2, firm 2 will choose the level of investment $e = e_1$ that solves

$$\frac{1}{4}\left(\theta^G + \theta^F\right) r'(e_1) = 1. \tag{7}$$

Under-investment occurs since the firm does not fully internalize the effect of e on the residual value, nor does it take into account the effect on the social benefits $B(a; e)$:

3.1.2 Ownership to Firm 2

When firm 2 owns the facility, firm 1 has no incentive to implement innovation a. However, firm 2 wishes the innovation to be implemented, for it increases the future value of the asset and reduces the costs of operating the facility. We therefore assume that the two firms will negotiate and agree to share the benefits from the innovation equally. It follows that firm 1 solves the problem,

$$\max_a \; P - (K_0 + a) + \frac{1}{2}\left[\frac{1}{2}(\theta^G + \theta^F)t(a) - c(a)\right].$$

Here, $[.]$ is the effect of the innovation a on the part of the residual value accruing to firm 2, together with the externality that a has on firm 2's cost.

Because of Nash bargaining with firm 2, firm 1 gets half of these benefits; that is, it receives from firm 2 the side-payment $s_2 = \frac{1}{2}[\cdot]$. Hence, firm 1 sets $a = a_2$ to solve

$$\frac{1}{4}\left(\mu^G + \mu^F\right) t'(a_2) - \frac{1}{2} c'(a_2) = 1. \tag{8}$$

Firm 2 foresees gains from the sale of the asset to the government and so it implements the innovation. Parallel to (6), it sets $e = e_2$ to solve

$$\frac{1}{2}\left(\mu^G + \mu^F\right) r'(e_2) = 1 \tag{9}$$

3.1.3 Ownership to Consortium (PFI)

Suppose now that the two firms operate as a consortium, which owns the facility. Since the consortium has control power as well as residual claimancy over the asset value, it will implement both the building and management innovation. The consortium acts as an integrated firm and so its profit-maximization problem is

$$\max_{a,e} \; P + p - (K_0 + a) - [C_0 + c(a) + e] + \frac{1}{2}\left(\mu^G + \mu^F\right)[t(a) + r(e)]$$

Thus the levels of a and e under consortium ownership are a_I and e_I respectively, which solve

$$\frac{1}{2}\left(\theta^G + \theta^F\right) t'(a_I) - c'(a_I) = 1 \qquad (10)$$

$$\frac{1}{2}\left(\theta^G + \theta^F\right) r'(e_I) = 1 \qquad (11)$$

Comparison of (10) and (11) with (2) and (3) reveals that, as in the ownership cases above, under-investment occurs.

3.2 Public Ownership

Suppose now that the government has control rights over the asset. Innovations cannot be implemented without the government's agreement. Thus, unlike in PFI, the government has a say on input specifications. A firm will not implement an innovation unless it has negotiated adequate rewards from the government. However, with regard to the building stage, we shall see that the choice of the level of a depends crucially on whether the two firms are integrated.

3.2.1 Firms in a Consortium

Assume first that the two firms are in a consortium. Since there are positive benefits for the government from the implementation of the innovation, both in terms of social benefits and in terms of higher residual value, it follows that Nash bargaining occurs. The consortium therefore faces the profit-maximization problem,[13]

$$\max_{a,e} \; p + P - (K_0 + a) - (C_0 + e) + \frac{1}{2}\{\theta^G[R_0 + r(e) + t(a)] + v(e) + u(a)\}.$$

Hence, the levels of a and e under public ownership are a_{GI} and e_{GI} respectively, which solve

$$\frac{1}{2}\left[\theta^G t'(a_{GI}) + u'(a_{GI}) - c'(a_{GI})\right] = 1 \quad (12)$$

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

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

[13] $p + P - (K_0 + a) - (C_0 + e)$ here is the integrated firm's default payoff (the costs $\{a, e\}$ having been incurred, but the innovations not being implemented). The remaining term is the firm's share of the surplus from implementation of $\{a, e\}$.

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 the externality across stages.

3.2.2 Separated Firms

As in the case where the two firms are integrated in a consortium, Nash bargaining occurs, for the government wishes the innovation to be implemented. However, now the government contracts with the two firms separately. It follows that in the Nash bargain between firm 1 and the government the externality across the building and management stages will not be taken into account. Firm 1 decides on the investment cost a, taking into account that it will share the bargaining surplus $u(a) + \mu^G t(a)$ with the government. Similarly, for firm 2 the cost is e and the surplus $v(e) + \mu^G r(e)$ is bargained over. Therefore the firms set $a = a_{GS}$ and $e = e_{GS}$, where

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

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

From (13) and (15), separation has no effect on the choice of e: $e_{GI} = e_{GS}$.

However, from (12) and (14) it does affect the choice of a. When firms are separate, neither the government nor firm 1 is interested in the effect of a on the cost of managing the facility.

3.3 Optimal Ownership and Task Allocation

We can now compare the ownership arrangements in terms of $\{a, e\}$. First we ascertain whether it is optimal to bundle building and management. Since all ownership structures lead to underinvestment compared to the first-best, while, from (6)-(15), $a_I > a_1; a_2$; $e_I = e_2 > e_1$; $a_{GI} > a_{GS}$; $e_{GI} = e_{GS}$, we obtain the following proposition.

Proposition 1 With a positive (or zero) externality, bundling of building and management 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 this proposition, the choice of the optimal ownership structure reduces to the choice between ownership to the government, which contracts with a consortium, and ownership to the consortium (PFI). The lemma below is obtained by comparing the first-order conditions for the choices of a and e:[14]

Lemma 1 *With a positive externality, (i) if $u'(a) < (>) \mu^F t'(a) - c'(a)$ investment a is higher (lower) under PFI than under public ownership; (ii) if $v'(e) < (>) \mu^F r'(e)$ investment e is higher (lower) under PFI than under public ownership.*

The next proposition follows immediately.

Proposition 2 *With a positive externality, if $u'(a) < \mu^F t'(a) - c'(a)$ and $v'(e) < \mu^F r'(e)$, PFI is optimal; but if both inequalities are reversed, public ownership is optimal.*

Intuitively, when the consortium owns the facility it would implement both innovations since it foresees gains from the eventual sale of the facility to the government and from the future reduction of operating costs. Thus,

[14] For simplicity, we consider only the possibility of strong inequalities in this lemma and in the rest of the paper.

it internalizes partially the effect of e and a on R (recall that it must share residual value with the government - see eq. (5)) and it internalizes totally the positive externality on costs, though 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, and it will get less of the asset value than it would if it were the owner. In particular, it loses half of the effects of the innovation on private residual value and half of the positive externality, while it gains half of the effects on social benefit: Hence, although it now partially internalizes the effect on social benefit, it also only partially internalizes the effect on the residual value and the positive externality. Therefore, if the effect of the building innovation on social benefit dominates that on the 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 the social benefit dominates that on the 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.

4 Negative Externality

We now consider the case where $c'(a) > 0$ and $c''(a) \geq 0$. 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. Another interpretation is that the facility may be designed such that highly skilled, expensive labour is required to manage provision of the service.[15] Note that the equilibrium choices of the …rms remain the same as in the previous section provided that they are interior, as we assume for simplicity. However, di¤erent conclusions than in the previous section tend to emerge as to the optimality of the di¤erent ownership structures.

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 respect to a, it may not now be optimal to induce the internalization of the externality. From (6), (8) and (10), we now have that $a_1 > a_I$ and $a_1 > a_2$, while from (12) and (14), $a_{GS} > a_{GI}$. The following lemma therefore holds.

Lemma 2 With a negative externality (a) ownership by …rm 1 yields a greater level of a and a smaller level of e than obtains if either …rm 2 or a consortium owns the asset; (b) under public ownership a is greater if the …rms are separate, than if they are in a consortium.

Intuitively, if …rm 1 owns the asset it ignores the externality when choosing a. In contrast, if …rm 2 is the owner, the bargain between the two …rms causes …rm 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

[15] Under this interpretation we might expect that $t'(a) = 0$.

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 or e that exceeds the respective first-best level. Using (2) and (3), if the negative externality is sufficiently strong ($c'(a)$ is sufficiently positive in the relevant range) then a may exceed its first-level under private ownership by either firm 1 or firm 2 or under public ownership when firms are separated. However, for simplicity, we shall restrict our attention to cases in which investment is less than the first-best level. The discussion above then leads immediately to the following proposition.[16]

Proposition 3 *Suppose there is a negative externality and that each ownership structure leads to under-investment in a. With public ownership, it is optimal for the government to contract with separate firms rather than a consortium. With private ownership, any of the three ownership structures may be optimal.*

[16] The conditions for under-investment stated in the proposition are derived from comparing (2) and (3) with the first-order conditions for a and e under each ownership structure. These equations can also be used to give a full typology of the conditions under which each type of ownership structure is optimal.

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

Proposition 4 Suppose there is a negative externality and that each ownership structure leads to under-investment in a. If $v'(e) > \mu^F r'(e)$ and $u'(a) > \mu^F t'(a)$ then public ownership, with separate firms, is optimal.

The results above show, amongst other things, the possibility that unbundling of the building and management functions constitutes the optimal choice for a; i.e., it may not be optimal to induce the firm who chooses the level of investment in building quality to internalize the externality that its choice produces on the level of management costs. This result can be understood intuitively by noticing that none of the ownership structures allows full internalization of the positive effects of a on $B(\cdot)$ and $R^i(\cdot)$; and therefore underinvestment may result 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 $C(a, e)$. This can be achieved by separating the building and the management functions. Clearly, the optimal ownership structure for the choice of a does not necessarily coincide with that which is preferable in terms of e. However, if, as stated in Proposition 4, the marginal effects of a and e on social benefit are relatively large compared to the effects on the market residual value of the asset, public ownership with separation of firms is optimal.

5 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 private ownership unbundled provision may then be preferable, while with public ownership unbundled provision is always preferable. In general, 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.

The prison sector is often cited as an example where the integration of building and management could have significant effects, and there is a widespread bundling of functions in the prison sector in US (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 under which it operates; 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. 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 in schools. The case is reinforced, at least for some schools, if, as suggested in n.8, market 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. Also, 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 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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