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Contracting out public service provision to not-for-profit firms

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In an incomplete-contract setting, we analyse the contracting out of public service provision, comparing the performance of for-profit (FP) and not-for-profit (NP) firms. Two institutional arrangements are considered, control rights lying either with the firm (PPP) or the government (traditional procurement). We show that provision by an NP may be associated with overinvestment in quality improvement, but that under conditions that restrain this overinvestment, the NP may yield greater welfare than obtains with FP-provision. Although none of the four possible arrangements is preferable under all conditions, the introduction of PPP has enhanced the scope for advantageous provision by an NP.

JEL classifications: H41, L31, L33.

1. Introduction

Recent years have witnessed a steady stream of innovations in the way public services are provided, particularly through the development of public-private partnerships (PPPs). In the UK, under the Private Finance Initiative (PFI), it has become common for the government to contract out the provision of public services to a consortium of private firms that designs, finances, builds, and manages the facilities concerned (HM Treasury, 2006). In Canada, similar PPPs have been used for major infrastructure projects, such as the 407 Express Toll Route to the north of Toronto and the redevelopment of Pearson International Airport (Daniels and Trebilcock, 2000), while in the US, in much of the European Union, and in developing economies, there has been increasing use of such schemes (Linder and Rosenau, 2000). Provision through PPPs contrasts sharply with the way public services have traditionally been procured. Under traditional procurement, the government specifies the inputs and retains control rights over how the service is delivered. Instead, under PFI-type PPPs, the government specifies the output,

that is, it specifies a basic service standard, but it is the firm that has control rights over how to deliver the service.

Not-for-profit firms (NPs) have long been established in public service provision, for example in health and education. However, there has recently been an extensively-debated expansion in the role of NPs (see Weisbrod 1997, Bennett *et al.,* 2003, and Maltby, 2003). An important example in the UK is the responsibility for rail track facilities that the government gave to the NP, Network Rail, in 2002. Among the other well-publicized cases are Glas Cymru, which was created on a private initiative in April 2000 as a holding company for the assets of Dwr Cymru, the Welsh water utility, and NAV Canada, which was established in 1996, and owns and operates Canada's civil air navigation service.

In this paper, we analyse the contracting out of service provision to private firms, and we compare the case in which the contractor is an NP to that in which it is a for-profit firm (FP).[1] We consider these cases for two different institutional arrangements. The first is a PPP, under which the private firm has control rights over the project; the second is traditional procurement, the government retaining control rights. The primary contribution of the paper is to specify conditions under which provision by an NP is preferred, in the sense that it yields the highest level of welfare among the four possibilities examined, and in particular to consider whether the introduction of PPP has increased the scope for advantageous reliance on NPs.

We take an incomplete-contract approach (see, e.g., Hart, 1995), building on the seminal work on public service provision by Hart *et al.* (1997). We assume that the firm may make an observable but unverifiable investment, researching innovative approaches to perform its task in excess of the basic standard specified in the initial contract. An innovation, if implemented, has an effect both on the social benefit that is generated by the production of the public service and on the firm's profit. Control rights (i.e., ownership of the project) give the power of veto over the implementation of any given innovation. With a PPP, the firm's control rights over the project give it the power to implement an innovation without consulting the government (provided basic standards are met), whereas with traditional procurement the firm must obtain the government's agreement for implementation, and this involves bargaining.[2]

[1] This is a much revised version of Bennett and Iossa (2005).

[2] In the UK renegotiation does sometimes occur under PFI, for example when the contractors refinance a project. However, it is not in the spirit of PFI, which is specifically designed to stimulate innovation by allowing contractors to keep the resulting financial rewards (Audit Commission, n.d.). According to the National Audit Office (National Audit Office, 2003), 73% of UK construction projects using traditional procurement had a final price that exceeded that in the original contract, but the corresponding figure for PFI was 22%, and most of these were the result of changes led by the relevant government department, not by the contractor.

Whereas an FP may be assumed to maximize profits, an NP operates under a non-distribution constraint, which bans it from redistributing profit to its members. Also, an NP may be founded with a specific mission in mind; its users and stakeholders may participate on its board of trustees; and there may be self-selection of managers and workers with concern for this mission (see, e.g., Bilodeau and Slivinski, 1996, and Besley and Ghatak, 2004). Nonetheless, the profit from a project matters to an NP because, for example, it may be used to subsidize other projects, to save or pay off debts, or to finance perquisites (see, e.g., James, 1983, and Glaeser and Shleifer, 2001). To capture these considerations as simply as possible, we assume that the NP's objective is to maximize a weighted sum of benefits and profits, and that the NP is subject to a profit constraint. Such a constraint is particularly important for an NP because, given its non-distribution constraint, an NP does not have the option of raising funds on the stock market. Indeed, because of this, the NP is not subject to the market for corporate control, and this frees it to pursue its mission objective.[3]

We compare the investment behaviour of an NP and an FP, and the implications for public service provision, under three alternative scenarios. In scenario 1, implementation of an investment increases both the contractor's profit and social benefit (we refer to this as 'profitable quality improvement'). For example, aspects of building quality, such as the reliability of the numerous pipe joints hidden within a building fabric, cannot, for practical purposes, be fully monitored, and so are not contractible. Investment in asset quality (e.g., of a hospital or a school building) can generate both lower maintenance costs for the contractor and greater social benefit from the use of the asset for public service provision (e.g., fewer disruptions to teaching or health care).[4] In contrast, scenarios 2 and 3 are characterized by a conflict between social benefit and profit. Scenario 2 (unprofitable quality improvement) occurs because implementation of an investment that increases social benefit is costly and, in the absence of a side-payment from the government, will cut the contractor's profit. For example, implementation of the investment might improve safety, but the original contract may not offer scope to raise revenue to cover the

[3] In contrast, in Glaeser and Shleifer (2001), NP status is chosen by a self-interested entrepreneur as a commitment device to reassure customers and other agents against *ex post* expropriation (e.g., on noncontractible output quality). In their model the NP entrepreneur pursues profit (as well as output quality—for reputational reasons or out of altruism) to an extent that is limited by the fact that, because of the non-distribution constraint, profits can only be used to buy perquisites. As a referee has pointed out, this ignores that NPs are generally exempt from corporate income tax in the US, so that, if we were to accept the view that the NP entrepreneur is self-interested, this could in principle imply that the NP would put a greater weight on profit than an FP does.

[4] The profitable quality improvement scenario may also apply for free-standing projects, such as leisure centres and nursing homes, where users are charged a fee and where there is competition among providers, so that a higher quality of service may well raise total revenues and profits.

costs of implementation.[5] In scenario 3 (cost cutting at the expense of quality) implementation of an investment increases profit, but has an adverse impact on social benefit. This may be in the form of reduced safety, for example in railway maintenance or air traffic control, but may relate to any quality aspect of the service (e.g., quality of health care).

If provision is by an NP, the impact of investment on social benefit will be taken into account because the NP cares about social benefit directly. This impact will also be recognized in decision-making if there is traditional procurement, for then, since the government has control rights, bargaining between the firm and the government must occur for an innovation to be implemented. Social benefit is then taken into account because the government cares about it directly. But if traditional procurement is used with an NP, too much weight, in welfare terms, may be put on social benefit, relative to revenue, because both the government and the NP care about social benefit. This public good aspect of the service may result in overinvestment in quality.

We show that provision by an NP yields the highest welfare among the four arrangements if conditions exist that sufficiently restrain its tendency to overinvest. With the use of PPP, rather than traditional procurement, the NP has control rights over the implementation of any investment and must rely on its own profit to finance investment. This acts as a constraining factor on its investment—in fact, underinvestment may also occur—and, as a result, there is found to exist a range of parameter values for which NP provision under PPP is optimal.

Alternatively, if traditional procurement is used the NP's tendency to overinvest is limited if the government's concern for social benefits is relatively small, compared to how much it values retaining funds. This restricts the amount that the government is willing to pay a firm for implementing an innovation and, foreseeing this, the firm (FP or NP) will determine its level of investment accordingly. An FP would invest substantially less than the first-best level, whilst an NP may invest closer to the first-best level because of the direct concern it has for social benefits. Consequently, for a range of parameter values NP under traditional procurement is the optimal arrangement.

The theoretical literature on the provision of public services is expanding rapidly. Hart *et al.* (1997) and Schmitz (2000) compare public provision with contracting out to an FP. The optimality of bundling building and managing operations in PPP projects with FPs is discussed by Hart (2003) and Bennett and Iossa (2006) under incomplete contracts, and by Benz *et al.* (2001) and Martimort and Pouyet (2008)

[5] Many public services are characterized by an inelastic demand and are offered in conditions of limited competition among the private providers. If also the government is the purchaser of the service or if user fees are specified in advance, increasing some nonverifiable quality aspect of the service is likely to be unprofitable for the contractor. In this context, it is interesting to note that the NHS Confederation in the UK has reported that PPP hospitals designed and built by FPs often failed to create a good healing environment with less noise and more daylight. See *PublicPrivateFinance*, 85, July/August 2004.

under complete contracts.[6] Iossa and Martimort (2008) provide a unified framework to discuss the main contractual issues for PPPs and the design of the optimal incentive contract. However, none of these papers considers public service provision by NPs.

There is also an extensive literature on NPs, though, for many years, its main focus was on the relationship between the firm and its donors (see e.g., Rose-Ackerman, 1996). However, a related branch of the literature considers NPs that do not rely on donations (see Hansmann, 1986, 1996). Glaeser and Shleifer (2001) model NP status as a device to maximize the returns of a self-interested entrepreneur producing a private good (see footnote 3 above), but closer to our work is that of Besley and Ghatak (2001). In their model, as in ours, a critical role is played by the service provider's valuation of social benefit. They show that control rights should be left with the party that values services more highly, thus indicating a role for 'benevolent' NPs. However, contrary to us, they do not explicitly consider PPP—which is shown in our analysis to widen the potential role for NPs in effective public service provision, and they do not allow for the possibility that the NP has a budget constraint. The paper is also related to a more recent literature on the role of pro-social motivation in the provision of social services, though the focus there is on workers' intrinsic incentives (see Francois and Vlassopoulos, 2008, for a review of this literature.).

The paper is organized as follows. Section 2 outlines the model, and, on the assumption that innovations have their primary effect on social benefits, rather than profits, it compares the alternative institutional arrangements. Section 3 analyses what happens if the dominant effect of an innovation is instead on profit. Section 4 considers how results depend on the extent to which the government cares about social benefits. Section 5 gives concluding comments. Proofs are provided in an appendix.

2. The model

We consider a setting where, initially, the government and the firm agree a contract that specifies observable and verifiable basic standards for the provision of a public service. However, before operations begin, the firm may make an observable but unverifiable investment, which we denote by $x \geqslant 0$, researching innovative approaches to performing its task in excess of the basic standard. The cost of this investment in monetary terms is $C(x)$, which, for simplicity, we shall assume to be quadratic: $C(x) = x^2/2$. The investment is 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. Furthermore, the innovation can be implemented only by the firm that

[6] Bundling in an incomplete-contract model is also analysed by Bös and De Fraja (2002), who examine the case of health care for which quality is unverifiable.

has discovered it, and has no value for the firm outside the relationship. We assume that an innovation, if implemented (in our solutions x is always implemented) affects both the profit and the social benefit generated by the provision of the public service.

The impact of the innovation depends on which of three scenarios obtain:

(1) Profitable quality improvement: implementation of innovation x raises both social benefit and profit.
(2) Unprofitable quality improvement: implementation of innovation x raises social benefit but cuts profit.
(3) Cost cutting at the expense of quality: implementation of innovation x raises profit but cuts social benefit.

Scenarios are denoted by the subscript $i = 1, 2, 3$. Which one obtains is exogenously determined, reflecting the characteristics of the service being produced, and is known in advance to both the firm and the government.

The social benefit generated by the provision of the public service is

$$B_i(x) = B_0 + \beta_i bx, \quad b \geqslant 0, \tag{1}$$

where B_0 is a positive constant denoting verifiable basic standards and β_i is a shift parameter whose value is either 1 or -1. In scenarios 1 and 2, $\beta_i = 1$ $(i = 1, 2)$, so that x increases social benefit; in scenario 3, $\beta_i = -1$, so that x decreases social benefit.[7]

Gross profit is defined to be

$$\Pi_i(x) = \Pi_0 + \gamma_i \pi x, \quad \pi \geqslant 0, \tag{2}$$

where Π_0 is the default profit that the firm earns by satisfying basic standards with $x = 0$. We assume that $\Pi_0 = 0$. γ_i is a shift parameter whose value is either 1 or -1. In scenarios 1 and 3, $\gamma_i = 1$ $(i = 1, 3)$, so that x increases profit; in scenario 2, $\gamma_i = -1$, so that x decreases profit. We assume that $B_i(x)$, $C(x)$ and $\Pi_i(x)$ are observable but unverifiable. Net profit $\hat{\Pi}_i(x)$ is defined also to include the investment cost $C(x)$ and the monetary transfer z that is received from the government should bargaining occur in order to get the firm to institute the innovation x. Thus,

$$\hat{\Pi}_i(x) = \Pi_0 + \gamma_i \pi x - C(x) + z. \tag{3}$$

An FP chooses x to maximize net profit $\hat{\Pi}_i(x)$ and will be willing to participate if $\hat{\Pi}_i(x) \geqslant 0$. An NP cares about social benefits directly, and has some concern for profit. Also, it is subject to a net profit constraint, its objective function being

$$\max_x \Omega_i(x) = \alpha B_i(x) + (1 - \alpha)\hat{\Pi}_i(x) \text{ subject to } \hat{\Pi}_i(x) \geqslant 0; 1/2 < \alpha < 1. \tag{4}$$

[7] We might have assumed the value of b (and of π in (2)) to depend on which scenario obtains. This would have no effect on the results of this section.

It will be willing to participate if $\Omega_i(x) \geqslant 0$, with $\hat{\Pi}_i(x) \geqslant 0$. Thus, from (3), any profit for the NP related to innovation, $\gamma_i \pi x - C(x) + z$, must be non-negative. The government is assumed to maximize $B_i(x) - z_0 - z$, where z_0 is the payment it makes for satisfying basic standards; that is, it maximizes benefits minus any payments to the firm.[8] The firm and the government are assumed risk-neutral.

We compare two institutional arrangements: public-private partnership (PPP) and traditional procurement. We assume that under PPP the firm has control rights over the project, being free to implement the innovation without consulting the government. Under traditional procurement, however, the government has control rights over the project, and if there are gains from implementing the innovation, bargaining between the firm and the government will take place. To simplify, we assume that with probability 1/2 the government makes a take-it or leave-it offer, while with probability 1/2 the firm makes a take-it or leave-it offer.

In this setting, for each institutional arrangement, PPP, or traditional procurement, and for each type of firm, FP or NP, we compare investment levels, and thus welfare levels. The timing of the game is as follows. Given which scenario obtains, in period 0 the government sets the basic standards for service provision, and the institutional arrangement and type of firm is chosen: PPP or traditional procurement, and FP or NP. Also, the chosen FP or NP agrees a contract with the government to provide at least the basic standards B_0 for price z_0.[9] At the beginning of period 1 the contractor (FP or NP) undertakes investment x researching improved methods for performing its task in excess of the basic standards. In period 2, the contractor can implement the innovation—without consulting the government if the contractor has control rights (PPP), but after bargaining with the government if the government has control rights (traditional procurement) provided a mutually beneficial deal is agreed. In period 3 the service is provided. For simplicity, there is no discounting.

As a benchmark, we specify the first-best solution. Welfare in scenario i, $W_i(x)$, is defined to be the sum of benefits, gross profits and (negatively) the investment cost; that is,

$$W_i(x) = B_i(x) + \Pi_i(x) - C(x). \tag{5}$$

The first-best investment x_i^* maximizes $W_i(x)$. We assume for now that $b > \pi$, that is, in each scenario the dominant effect of an innovation is on benefits, rather than

[8] We are assuming here that 'the government' is a government agency, such as a local government or ministry, with its own objectives, rather than an abstract welfare-maximizing government.

[9] We do not consider how the contractor was chosen. On the difficulties of competitive bidding schemes when NPs are involved, see Steinberg (1997).

gross profits. (The reverse of this inequality is considered in the next section.) x_i^* is therefore given, for the respective cases, by

$$\begin{aligned} x_1^* &= b + \pi; \\ x_2^* &= b - \pi; \\ x_3^* &= 0. \end{aligned} \tag{6}$$

2.1 Traditional procurement

We assume in this section that the government has control rights over the project. We consider first the investment behaviour of an FP and then of an NP.

Under traditional procurement, an innovation cannot be implemented without the government's approval. If there are positive gains from implementation, bargaining between the firm and the government occurs.[10] We assume that the outside option is zero for each player. Hence, if bargaining occurs the default payoff for each player is the payoff that would obtain if there were no implementation of x and only the basic standards were achieved. Thus, the default payoffs are $B_0 - z_0 \equiv V_0$ for the government, z_0 for an FP, and $\alpha B_0 + (1-\alpha)z_0$ for an NP.

Suppose first that the firm is an FP. With bargaining, if the FP makes the offer, the best it can do is ask the government to pay the amount that makes the government indifferent between agreeing to the offer or not; that is, the offer the FP makes is $z = \beta_i bx$. If the government makes the offer, the best it can do is ask the FP to pay the amount for which the FP is indifferent between accepting or not; that is, the government makes the offer $z = -\gamma_i \pi x$.[11] Hence, given the simple formulation of alternating-offers bargaining, there is an equal chance that $\hat{\Pi}_i(x) = \gamma_i \pi x - C(x) + \beta_i bx$ or $\hat{\Pi}_i(x) = \gamma_i \pi x - C(x) - \gamma_i \pi x = -C(x)$. Thus, $E[\hat{\Pi}_i(x)] = \frac{1}{2}(\gamma_i \pi x + \beta_i bx) - C(x)$. We therefore have that in scenarios 1 and 2 the FP will set $dE[\hat{\Pi}_i(x)]/dx = \frac{1}{2}[\gamma_i \pi + \beta_i b] - x = 0 \quad (i = 1, 2)$. In scenario 3 $E[\hat{\Pi}_3(x)] = \frac{1}{2}(\pi - b)x - C(x)$, which, for $b > \pi$, is decreasing in x. Thus,

$$\begin{aligned} x_1^{tf} &= \frac{1}{2}(\pi + b); \\ x_2^{tf} &= \frac{1}{2}(b - \pi); \\ x_3^{tf} &= 0. \end{aligned} \tag{7}$$

Compared to the first-best, there is underinvestment in scenarios 1 and 2. If the FP makes the offer, it asks the government to pay the value of benefits from

[10] Thus, we follow Hart *et al.* (1997) and assume that the control rights of the government work as a commitment device for renegotiation to take place over how to share the gains from implementation. Investment cost $C(x)$ is a bygone but implementation of the investment is not.

[11] Since cost $C(x)$ has already been incurred the government does not have to take $C(x)$ into account in its offer.

implementation, which, if this offer is accepted, will cause the FP to internalize benefits fully and therefore the first-best is achieved. However, if the government makes the offer it asks the FP to pay the amount of profits that result from implementation. If this offer is accepted, the FP will not earn these profits, and therefore it will internalize neither the profits nor the value of benefits. It is because there is a 50% chance that the government will make the offer that hold-up occurs and the FP's investment is below the first-best level. However, scenario 3 coincides with the first-best solution.

Suppose now that the firm is an NP and that $\beta_i = 1$, as in scenarios 1 and 2. If the NP makes the offer, it will extract all the benefit that an innovation generates for the government, who will therefore pay $z = bx$. If the government makes the offer, it will demand the highest z that, given the choice of x by the NP, is compatible with the NP's budget constraint, i.e., $\gamma_i \pi x + z - C(x) \geqslant 0$, and such that the firm is willing to accept the offer, i.e., $\alpha(B_0 + bx) + (1-\alpha)(\gamma_i \pi x + z) \geqslant \alpha B_0$. At the equilibrium the government will demand a payment up to the point at which the NP's budget constraint is binding, which gives $z = -\gamma \pi_i x + x^2/2$. Anticipating this, the NP chooses x such that the budget constraint binds at $z = bx$; the government will pay it this amount. It is not relevant here which player makes the offer, for there is only one value of z that is acceptable to both players. Given also that in scenario 3 the NP will choose not to invest, we have

$$\begin{aligned} x_1^{tn} &= 2(\pi + b); \\ x_2^{tn} &= 2(b - \pi); \\ x_3^{tn} &= 0. \end{aligned} \tag{8}$$

In scenarios 1 and 2 there is overinvestment relative to the first-best because benefit is increasing in investment and the budget constraint enables the firm to extract all the benefits of investment from the government. In scenario 3, however, x_3^{tn} equals the first-best level.

Our first proposition brings these results together and also specifies that in scenarios 1 and 2, for which we have found underinvestment by an FP but overinvestment by an NP, welfare is higher with the FP.

Proposition 1 For traditional procurement with $b > \pi$, the FP weakly dominates the NP in welfare terms.

With traditional procurement, social benefits are internalized to some extent by the FP because it bargains with the government, although there is underprovision compared to the first-best. In contrast, an NP prioritizes benefits and, as a result, if it also bargains with the government, it overprovides relative to the first-best. We find that the NP overprovides to such an extent that welfare is lower than with an FP. In particular, in scenarios 1 and 2, $x_i^{tn} > x_i^* > x_i^{tf}$, with welfare higher with an FP than with an NP. In scenario 3 $x_3^{tn} = x_3^* = x_3^{tf}$.

We return to this result and its sensitivity to our assumptions in succeeding sections.

2.2 PPP

We now turn to PPP, the firm having control rights. We consider first the investment behaviour of an FP and then of an NP.

When the firm is an FP it chooses x to maximize $\hat{\Pi}_i(x)$, as given by (3). Thus, writing x_i^{pf} for the level of x it chooses in scenario i, we have

$$\begin{aligned} x_1^{pf} &= \pi; \\ x_2^{pf} &= 0; \\ x_3^{pf} &= \pi. \end{aligned} \tag{9}$$

In scenarios 1 and 3, with profit increasing in x, an interior solution obtains; and in scenario 2, with profit decreasing in x, the FP does not invest. In each scenario the solution is different from the first-best because the FP does not take into account the effect of x on benefits. In scenarios $i = 1$ and 2, $x_i^{pf} < x_i^*$ since the FP does not take into account the positive effect of x on B_i; in scenario 3, $x_3^{pf} > x_3^*$ since the FP does not take into account the negative effect of x on benefits.

Suppose now that the firm is an NP, maximizing $\Omega_i(x)$ subject to its budget constraint. Denote the NP's investment by $x = x_i^{pn}$. The interior solution that maximizes $\Omega_i(x)$ is given by $x_i^{pn} = \hat{x}_i^{pn}$, where

$$\hat{x}_i^{pn} = \frac{\alpha}{1-\alpha} b\beta_i + \pi\gamma_i.$$

However, this is not feasible, as it violates the budget constraint:

$$\hat{\Pi}_i(\hat{x}_i^{pn}, z = 0) = \frac{1}{2}\left[(\pi\gamma_i)^2 - \left(\frac{\alpha}{1-\alpha} b\beta_i\right)^2\right] < 0 \quad (i = 1, 2, 3).$$

Instead, corner solutions obtain. In scenario 1, as both benefits and gross profit are increasing in x, the NP invests up to the point at which the budget constraint $\pi x_1^{pn} - C(x_1^{pn}) \geqslant 0$ is binding; that is,

$$x_1^{pn} = 2\pi. \tag{10}$$

In scenario 2, although x increases benefits, it violates the budget constraint. In scenario 3, x decreases benefits by more than it increases profits. Therefore the NP does not invest in scenario 2 or 3:

$$x_2^{pn} = x_3^{pn} = 0. \tag{11}$$

Compared to the first-best (9), in scenario 1 there is underinvestment, given that $b > \pi$. Since B_i is increasing in x, the NP invests up to where the budget constraint binds. Since π is low compared to b, the budget constraint binds at a point from which welfare could have been raised by further increasing x, but the budget constraint prevents the NP from doing so. In scenario 2 the first-best involves positive

investment, but the budget constraint prevents any investment.[12] In scenario 3 $x_3^{pn} = x_3^*$ since both are zero.

These conclusions lead immediately to our second proposition.

Proposition 2 For PPP with $b > \pi$, the NP weakly dominates the FP in welfare terms.

With PPP the firm has control rights over service provision. If it is an FP, being only concerned with profit, the benefit effect is not taken into account. This suggests that, when the benefit effect is large relative to the profit effect, provision by an NP, which cares about benefit, is preferable to provision by an FP. In particular, in scenario 1 $x_1^{pf} < x_1^{pn} < x_1^*$: there is underinvestment under both arrangements, but investment and welfare are greater with an NP than with an FP. In scenario 2 $x_2^{pf} = x_2^{pn} < x_2^*$: there is the same amount of underinvestment under each arrangement. In scenario 3 $x_3^{pf} > x_3^{pn} = x_3^*$: provision by an NP yields the first-best level of investment, but there is overinvestment by an FP.

A significant feature to emerge from Propositions 1 and 2 is that the introduction of PPP has opened up new opportunities for welfare-enhancing public service provision by NPs. Whilst provision by an NP is never optimal under traditional procurement, it is (weakly) optimal under PPP.

2.3 PPP versus traditional procurement

The above results can be used to give an overall comparison of the four arrangements—with PPP or traditional procurement, and FP or NP provision. From Propositions 1 and 2, we obtain the following.

Lemma 1 Assume that $b > \pi$. There is a (weakly) optimal match: FP provision with traditional procurement on the one hand; NP provision with PPP on the other.

There are two ways to ensure that the effect of investment on benefits is taken into account. One is provision by an NP (because it cares about benefits) and the other is through traditional procurement (since control rights are then with the government, and it cares about benefits). However, when the benefit effect of investment dominates the profit effect, if we have both an NP and traditional procurement, then the effect on benefits may be taken into account excessively. In social welfare terms, it is preferable to use either an NP or traditional procurement—but not both.[13]

[12] Note that in this case the budget constraint prevents the firm from implementing a Pareto-improving innovation. Our main results would continue to hold if we allowed instead the firm to bargain with the government over the implementation of the innovation. See footnote 14.

[13] The analysis becomes more complicated when other functional forms are used. Suppose for example, the benefit and profit functions are quadratic. Specifically, assume that bx in (1) is replaced by $\eta x^2/2$, where $\eta > 0$, and that πx in (2) is replaced by $\delta x^2/2$, where $\delta > 0$. Then corner solutions are generally

Our third proposition specifies which of the two options, FP with traditional procurement or NP with PPP, yields the greater welfare.

Proposition 3 Assume that $b > \pi$. With profitable quality improvement (scenario 1), the (weakly) preferred arrangement is an NP with PPP if $b < 3\pi$; but with unprofitable quality improvement (scenario 2) or cost-cutting at the expense of quality (scenario 3), an FP with traditional procurement is the (strongly) preferred arrangement.

Consider scenario 1, where investment is in profitable quality improvement. With both an NP under PPP and an FP under traditional procurement there is underinvestment. However, for given b, a higher level of π increases the investment of the NP more than that of the FP. The reason is that the FP must share the additional profit with the government through the bargain, whilst the NP will use the entire additional profit to finance more investment. We then find that the preferred arrangement is an NP with PPP if $b < 3\pi$; but it is an FP with traditional procurement if $b > 3\pi$.

In scenario 2, where investment is in unprofitable quality improvement, the NP does not have the funds to invest under PPP. With traditional procurement the government's control rights work as a commitment device to share the benefit effect with the FP, through bargaining, i.e., the government provides funding for unprofitable investment. Thus, there is some investment (though less than the first-best level) and welfare is higher than with an NP under PPP.[14]

In scenario 3, each arrangement yields zero investment, as in the first-best.

3. Dominant profit effect

Suppose that $b \leqslant \pi$ (this includes $b = 0$); that is, assume that the dominant effect of an innovation is on gross profits, rather than benefits.

A repeat of our earlier analysis gives the values of x shown in Table 1. We focus on the case in which $\pi \leqslant \alpha b/(1-\alpha)$.[15] Compared to our results for $b > \pi$, the values in the table only change for scenarios 2 and 3. However, the implications of the

generated, with, for example, the first-best level of investment x^* being zero if $\eta + \delta < 1$, but infinity if $\eta + \delta > 1$. We then find that if $\eta > \delta$ an FP and an NP perform equally under PPP, but that the FP is weakly preferred under TP. If instead $\eta < \delta$ then for PPP the NP becomes weakly preferable. We then find that, if both $\eta > \delta$ and $\beta_i\eta + \delta\gamma_i$, a form of the matching result in Lemma 1 still holds; but it may not hold otherwise.

[14] This conclusion would be unaffected if we were to relax the assumption that there is no bargaining under PPP. Bargaining with an NP under PPP would yield the same level of investment as bargaining with an NP under traditional procurement. But we have already seen that welfare is weakly higher with an FP under traditional procurement than with an NP.

[15] If $\pi > \alpha b/(1-\alpha)$ then for NP provision with PPP the budget constraint does not bind at the interior solution for scenarios 1 and 3 and so we obtain $x_1^{pn} = \pi + \alpha b/(1-\alpha)$ and $x_3^{pn} = \pi - \alpha b/(1-\alpha)$. The welfare rankings are then less clear-cut than in Proposition 3; in particular, they depend on the value of α.

Table 1 Levels of x_i when $b \leqslant \pi$

	x_i^*	x_i^{pf}	x_i^{pn}	x_i^{tf}	x_i^{tn}
1	$b+\pi$	π	2π	$(b+\pi)/2$	$2(b+\pi)$
2	0	0	0	0	0
3	$\pi-b$	π	0	$(\pi-b)/2$	0

values in the table affect the welfare comparisons across all three scenarios. In contrast to when $\pi > b$, the first-best solution in scenario 2 is now zero investment because each unit of investment would cut gross profit by more than it would raise benefit; but the first-best now involves a positive investment in scenario 3 because each unit of investment raises gross profit by more than it cuts benefit. In scenario 2 each of the four arrangements now leads to the first-best solution, so we focus on scenarios 1 and 3, highlighting the differences from our analysis for $b > \pi$.

Consider traditional procurement first. Since in scenario 1 π and b play symmetric roles in the formulae for x_1, the analysis is identical to that in the previous section: $x_1^{tn} > x_1^* > x_1^{tf}$, with welfare higher with an FP than an NP. In scenario 3 there was no investment when $b > \pi$, but with $b \leqslant \pi$ there is a positive surplus from the bargain between the FP and the government for implementation of the innovation. Because the FP must share surplus with the government it invests less than the first-best amount. However, provision by an FP still outperforms provision by an NP, which (since investment reduces benefits) does not invest at all; that is, $x_3^* > x_3^{tf} > x_3^{tn}$ and $W(x_3^{tf}) > W(x_3^{tn})$. Thus, under traditional procurement, welfare is (weakly) higher with an FP than with an NP, regardless of the scenario.

Consider now PPP. In both scenarios 1 and 3, with $b \leqslant \pi$ it is found that $W(x_i^{pf}) \gtreqless W(x_i^{pn})$ $(i = 1, 3)$ as $\pi \gtreqless 2b$.[16] Row 1 of the table gives the same values as when $b > \pi$. But, with $b \leqslant \pi$, whereas the FP is again underinvesting (as when $b > \pi$), the NP is (weakly) overinvesting (in contrast to when $b > \pi$). If benefit b is sufficiently small compared to profit π (i.e., if $\pi > 2b$) then x_i^{pf} is closer to x_i^* than x_i^{pn} is, and so the FP yields greater welfare; but if $\pi < 2b$ the NP yields greater welfare. For scenario 3, the reverse results hold, in that the FP overinvests, while the NP (weakly) underinvests, but the same conclusion obtains with respect to welfare: $W(x_3^{pf}) \gtreqless W(x_3^{pn})$ as $\pi \gtreqless 2b$. Thus, under PPP, welfare is (weakly) higher with an FP when the profit effect and the benefit effect of an innovation differ substantially, regardless of the scenario. But when the difference in these two effects is small, welfare is (weakly) higher with an NP.

Proposition 4 1. With profitable quality improvement (scenario 1), PPP with an FP maximizes welfare for $\pi > 2b$, while PPP with an NP maximizes welfare for

[16] $|x_i^{pf} - x_i^*| = b$ and $|x_i^{pn} - x_i^*| = \pi - b$ for both $i = 1$ and $i = 3$. Hence, $|x_i^{pf} - x_i^*| - |x_i^{pn} - x_i^*| = 2b - \pi$ and the welfare ranking in the text follows.

$\pi < 2b$. 2. With unprofitable quality improvement (scenario 1), each of the four options yields the first-best investment (zero). 3. With cost-cutting at the expense of quality (scenario 3), PPP with an FP maximizes welfare for $\pi > 3b$, while traditional procurement with an FP maximizes welfare for $\pi < 3b$.

When the profit effect is dominant, provision by an NP is never preferred under traditional procurement, whilst it can be preferred when PPP is used. Furthermore, when provision may be by traditional procurement or by PPP, we find that (as in Proposition 3) NP provision can only be strictly preferred when the profit effect and the benefit effect of an innovation do not differ substantially.

4. The government's valuation of social benefits

We now allow for the possibility that the government places a lower weight on social benefits $B(x)$. Assuming, as in Section 2, that $b > \pi$, suppose that, with the first-best solution still given by (6), the government places the value $gB(x)$ on benefit, where $1 > g > 0$.[17] This might apply, for example, if the project is a pollution control scheme with benefits outside the government's locality, and the government does not value benefits to outsiders.[18] Thus (9)–(11) and Proposition 1 still hold. For PPPs, this amendment has no effect on the amount of investment. For traditional procurement, however, our earlier analysis must be amended.

With an FP under traditional procurement, if the FP makes the offer, the best it can do is ask the government to pay the amount that makes the government indifferent between agreeing to the offer or not; that is, the offer the FP makes is now $z = g\beta_i bx$. With this change, solutions are then obtained as above, though with one further complication: in scenario 2, the government and the firm will agree to implement the innovation if and only if their total gain from implementation is positive, that is if $gb - \pi \geqslant 0$. Hence, instead of (7) we have

$$\begin{aligned} x_1^{tf} &= \frac{1}{2}(\pi + gb); \\ x_2^{tf} &= \frac{1}{2}(gb - \pi) \quad \text{if } g > \pi/b, \text{ but is zero otherwise;} \\ x_3^{tf} &= 0. \end{aligned} \tag{12}$$

We note that the fact that g appears, rather than unity, makes the underinvestment problem with the FP (weakly) more severe. The FP cares about benefit only to the extent that it can appropriate, through bargaining, some of the positive value that

[17] Our propositions hold independently of the value of the weight α in the NP's objective function. Therefore we do not need to analyse the role of the relative weights that the NP and the government place on social benefit. However, as we shall see, the absolute weight that the government places on social benefit does play an important role.

[18] The analysis is easily amended to allow for the possibility that $g > 1$.

the government places on benefit. Thus, the less the government values benefit, the less will the FP internalize the positive effect that its innovation has on benefit.

We now turn to provision by an NP. An NP under traditional procurement will, in scenarios 1 and 2, now make the offer $z = gbx$. Substituting this into the NP's budget constraint, we have $gbx + \gamma\pi x - x^2/2 = 0$. Given also the complication in scenario 2 identified above for $g \leqslant \pi/b$, and since in scenario 3 the NP will choose not to invest, instead of (8) we have

$$\begin{aligned} x_1^{tn} &= 2(\pi + gb); \\ x_2^{tn} &= 2(gb - \pi) \text{ if } g > \pi/b, \text{ but is zero otherwise;} \\ x_3^{tn} &= 0. \end{aligned} \tag{13}$$

With $g = 1$, we found that there was overinvestment relative to the first-best in scenarios 1 and 2. Now there may be overinvestment or underinvestment, depending on the size of g. Thus, the undervaluing of social benefit by the government can actually make an NP under traditional procurement come closer to the first-best solution.

With $g < 1$ all results (apart from Proposition 2) must be modified, but, for brevity, we only consider the intuition here, rather than spelling out the revised propositions and proofs. In place of Proposition 1 it is found that, under traditional procurement, provision by an FP no longer weakly dominates NP provision.[19] Because the government now places a lower value on benefits, the NP cannot squeeze so much money from the government and so its tendency to overinvestment is inhibited. Consider solutions for NP provision in which investment is positive. The effect of steadily reducing g from unity is that investment by both the FP and the NP falls. However, even for $g = 1$ the FP is underinvesting relative to the first-best, whereas the NP is overinvesting. As g is reduced the NP's investment falls steadily through the first-best level. When it is close enough, from above, to the first-best, welfare is higher with NP provision than with FP provision. Given that $x_i^{tn} > x_i^{tf}$ $(i = 1, 2)$, the same conclusion holds for further reduction in g.

If provision is by an FP it is now found, unlike in Lemma 1, that PPP can be preferred to traditional procurement. This occurs at a low level of g, for which under traditional procurement the FP here secures a relatively small payment from the government and so invests little. However, if provision is by an NP it is found, again unlike in Lemma 1, that traditional procurement investment can be preferred to PPP. This also occurs at a low level of g, for which under traditional procurement is sufficiently close to the first-best.

[19] In the revised Proposition 1 it is found that in scenario 1 $W(x_1^{tf}) \gtreqless W(x_1^{tn})$ as $\frac{4b-\pi}{5b} \lesseqgtr g$; in scenario 2 if $g > \pi/b$, $W(x_2^{tf}) \gtreqless W(x_2^{tn})$ as $\frac{\pi+4b}{5b} \lesseqgtr g$, while if $g \leqslant \pi/b$, then $x_2^{tf} = x_2^{tn} = 0 < x^*$; in scenario 3 $x_3^{tf} = x_3^{nf} = 0 = x^*$. The revised Proposition 3 is considerably more complicated.

These results lead to the following proposition.

Proposition 5 The lower the weight g placed by the government on social benefit, the greater the scope for NP provision.

We have previously argued that the combination of NP and traditional procurement would perform relatively badly because a weight would be given to benefit both because of the NP's concern for benefit and through the government's concern, which is felt through the payment it makes for implementation of the innovation. Thus, too much weight would be put on benefit in the solution. When $g < 1$, however, the government is not willing to pay so much for implementation, so the weight placed on benefit in the solution is smaller. With an FP under traditional procurement, the lower value of g is associated with less internalization of social benefit, exacerbating the underinvestment problem; but, conversely, with an NP under traditional procurement it is associated with less overinvestment.[20]

5. Concluding comments

In this paper we have analysed a simple stylized model of contracting out to an NP and to an FP under two alternative procurement arrangements. The first is PPP, whereby the firm is allocated control rights over how to deliver a public service; the second is traditional procurement, whereby the government retains control rights. We have shown that public-service provision by an NP may be associated with overinvestment in quality improvement, but that under conditions that restrain this overinvestment, the NP may yield a higher level of welfare than would obtain with provision by an FP. Thus, the introduction of PPP has enhanced the scope for advantageous provision by an NP.

Future research might examine the robustness of the results to changes in functional form. Also, it would be interesting to consider the effects of alternative timing and informational assumptions. Throughout the paper we assume that

[20] Another variation on the model that could be explored in detail is to consider the role of the budget constraint for the NP. Briefly, if, for the NP, the government varies z_0, the payment for satisfying basic standards, this may affect the NP's investment (variation of z_0 for the FP would have no effect on its investment). In Scenarios 1 and 2, since investment has a positive effect on benefits, the NP invests up to the point at which its budget constraint binds. As a referee has pointed out, in principle, it follows that, through an appropriate choice of z_0 (thus making $\Pi_0 \gtrless 0$) the government can induce the first-best level of investment by the NP.

However, there are practical problems in implementing this solution. First, focusing on the case in which $\alpha = 1$, $b > \pi$ and $g = 1$, there is a significant difference between PPP and traditional procurement. Under PPP, if $\Pi_0 = 0$ the NP underinvests; thus to induce optimal investment it is necessary that $\Pi_0 > 0$, the government subsidizing the NP. In contrast, under traditional procurement, if $\Pi_0 = 0$ the NP overinvests and so we would need $\Pi_0 < 0$ for the optimal investment to be undertaken. If the NP is subject to limited liability, setting $\Pi_0 < 0$ may be problematic, suggesting that PPP may be preferable to traditional procurement. Second, even with PPP, the first-best may not be achievable because the government may be unable to commit, for any contingency that may arise, to the funding that this requires.

which of the scenarios is realized in period 2 is exogenously determined and that scenarios are realized before the firm chooses its level of investment. However, it is possible that effort by the firm will have an impact on the probability that a particular scenario occurs. Allowance for endogenous scenarios would enable an analysis of how an NP might choose to invest in profit-enhancing activities to raise funds for cross-subsidization of their public service provision. Another extension of our analysis would be to consider the possibility that the firm, but not the government, can observe the realized scenario, and to study mechanisms through which the government optimally offers funds to the firm based on the scenario it reports. Such asymmetric information between the firm and the government is likely to introduce further inefficiencies in service provision.

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Appendix: proofs

Proposition 1 The rankings of x_i^{tf}, x_i^{tn} and x_i^* $(i = 1, 2, 3)$ follow from (7) and (8). Consider $i = 1, 2$. From (1), (2), and (5), $W_i'(x) = \beta_i b + \gamma_i \pi - x$; and from (6), $W_i'(x^*) = \beta_i b + \gamma_i \pi - x_i^* = 0$. Since $W_i''(x) < 0$, it follows that for any value of x such that $W_i'(x) < 0$ we have that $x > x_i^*$, and for any value of x such that $W_i'(x) > 0$ we have that $x < x_i^*$. Using Taylor expansions, given that $W_i'''(x) = 0$, we have $W_i(x) = W_i(x_i^*) + W_i'(x_i^*)(x - x_i^*) + W_i''(x_i^*)(x - x_i^*)^2/2$. Since $W_i'(x_i^*) = 0$ and $W_i''(x) < 0$, it follows that for $x = x^A$ and $x = x^B$, $W_i(x^A) \gtreqless W_i(x^B)$ as $(x^A - x_i^*)^2 \gtreqless (x^B - x_i^*)^2$; that is, as $|x^A - x_i^*| \gtreqless |x^B - x_i^*|$. From (6), (7) and (8), in scenario 1 $|x_1^{tf} - x_1^*| = |-(\pi + b)/2| = (\pi + b)/2$, while $|x_1^{tn} - x_1^*| = \pi + b$. Hence, $|x_1^{tf} - x_1^*| < |x_1^{tn} - x_1^*|$, so that $W_1(x_1^{tf}) > W_1(x_1^{tn})$. In scenario 2, $|x_2^{tf} - x_2^*| = |-(b - \pi)/2| = (b - \pi)/2$, while $|x_2^{tn} - x_2^*| = |b - \pi| = b - \pi$. Hence, $|x_2^{tf} - x_2^*| < |x_2^{tn} - x_2^*|$, so that $W_2(x_2^{tf}) > W_2(x_2^{tn})$.

Lemma 1 This follows immediately from comparison of the first-order conditions except in two cases. For scenario 1, using the same approach as in the proof of Proposition 1, since $x_1^{pn} = 2\pi$ and $x_1^{tn} = 2(\pi + b)$, we have $|x_1^{pn} - x_1^*| = |\pi - b| = b - \pi$ and $|x_1^{tn} - x_1^*| = \pi + b$. Hence, $|x_1^{pn} - x_1^*| < |x_1^{tn} - x_1^*|$, so that $W_1(x_1^{pn}) > W_1(x_1^{tn})$. For scenario 2, $x_2^{pn} = 0$ and $x_2^{tn} = 2(b - \pi)$, and so $|x_2^{pn} - x_2^*| = |-(b - \pi)| = b - \pi$ and $|x_2^{tn} - x_2^*| = b - \pi$. Hence, $|x_2^{pn} - x_2^*| = |x_2^{tn} - x_2^*|$, so that $W_2(x_2^{pn}) = W_2(x_2^{tn})$.

Proposition 3 Scenario 1: from Propositions 1 and 2, either an NP with PPP, or an FP with traditional procurement, yields the highest welfare. Since $|x_1^{pn} - x_1^*| = b - \pi$ and $|x_1^{tf} - x_1^*| = (\pi + b)/2$, we have that $|x_1^{pn} - x_1^*| \gtreqless |x_1^{tf} - x_1^*|$ as $b \gtreqless 3\pi$. Thus, $W_1(x_1^{pn}) \lesseqgtr W_1(x_1^{tf})$ as $b \gtreqless 3\pi$. For scenarios 2 and 3, the result follows from Propositions 1 and 2 and Lemma 1.

Proposition 4 In scenario 1, $|x_p^F - x^*| = b$ and $|x_t^F - x^*| = (\pi + b)/2 > b$. Therefore with an FP, PPP dominates traditional procurement. This also holds for an NP since $|x_p^N - x^*| = \pi - b$ and $|x_t^N - x^*| = \pi + b$. Since $W(x_3^{pf}) \gtreqless W(x_3^{pn})$ as $\pi \gtreqless 2b$, the result follows. In scenario 3, $|x_p^F - x^*| = b$ and $|x_t^F - x^*| = (\pi - b)/2$. Therefore $|x_3^{pf} - x_3^*| - |x_3^{tf} - x_3^*| = (3b - \pi)/2$ and $W(x_3^{pf}) \gtreqless W(x_3^{tf})$ as $\pi \gtreqless 3b$.