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Risk transfer in Private Finance Initiatives (PFIs)

An economic analysis

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Abstract

This paper models risk transfer in Private Finance Initiatives (PFIs) using a simple microeconomic framework. The effects of different levels of risk aversion on the part of the Government and the PFI contractor are analysed, as are the effects of Government risk diversification. The ability of the contractor to control cost uncertainty is modelled and a simple microeconomic condition indicating when PFIs might be optimal is derived. The effects of PFIs on efficient technology use are discussed and the implications of the Government's access to cheaper capital analysed. Lastly the framework is used to understand some findings from PFI survey data.

Private Finance Initiatives

When the Government commissions a project it can undertake the financing itself or enter into a Private Finance Initiative (PFI) where the design, finance and maintenance of the project are all provided (in some cases it may be a subset of the 3) by a private consortium. PFIs are typically run on a fifteen to thirty year contract, with the consortium being paid back in predefined instalments, conditional on performance. On expiry of the contract, ownership of the project's assets normally reverts back to the public sector. Projects procured under PFI have included: hospitals, offices, schools, housing and roads. Although most PFIs are for new construction work they can also be used for refurbishments and service provision.

Project risks and their allocation

Construction projects are subject to risks at all stages of their development. Planning permission can be hard to obtain and designs may not be finalised before work starts. The construction process itself may face difficulties e.g. defective materials, labour disputes, design changes and disruption of work by the elements. All these can lead to projects running over time and/or over budget. Even after completion there are risks that buildings become prematurely obsolete or face wear and tear, leading to refurbishments and extra cost.

The allocation of these risks should in principle depend on who is best able to bear and manage them. It will also depend on the extent to which it is possible to write suitable contracts. A project contract should stipulate how risks are allocated, though it is impossible to contract for every contingency and there is often legal ambiguity.

PFIs and traditional procurement

The guidance on PFIs is that risks should be transferred to the party that is best placed to internalise them. In practice this has usually meant the contractor, who undertakes to carry out the project for a given fee and bears much of the risk during the life of the contract. PFIs long-term contracts, under which the contractor maintains the project for an extended period after construction have also not traditionally been a feature of public procurement. It has been argued that the risk transfer and long-term contractual arrangements in a PFI can lead to efficiency gains.

Traditional procurement arrangements take many forms, however it is generally agreed that, at least historically, they have passed less risk to the contractor than PFIs. This is evidenced by studies finding PFIs provide greater cost and time certainty[1]. More anecdotally there are some cases where risk has severely backfired on the Government under traditional procurement. The Scottish Parliament building for example, which it was estimated could be built for £40m, ended up costing £431m under a variable fee arrangement. The reasons for this particular overrun and others are various and complicated. For the purpose of the analysis we will assume that project risk takes a very simple form, that is not passed to the contractor under traditional procurement, but is under a PFI.

This is not to say that PFIs are necessarily better, as contractors will in general want to be compensated for bearing risk, also they have a higher cost of capital than the Government. The official test for undertaking a PFI is that it should represent better value for money than traditional procurement, *once* risk transfer has been taken into account. This is assessed by estimating the cost and risk of the project to the Government under traditional procurement and comparing it with the project as a PFI.

The issues analysed

To analyse risk transfer in PFIs this paper lays out a simple theoretical framework, in which the following will be examined:

Risk bearing

1. The premium that the Government would be prepared to pay to transfer the project risk, and its relation to the rules for undertaking PFIs.

2. How PFIs and traditional procurement compare, given the differing attitudes of Government and PFI contractors to risk.

Incentive effects

3. The incentives for the contractor to manage risk under a PFI compared to traditional procurement.

4. How PFIs long-term contractual arrangements might affect investment in efficient technologies.

Financing

5. The implications of Government having a lower cost of capital than the contractor.

6. Project completion and financial difficulties.

Net benefit and risk transfer

7. How the framework developed explains some PFI survey findings.

[1] See pp. 45-48, "PFI: meeting the investment challenge", HM Treasury 2003.

The main focus of the analysis is the risk transfer in PFIs, rather than the quality of the delivered project as such. Issues around the competitiveness and cost of the bid process are also not discussed. These are obviously very important areas, but we do not address them directly. The analysis does not attempt to be a completely realistic description of the complexities of actual procurement, or a completely rigorous formal model. Rather it aims to strip the problem down to the bare essentials, to bring out the underlying issues and stimulate debate.

Although not based on any pre-existing model of PFIs as such, our approach is influenced by work on risk transfer in occupational pensions (McCarthy, 2005 and Besley and Pratt, 2003) and earlier work on the economics of PFI (Palmer, 00 and Grout, 97).

The project assumptions:

We now describe the underlying assumptions of the simple project that will be analysed.

1. The hypothetical project of our analysis lasts two periods, with financing raised in period 1 and repaid at the end of period 2, after project completion. The cost of finance (the interest rate r) will initially be the same for both Government and the PFI contractor.

2. There is uncertainty as to the cost (£ millions) of the project which takes the form of a 2 state payoff G (< 0) or B (> 0) with probabilities π and $(1 - \pi)$ respectively. In state G the project costs £100 + G to complete (low cost) and in state B it costs £100 + B (high cost), with £100+G < £100 < £100+B. The risk is mean 0, so $\pi G+(1-\pi)B = 0$ and the expected cost of the project is £100. This is all assumed to be common knowledge.

   When we examine the effects of contractor effort, the uncertainty will take the form of a continuous random variable, which is symmetrically distributed. The contractor will be able to control the variance but not the mean.

3. The contractor earns £100+G whatever the state of the world. The cost uncertainty should be taken as payments that may, or may not need to be made to third parties (i.e. component suppliers, extra/fewer workers) depending on the state of the world, rather than payments that go directly to the contractor.

4. Whether it is the contractor or the Government who is responsible for raising the finance, the amount borrowed will be equal to the expected cost of the project (the £100). It must be acknowledged that in practice the payoff pattern could be arranged differently, so this is a weakness in our approach. However without imposing some restrictions on the financing arrangement the analysis would become indeterminate. A justification of this assumption might be that no financier would be prepared to lend the maximum potential cost of the project, and that the Government/contractor would not borrow the lowest potential cost as

otherwise the project might not be able to go ahead. Borrowing the expected cost of the project could therefore be seen as a rule of thumb.

5. It is not possible to insure the project cost uncertainty directly in the financial markets[2].

6. Although there may be different abilities to bear and manage risk amongst contractors, we assume that the delivered product will be the same i.e. be it procured from contractor A or contractor B the delivered PFI building/service will be identical.

7. The delivered project will meet requirements. Effective assessment of PFI bids should ensure that contractors are unable to win a tender process by offering a low bid price at the expense of producing a poor result.

When we analyse the effects of PFI's long-term contractual relationship on efficient technology use, a two period framework with no cost uncertainty will be used, consisting of a construction phase, followed by a maintenance phase.

Risk bearing

Traditional procurement

Under traditional procurement the Government borrows the £100 at the interest rate r, and has to make debt repayments of £100(1+r) at the end of period two on project completion[3]. In state G under traditional procurement this means that the Government has a saving of £G. In state B however it needs to find an extra amount £B to pay for the project.

The expected cash flow of the Government is therefore:

Expected cash flow of Government under traditional procurement
Period 1: + 100 (borrowed)
Period 2: - 100(1+r) - (πG +(1-π)B)

As we have assumed that the expected cost of the project is known and the uncertainty is mean 0, the expectation of the cost uncertainty (πG +(1-π)B) vanishes. Given that construction projects have a reputation for cost overruns the realism of this is questionable. The basis for the assumption is that we want to keep the analysis as simple and accessible as possible. The cost uncertainty will have an effect as we assume that the Government's (and also the contractor's) utility is decreased by the uncertainty's variance.

[2] The existence of construction insurance and ability of the contractors to sell PFI risk by refinancing the project raises questions about this assumption. We assume that the market is sufficiently illiquid that the cost of the PFI is not already implicitly quoted.

[3] Although we are using a 2 period framework, both the debt repayment 100(1+ r) and the PFI payment P can be seen as the PV of a payment stream spread over a longer time period
e.g. $100(1+r) = \sum_{i=1}^{30} \frac{d_i}{(1+r)^i}$ where d_i is the agreed debt repayment in period i repaid over 30 years.

In practice cost overruns can take many forms. It may be that the project was not objectively costed, with the actual cost of the efficiently run project being considerably greater than the original estimate. A benefit of a fixed price PFI arrangement is that the contractor, as it bears the cost overrun risk is incentivised not to produce unrealistically low cost estimates. However to ensure value for money, the public sector still needs to be able to assess costs and risks accurately.

Alternatively the project may have been reasonably costed, but in the undertaking due to inefficiencies/accidents the costs exceed expectations. The decision-making and project management process should ensure that this does not happen systematically across large numbers of projects.

In the model under traditional procurement the contractor is assumed to bear none of the cost uncertainty risk. In carrying out the project it may well be best placed to control costs, however unless contractually obliged to manage the uncertainty it does not have a direct incentive to do so.

PFI procurement and the risk premium

In our PFI the situation is different, here the contractor borrows the £100 in period 1, which it then has to repay in period 2 and undertakes to deliver the project for the PFI payment P from the Government. The expected cash flow to the contractor is given below.

<u>Expected cash flow of contractor under the PFI</u>

Period 1: + 100 (borrowed)
Period 2: $- 100(1+r) - (\pi G + (1-\pi)B) + P$

We are assuming that the cost of financing is the same for the contractor and the Government, with both facing an interest rate r. This is undoubtedly a simplification, as in practice the Government has a lower cost of capital. Also the financier may well want a return on financing that reflects the risk of the project, so r won't in practice be exogenous. We will attempt to address these issues in the penultimate section of the paper.

Under the PFI the risk is born by the contractor, so whatever the state of the world, the payment by the Government is fixed at P. In a sense the PFI acts as insurance passing the burden of project cost uncertainty to the contractor.
We can analyse the maximum P that the Government would be prepared to pay for this certainty, by equating the utility of traditional procurement arrangements with the PFI payment. For simplicity we assume that the Government's/contractor's utility takes the form of a mean-variance utility function[4] and that utility is a function of project payments only.

<u>Mean-variance utility function</u>

$$U(\text{project}) = \mu - \beta\sigma^2$$

β is a positive coefficient, μ is the mean of the project costs/revenues and σ^2 the variance

[4] Although it's an abstraction of how the two parties assess risk, this type of approach is sometimes advocated in practice. See annex 4 on Risk and Uncertainty, p89, The Green Book Appraisal and Evaluation in Central Government, HM Treasury 2003.

A random variable X with E(X) = 0 has $\sigma^2 = E(X^2)$, therefore the variance of our risk is $(\pi G^2 + (1-\pi)B^2)$ so:

$$-P = -100(1+r) - \beta(\pi G^2 + (1-\pi)B^2)$$

Utility under PFI = Utility under traditional procurement

Implying

<u>The PFI payment that would make the Government indifferent between traditional procurement and PFI</u>

$$P = 100(1+r) + \beta(\pi G^2 + (1-\pi)B^2)$$

The PFI payment = The cost of financing + The risk premium

In the case where the Government is risk averse ($\beta > 0$) it would be prepared to pay a risk premium of at most $\beta(\pi G^2 + (1-\pi)B^2)$. Correspondingly a risk averse contractor would be unwilling to undertake the project as a PFI without one. If the Government is risk neutral ($\beta = 0$) then it would be prepared to pay $P = 100(1+r)$, and the return on the PFI for a contractor undertaking the project would be equal to the cost of finance.

The relation to the Public Sector Comparator (PSC)

The above analysis relates to the way decisions on whether a project should be a PFI are actually made. In principle a project should not be undertaken as a PFI unless it "costs" less than the project under public financing. This cost is estimated by the public sector comparator (PSC)[5], which is calculated as the cost of the project, plus an extra amount representing the risk that is transferred in the PFI. In our microeconomic setting we take the PSC to be equivalent to the PFI payment just calculated.

<u>The Public Sector Comparator (PSC)</u>

$$PSC = 100(1+r) + \beta(\pi G^2 + (1-\pi)B^2)$$

The cost of financing + The disutility to the public sector of the risk transferred

The difference between the PSC and the cost of financing corresponds to the maximum premium that the Government would be prepared to pay to transfer the project risk. If a contractor is willing to undertake the project for less than the PSC then in our model the PFI would be approved.

[5] Technically this is the risk adjusted public sector comparator, which is used to make the decision about whether to proceed with a PFI, but to simplify notation we call it the public sector comparator (PSC).

Calculating a real PSC is naturally more complicated than it is in our simple utility based framework and the PFI approval procedure is more involved. Details of how things are done in practice can be found in the Treasury guidance on value for money appraisal[6].

In the model, and in reality, the decision as to whether the PFI project should proceed is based on an ex ante assessment of whether the project is value for money. Once a project is underway it may well be that in some instances the project comes in below cost, in which case the contractor stands to make a high return, in others costs may overrun and the contractor will lose out. Neither should necessarily be seen as evidence for or against the PFI's approval, provided that the original risk assessment was reasonable.

Risk diversification

If the Government has a large number of projects then there is scope for it to diversify away cost uncertainty. To give an extreme example, if individual project risks are uncorrelated with identical variances then the total cost risk approaches 0 as the number of projects increases.

<u>The variance of aggregate cost uncertainty across n identical projects</u>

$$\sigma^2 \text{ of total overruns} = (\Sigma\sigma_i^2)/n^2 = \sigma_i^2/n \quad \text{so} \quad \sigma^2 \rightarrow 0 \text{ as } n \rightarrow \text{infinity}$$

(This relationship only holds if the cost overrun risks are uncorrelated.)

Presumably the contractor does not run as many projects as the Government and so is less able to diversify the risk[7]. If the Government is able to completely diversify away project risk, then it has no incentive to pay a risk premium. For example if there are n identical projects, with uncorrelated cost uncertainty then the PFI payment that equalises utility with traditional procurement is:

<u>The PFI payment that makes the Government indifferent</u>
<u>(under diversification across n projects)</u>

$$Pn = 100(1+r)n + \beta(\pi G^2 + (1-\pi)B^2)/n$$

As $n \rightarrow$ a large number
we get back to the case where Government is effectively risk neutral and

$$P \approx 100(1+r)$$

In this situation the Government would not factor the risk transferred on an individual project into the PSC

The above analysis is obviously unrealistic; in practice risks are not identical and may be correlated e.g. common shocks to factor prices, costs being systematically underestimated. Diversification possibilities may also be limited due to projects being spread over time. However the analysis does highlight

6 http://www.hm-treasury.gov.uk/documents/public_private_partnerships/key_documents/ppp_keydocs_vfm.cfm
7 However depending on the ownership structure of the contractor, it may it be possible for its owners to spread the risk by diversifying their own asset portfolios.

how opportunities for diversification can change attitudes to risk. If contractors were risk averse then they would not be prepared to take on the PFI project and its risk without a premium above the cost of financing. However a risk neutral/diversified Government would not want to pay such a premium, and so only traditional procurement would be optimal.

In our model different attitudes to risk and/or the diversification capabilities of the contractor and Government have implications for the existence of PFI vs. traditional procurement, which are laid out in the table below.

	Government	
Contractor	**Risk averse**	**Risk neutral** (risk diversified)
Risk averse	The contractors would require a risk premium and Government would be prepared to pay one. Possible scope for both PFI and traditional procurement.	PFIs would never be undertaken, as the Government would not be prepared to pay a risk premium to the risk averse contractor.
Risk neutral (risk diversified)	PFIs would always be undertaken as the contractor would be prepared to bear the risk for no extra premium.	If both Government and the contractor are risk neutral, then PFI and traditional procurement are equivalent.

The analysis so far has not taken account of the incentive effects of procurement systems on contractor behaviour and the difference in the public and private sectors cost of capital. The paper will now cover these in turn.

Incentive effects

The effects of procurement methods on contractor risk management

In the PFI the contractor has to internalise the cost uncertainty and therefore if risk averse ($\beta > 0$) has an incentive to reduce it. We examine the situation where the cost uncertainty depends on contractor effort (e). The uncertainty is assumed to be symmetrically distributed with mean 0, and has a finite range. The variance σ^2 of the uncertainty decreases with contractor effort, albeit with diminishing returns and the effort costs a fixed amount w per unit of effort. The relationship between cost uncertainty and effort takes the following functional form:

How the variance of the project's costs depends on effort

$$\sigma^2(e) = \sigma^2 - e^{\alpha}$$

Where $0 < \alpha < 1$

σ^2 is the variance with no contractor effort[8] ($e = 0$)

For $e \geq \underline{e}$ all uncertainty is eliminated i.e. $\sigma^2(e) = 0$

[8] We also assume that a minimum level of effort of e=1 is required to reduce uncertainty. This allows increases in alpha to be interpreted consistently as improvements in contractors risk management.

The utility for the contractor under a PFI is:

$$P - 100(1+r) - \beta(\sigma^2 - e^{\alpha}) - we$$

Maximising with respect to effort (e) gives the utility maximising level[9]:

$$e^* = (\alpha\beta/w)^{1/(1-\alpha)}$$

And cost variance:

$$\phi = \sigma^2 - (\alpha\beta/w)^{\alpha/(1-\alpha)}$$

$$(\alpha\beta/w) > 0 \quad \text{so:}$$

ϕ	<	σ^2
(The cost uncertainty under PFI)	<	(The cost uncertainty under traditional procurement)

In our model under the PFI the contractor manages the project to reduce its risk. With traditional procurement (at least as we are analysing it here) unless the Government is able to contract on a level of variation, then as effort is costly, the contractor has no incentive to reduce the cost uncertainty, and the risk σ^2 will be born by the taxpayer.

<u>Difference between project cost uncertainty under PFI and traditional procurement</u>

σ^2	-	$(\sigma^2 - (\alpha\beta/w)^{\alpha/(1-\alpha)})$	=	k
Under traditional procurement		Under PFI		

$$\text{so} \quad k = (\alpha\beta/w)^{\alpha/(1-\alpha)}$$

<u>Conditions under which the difference in cost uncertainty between the PFI and traditional procurement (k) falls:</u>

1. As the cost of contractor effort (w) rises $k \to 0$
2. As the risk aversion (β) of the contractor falls $k \to 0$
3. As the ability of the contractor to manage risk (α) falls $k \to 0$

The circumstances under which PFIs should be undertaken

Having examined the risk premium that the Government would be prepared to pay for a PFI and the contractor's management of risk, we now assess the conditions under which the contractor would be willing to undertake the project as a PFI, and when a PFI would be optimal. The effect of the Government and the contractor having different attitudes to risk will be captured by letting our measure of risk aversion β take the values of β_G and β_C respectively.

[9] There are issues concerning the existence of corner solutions, which it would probably be unnecessarily rigorous for our purposes to discuss. We will assume that the parameters are such that optimal solutions are interior and that the first order conditions hold (unless stated otherwise).

The PSC for the Government is the risk that it perceives itself as transferring plus the cost of the financing, or as we have seen:

$$PSC = 100(1+r) + \beta_G \sigma^2 \qquad (1)$$

It is important to note that this assumes that the Government would use its risk exposure under traditional procurement σ^2 rather than the risk level $\sigma^2 - e^{*\alpha}$ in setting the PSC. The minimum payment that the contractor would require to carry out the project is the payment MP that sets its utility from carrying out the project to 0 or:

$$MP = 100(1+r) + \beta_C(\sigma^2 - e^{*\alpha}) + we^* \qquad (2)$$

A project can be carried out as a PFI if the contractor is prepared to undertake the project for less than the PSC (i.e. when MP < PSC). We examine the conditions that determine this.

Subtracting (2) from (1) gives:

$$PSC - MP = \sigma^2(\beta_G - \beta_C) + (\beta_C e^{*\alpha} - we^*) \qquad (3)$$

Leading to:

<u>The condition that must be satisfied in order for the project to be carried out as a PFI</u>

(Government and the contractor having the same cost of capital)

$$\sigma^2(\beta_G - \beta_C) + (\beta_C e^{*\alpha} - we^*) > 0$$

The cost of reducing uncertainty for the contractor

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The difference in the Government's and the contractor's attitude to risk

β_C x The reduction in cost uncertainty by the contractor

(The sum of these two must be ≥ 0)

Where e* is the contractor's utility maximising level of effort $(\alpha\beta_c/w)^{1/(1-\alpha)}$

The left-hand term of the relation corresponds to the relative attitudes to cost uncertainty on the part of the Government and the contractor. If the contractor has no control over the uncertainty, then the right-hand term vanishes, and as seen earlier, relative risk preference is all that matters in deciding the form of procurement. If the Government cares more about the risk than the contractor ($\beta_G > \beta_C$) then PFI is favoured. On the other hand if $\beta_G < \beta_C$ then traditional procurement would be preferred.

The right-hand term gives the net benefit to the contractor of reducing uncertainty. If the contractor finds it profitable to reduce risk ($\phi < \sigma^2$) and has similar risk preferences to the Government ($\beta_G = \beta_C$) or is less risk averse ($\beta_G > \beta_C$), then it would be prepared to carry out the work for less than the PSC and PFI would be the favoured means of procurement. If the contractor is more risk averse than the Government ($\beta_C > \beta_G$), then in order for PFI to go ahead, this will have to be offset by a reduction in the contractor's risk exposure through better management. In principle a third term could be added to take account of the Government's ability to manage the risk, but the essentials of the arguments discussed would remain unchanged.

Substituting in for e* (see Appendix 1) makes the effects of contractors risk aversion more transparent.

<u>The condition that must be satisfied in order for the project to be carried out as a PFI</u>

$$\sigma^2(\beta_G - \beta_C) + A(\beta_C/w^{\alpha})^{1/(1-\alpha)} > 0 \quad \text{for the PFI to take place}$$

The difference in the Government's and the contractor's attitude for risk

The efficiency gain due to better risk management

Where $A = (\alpha^{\alpha/(1-\alpha)} - \alpha^{1/(1-\alpha)}) > 0$

If the contractor is incentivised to eliminate all risk, this becomes:

$$\sigma^2\beta_G - w\underline{e} > 0 \quad \text{for the PFI to take place}$$

The disutility of risk to Government

The cost of risk elimination to the contractor

$\underline{e}$ is the effort level that eliminates the cost uncertainty i.e. $(\sigma^2 - \underline{e}^{\alpha}) = 0$

If risk neutral ($\beta_C = 0$) a contractor has no incentive to manage the uncertainty and the right-hand term of the first expression vanishes. However if a contractor is risk averse ($\beta_C > 0$) it is less willing to bear risk, and will try and manage the project to reduce its exposure, increasing the size of the efficiency gain. As the cost of contractor risk management (w) falls, so the efficiency gains from PFI will rise. In the extreme case where the contractor eliminates all risk we get the second expression above. The decision as to whether a PFI should go ahead then depends on whether the cost to the contractor of eliminating the risk is less than the disutility of the risk to the Government.

We have argued that when the PFI contractor is forced to bear the cost uncertainty, it has an incentive to reduce the project's cost variation. This should not necessarily be seen as a benefit of PFI however, as it's conceivable that suitably contracted traditional procurement could achieve this result. If all cost uncertainty is passed to the contractor by means of a fixed price contract (effectively the variance is 0 for the Government and $\sigma^2(e) = \sigma^2 - e^{\alpha}$ for the contractor), then as with PFI, it would have an incentive to reduce the uncertainty to ϕ, given the optimisation problem it faces is unchanged.

Palmer (2000) notes the incentive equivalence of PFIs and fixed price contracting. He argues that a benefit to publicly financed fixed price contracts is that they allow greater flexibility than PFIs. In certain projects such as hospitals it is felt by some that PFIs lack of flexibility may be a disadvantage when dealing with changing situations (e.g. new treatments, demographic changes) over a contract's often lengthy life.

However in a PFI the private institution providing the finance has an incentive to monitor the project closely to safeguard its interests. It is also possible that economies of scale can be achieved by integrating finance and project implementation in one package. If one believes that the private sector is better at project management than the public sector, then this is an advantage of PFIs. A basis for this might be that the public sector lacks the profit motive of the private sector and owing to its access to funds through compulsory taxation, may sometimes have a less vigilant attitude to project management. Though this could also be a procurement culture and training issue, rather than a principle of private vs. public finance per se.

Long-term contracts and investment in efficient technologies

In examining the case where project risk has been transferred to the contractor, we have seen that a gain from PFIs/fixed price contracting is that the contractor has to internalise the risk and therefore manages the project more efficiently. There are also potential gains from the adoption of a PFI, which stem from its long-term contractual nature.

Even if there is no project risk, it is possible that by ensuring the contractor takes a longer view of the project, efficiencies can be achieved. An example of this is the use of more energy efficient technologies, which may require a substantial upfront investment, but be better in present value (PV) terms than alternatives with low upfront costs. With traditional procurement, where the contractor hands over the building after completion and does not have to maintain it, technologies that are in PV terms undesirable may be installed. However in a PFI, as the contractor has to manage the project for an extended period, this is less likely.

We show this with a simple example in which the project has two stages: construction and maintenance. Contractors choose the technology to install in the construction phase, and then under a PFI pay maintenance fees in the second period. There are two types of building technology with different installation and maintenance costs, and the procurement market is assumed to be sufficiently competitive as to ensure that the contractor earns 0 profit and undertakes the job at cost. The contract is awarded to the tender which carries out the project for the lowest price.

Technologies that the contractor could use:

Technology 1: costs C_1 to install, leads to maintenance costs M_1

Technology 2: costs C_2 to install, leads to maintenance costs M_2

Technology 2 is cheaper than Technology 1 to install ($C_2 < C_1$) but more expensive to maintain ($M_1 < M_2$).

Under traditional procurement the contractor does not manage the project after period 1 and so we assume its choice is determined by which technology is cheapest to install, in this case Technology 2. A counterargument might be that the Government would be forward looking in its procurement and ensure that firms install the most efficient technology. However there is probably an asymmetry of information, in that the procurers may know less about these issues than the contractor, who has an incentive to use the technology with the lowest installation costs.

If the contractor makes 0 profits, this means that the cost of the project for the Government under traditional procurement is $C_2 + M_2/(1+r)$, where M_2 is paid by the Government after the contractor has handed back the project. Under a PFI however, as the contractor incurs costs in the second period, its decision is based on which technology has the lowest PV cost stream. An example of this is given below.

Choose Technology 1 if:

PV cost of Technology 1 < PV cost of Technology 2

$$C_1 + M_1/(1+r) < C_2 + M_2/(1+r) \quad \text{or}$$

$$(C_1 - C_2) + (M_1 - M_2)/(1+r) < 0$$

If this relationship is satisfied, then Technology 1 would be adopted under PFI. The cost of the project to the contractor would then be lower and (assuming a competitive bidding process) so would the cost of the entire project for the Government. The gain from adopting the PFI (or other long-term contracting arrangement) is then:

The gain from installing more efficient technologies due to the PFI

$$\text{Gain of PFI} = (C_1 - C_2) + (M_1 - M_2)/(1+r)$$

It might not be the case that Technology 1 was in PV terms more efficient, so PFI and traditional procurement would have the same effects. However the principle that procurement methods which fail to take account of future maintenance costs may lead to the installation of inefficient technologies is still valid.

Financing

Why the Government has a lower cost of capital than the contractor

In our analysis we have assumed that the cost of capital is the same for both the Government and the contractor. In reality however the Government can borrow at a lower interest rate.

If the world was riskless the cost of capital should be equal to the productivity of the asset in which it is invested i.e. the capital stock. However in practice there are many other factors that determine its cost. Not least of these are the riskiness of the project and the credit worthiness of the party requiring finance. The Government has a lower cost of capital than other parties, and the reason for this is that (at least in the UK) it is very unlikely to default. This is due to:

1. The Government having the ability to raise virtually unlimited funds through taxation, borrowing and seignorage.
2. The Government's very size meaning that it has substantial reserves of assets that can be used to repay debt.
3. The consequences of the Government defaulting being potentially so severe, that it is almost inconceivable that it would be allowed to happen.
4. Extensive public information on the credit worthiness of the Government being available.
5. Government's large size meaning that it can diversify risk and hence face less cost uncertainty on its projects in aggregate.

The cost of capital that the PFI contractor faces will depend on the specific arrangements for carrying out the project. Usually it would be related to the financier's perception of the risk of a particular project. Alternatively if the debt in the PFI consortium is underwritten by a third party, then the cost of capital may be related to the party's credit worthiness. That the cost of capital will be higher than the Government's is not in doubt however.

Welfare implications

The Government having access to a lower cost of capital than the contractor does not necessarily imply that public financing is better for the taxpayer[10].
If the Government decides to finance a project where it is also bearing the project delivery risk (traditional procurement) then the project ostensibly costs less, but this is largely because the taxpayer has to bear the potential risk of cost overruns, which may end up being met by diversion of funds from other areas, higher taxation/borrowing or seignorage. Unless there are substantial gains from diversification then the Government's risk exposure is potentially unlimited. If the finance is raised by the contractor, who also bears the risk of delivering the project when costs overrun, then this may look more expensive, but the Government doesn't have the same level of risk exposure.

[10] For other statements of this position see p41, paragraphs 3.61-3.63, "PFI: meeting the investment challenge", HM Treasury 2003, Currie 2000 and Grout 1997.

We now examine the financing issues in the context of the earlier condition that was derived to determine whether or not the PFI should be undertaken. The contractor has a cost of capital r_C, which for the reasons given is higher than the Government's r_G, and the following extension of the condition is then obtained:

<u>The condition that must be satisfied in order for the project to be carried out as a PFI</u>

The difference between the Government's and the contractor's cost of capital

$$100(r_G - r_C) + \sigma^2(\beta_G - \beta_C) + A(\beta_C/w^{\alpha})^{1/(1-\alpha)} > 0$$

$$A = (\alpha^{\alpha/(1-\alpha)} - \alpha^{1/(1-\alpha)}) > 0$$

The difference in the Government's and the contractor's attitude to risk

The efficiency gain due to better risk management

Looking at the three terms there are some restrictions that we can impose: The right-hand term (the efficiency gain due to the contractor managing the risk better) is positive or 0. The left-hand term (the difference in costs of capital) is negative owing to the Government's lower cost of capital.

What determines whether the PFI is optimal or not, is then the relative magnitude of these terms vs. the relative risk preference of the Government and the contractor (the middle term). A priori there is no way to decide what the net position is.

If there was no project risk, then both terms on the right would vanish and PFI would not be an optimal form of procurement, owing to its higher cost of capital. This is a standard view on PFI. Quoting the Public Accounts committee[11]:

"Without risk-taking by the private sector, for example to reduce the likelihood of the Agency paying for the construction cost increases, the use of private finance can bring no benefits to offset the higher costs of finance".

Conversely with risk transfer to the private sector, a PFI despite its higher cost of capital is not necessarily sub-optimal, as there may be benefits from private sector risk bearing and management (the middle and right-hand terms).

The condition is derived from a very simple model of a PFI, which is clearly an abstraction of reality, but hopefully it helps clarify the issues. It demonstrates a rationale for PFIs, although it does not imply that they will always be the best solution.

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[11] The private finance initiative: the first four design, build, finance and operate road contracts. 47th report, session 1997/8, Public Accounts Committee.

In our framework we have made explicit assumptions about the welfare effects of cost uncertainty on the Government. This is a particular issue as we have assumed that the project risks were not already priced in the market, but more generally assumptions about the welfare value of risk transfer will always be important in deciding whether a PFI is value for money or not.

As part of a survey of PFIs the Construction Industry Council (CIC) asked participants from a number of projects to self assess their own level of risk aversion and those of the other parties involved in the PFI[12]. This was measured by a scale of 1 to 5, where 5 was the most risk averse category and 1 the least.

The survey found financiers to be by far the most risk averse with a score of around 4. This was a consensus across the different types of respondents, although the financiers themselves do not seem to have participated in the survey. The next most risk averse party was held to be the project client, both by its self assessment and by others. Those that were seen as most willing to bear risks were the special purpose vehicle and the PFI operators and contractors.

It is hard to say what the implications of these findings in our model are, as we have greatly abstracted the institutional details of a PFI. Also having the contractor and the Government care only about the variance of the cost uncertainty, is a simplistic way of capturing risk aversion and it is not clear what the CIC's survey's numerical assessments of risk aversion would mean in this situation. Doubtless some parties risk aversion is very context dependent, and there may be many factors behind these findings. It's possible that an implication is that, as suggested, the financier's high level of risk aversion is important in bringing greater discipline to PFI project management.

Project completion and financial difficulties

In our model PFI the contractor undertakes to find the amount B in the high cost state of the world and finish the project, whilst still only receiving the fixed PFI payment P from the Government. However in practice this may directly conflict with the debt repayment and solvency of the contractor. Implicitly we have assumed that completion of the project, will not bankrupt the PFI contractor or if it does, that someone, presumably the finance provider, not the Government, will step in and ensure project completion. In 2004 when the Jarvis group was in difficulties and unable to complete a number of PFI projects it sold on its interests in some of the projects to companies that then undertook to deliver them.

The analysis of bankruptcy is an important issue, but a complete discussion of it would take us beyond the scope of this paper. In practice what happens is complicated and dependent on the specific institutional set up of a project. Instead our approach will be to systematically examine the different possibilities of risk bearing. Traditional procurement and PFI (at least as we have analysed them) are on opposite sides of the downwards left-right diagonal in the table below. The other possibilities considered are a publicly financed fixed price contract and a privately financed variable fee arrangement.

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[12] p38, The role of cost saving and innovation in PFI projects, Construction and Industry Council, 2000.

		Debt default risk born by	
		Government	Contractor
Project delivery risk born by	Government	Traditional procurement Government can borrow at the lower interest rate, but unless there are diversification benefits the cheaper finance is due to the taxpayers bearing the risk in terms of potential higher taxation/borrowing/seignorage, funds diverted from other areas.	If the Government bears *all* the delivery risk then the finance raised by the contractor might be at a rate close to the Government's cost of capital, however the taxpayer will still bear the risk.
	Contractor	The contractor bears the delivery risk and so will want to be compensated by being paid a risk premium. The cost of capital is lower than private finance but the Government has to issue debt.	PFI Here the finance is privately raised by the contractor. The contractor and financier will want compensation for this risk bearing, however the taxpayers will be insured, provided bankruptcy does not prevent project completion.

In the case of traditional procurement, although the Government may be able to borrow at a cheaper rate, this is largely due to the risk being born by the taxpayer. An important issue is the extent to which the Government's lower cost of finance reflects its ability to diversify risk, which is a genuine gain.

If the contractor financed the project, but the Government is effectively committed to bearing all the performance risk, then *in principle* the contractor might be able to access funds at close to the risk free rate (depending on the efficiency of the capital markets), so the situation would be potentially similar to traditional procurement. Whether this could happen in reality seems questionable, also given that we have argued that there are benefits from having the contractor bear the delivery risk, neither of these situations is necessarily optimal.

In the case where the contractor agrees to undertake the project as a fixed price contract, then in theory there should be no delivery risk to Government. If the project was publicly financed, then despite the cost of capital being lower than private finance, it is unclear whether there would be a gain, as the Government would ultimately have to underwrite the risk of debt default. Though if the contractor is unlikely to default in the event of cost overruns the Government's risk exposure might be small.

A variant of publicly financed fixed price arrangements called Credit Guarantee Finance is currently being piloted by the Treasury. Under this the default on Government debt is underwritten by an Insurance provider. At present it is not envisaged that this approach will be used for more than a limited proportion of PFI projects[13].

In assessing the public vs. private financing of fixed price contracts an important question is whether the PFI arrangement is better at internalising the risk and completing the project without recourse to the Government, in the event of something going seriously wrong. We can't capture this explicitly in our

[13] For more details see paragraphs 9.12-9.22, pp 108-109 of "PFI: meeting the investment challenge" HM Treasury 2003.

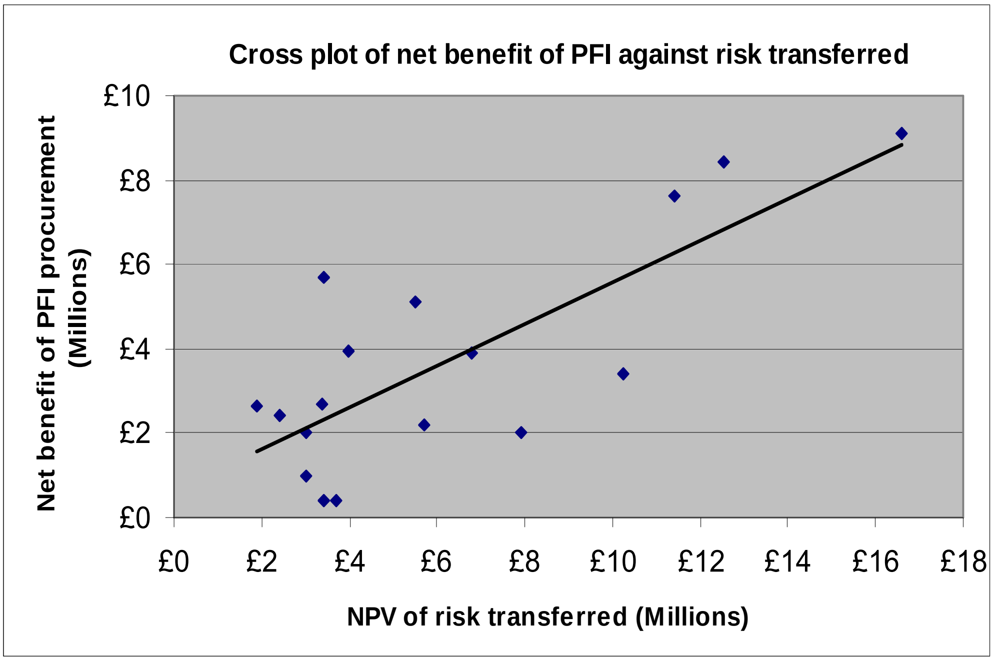
simple model, but the more comprehensive the risk protection to the public sector, the greater the risk premium that the Government will probably have to pay.

The analysis has focused on delivering the project in the event that costs overrun, but it is also possible that the project can take longer than expected and in a PFI the public sector is not directly insured against this, except in so far as it can invoke penalty clauses on payments. However in general PFIs have been found to provide greater time certainty than traditional procurement.

Net benefit and risk transfer

Although this paper has been largely theoretical, we will try and use our simple framework to interpret some actual PFI data.

Figure 1 is a Cross plot of the net benefit of PFI procurement against the NPV of the risk transferred. The source of the data is a voluntary survey by the DTI of PFI school projects procured by English Local Authorities[14] between 1996 and 2002.



In Figure 1 a clear positive relation is observed between the amount of risk transferred and the net benefit, with the slope of the line suggesting that roughly half of all net risk transfer is obtained as a net benefit of PFI. Although our model is undoubtedly a simplification of the PFI process we can, with some minor additions, use it to help understand this finding.

In order for these projects to have gone ahead the PFI payment (P) must have been less than the PSC or

PSC - P = Net benefit (NB) > 0

The difference between the actual unitary payment (P) and the minimum payment (MP) required by the contractor we label d.

[14] A detailed analysis of the survey returns has been completed and will be published shortly. PFI school procurement, Analysis of a DTI survey of English Local Authorities, John Davies and Asad Ghani, DTI.

$P = MP + d$ so $NB = PSC - MP - d$

The d term can be seen as a proxy for the competitiveness of the PFI market. If the market is competitive then contractors would be able to charge only a small amount above their minimum payment threshold so d would be low.

We then obtain the following variant of the earlier relation, which can be used to help understand the data. Here we take the welfare effect of the risk transferred ($\sigma^2\beta_G$) as proxying the risk transfer.

<u>The difference between the net benefit and the risk transferred</u>

$$NB - \sigma^2\beta_G = -\sigma^2\beta_C + 100(r_G - r_C) + A(\beta_C/w^{\alpha})^{1/(1-\alpha)} - d < 0$$

Net Benefit

The disutility of the risk transfer

Risk averse contractor's compensation

Effect of differing costs of capital

Efficiency gain due to better risk management

Contractor surplus

The net benefit of a PFI was in general less than the amount of risk transferred and from our model project we can see why this might be so. Of the four terms on the right hand side of the equation, three are negative:

1. The risk averse contractor wanting compensation ($\sigma^2\beta_C$) for bearing the risk.

2. The contractor having a higher cost of capital than the Government implying $100(r_G - r_C) < 0$

3. Contractors being able to charge a surplus (d) above their satisficing level of project payment (MP).

The only countervailing effect is that of the contractor being able to manage the project risk more efficiently $A(\beta_C/w^{\alpha})^{1/(1-\alpha)}$. However even when this is taken into account the net effect of all terms is negative (see Appendix 2). At most the contractor can eliminate its risk exposure, but it will still want to charge for the management costs. So in our model the net benefit is less than the risk transferred.

This is an effect of the particular way we have chosen to model PFIs, but there is an economic intuition to it. If the contractor was completely risk neutral, had an equivalent cost of capital, and faced a perfectly competitive market, then the Government should be able to transfer all the risk costlessly and extract it as a net benefit. In practice none of this is true, so the Government has to pay something extra for passing the risk to the private sector, resulting in its net benefit being less than the risk it transfers.

Conclusions

1. If neither party in the model is able to control the risk and each faces the same cost of capital, then the desirability of PFIs vs. traditional procurement will depend on which party is best able to bear risk. This is an argument that may favour traditional procurement methods, as the Government due to its size may be better at diversifying risk than private companies. In the extreme case where the Government is risk neutral but the contractors are risk averse, there would be no incentive to carry out a PFI as the best thing is for the Government to bear the risk.

2. However there is also the issue that party best placed to control cost uncertainty is often the contractor who carries out the work. Under a PFI arrangement, the contractor in having to internalise the risk of the project has as an incentive to reduce it, to hopefully everyone's benefit. Also by having to internalise project maintenance costs post-construction PFI contractors may have an incentive to install more efficient types of technology and deliver the project at a lower cost.

3. These need not necessarily be exclusive benefits of PFIs, as it is conceivable that some of them could be obtained with a fixed price long-term contract and public financing. However if one believes that the institution providing the private finance to the project is likely to be better at managing the project than the Government, then a PFI would still have advantages. There may also be economies of scale from integrating finance and project implementation.

4. The cost of capital is lower for the Government than the private sector, but this is largely due to the risk (at least in traditional procurement) being passed back to the taxpayer in the form of potential tax rises, seignorage or diversion of resources from other areas, so there is no clear-cut gain to public financing. In the case of a fixed price contract, where the contractor bears the delivery risk, this argument should be less applicable. However there is the question of what would happen in the event of contractor bankruptcy, where in a publicly financed fixed price arrangement the Government has issued the debt.

5. If a project has little/no risk then a PFI would not be optimal due to the private sector's higher cost of capital. In other words, it makes no sense to pay a risk premium where there is no risk. With project risk there is no a priori answer whether or not PFI in our model is optimal, it depends on the relative abilities of Government and the contractor to bear and manage risk and the difference in costs of capital.

6. Any assessment of the relative merits of risky projects being carried out under traditional procurement or PFI involves an implicit assumption about the Government's attitude to risk. In our framework we have assumed that the risk is not priced in the market and so have modelled the Government and contractors risk aversion explicitly.

7. A stylised fact of PFIs from the DTI survey of school procurement is that the net benefit of the PFI project is almost always less than the amount of risk transferred. This can be explained in our framework by the Government and private sector's differing costs of capital, the need for compensation for risk bearing/monitoring and the competitiveness of the PFI market.

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Appendix 1

If we have $\sigma^2(\beta_G - \beta_C) + (\beta_C e^{*\alpha} - we^*)$

Substituting in $e^* = (\alpha\beta_C/w)^{1/(1-\alpha)}$ gives:

$\sigma^2(\beta_G - \beta_C) + \beta_C(\alpha\beta_C/w)^{\alpha/(1-\alpha)} - w(\alpha\beta_C/w)^{1/(1-\alpha)}$

As $\beta_C\beta_C^{\alpha/(1-\alpha)} = \beta_C^{1/(1-\alpha)}$ and $ww^{-1/(1-\alpha)} = w^{-\alpha/(1-\alpha)}$ we get:

$\sigma^2(\beta_G - \beta_C) + \alpha^{\alpha/(1-\alpha)}\beta_C^{1/(1-\alpha)}w^{-\alpha/(1-\alpha)} - \alpha^{1/(1-\alpha)}\beta_C^{1/(1-\alpha)}w^{-\alpha/(1-\alpha)}$

$= \sigma^2(\beta_G - \beta_C) + (\alpha^{\alpha/(1-\alpha)} - \alpha^{1/(1-\alpha)})(\beta_C^{1/(1-\alpha)}w^{-\alpha/(1-\alpha)})$

$0 < \alpha < 1$ so $\alpha/(1-\alpha) < 1/(1-\alpha)$ and $(\alpha^{\alpha/(1-\alpha)} - \alpha^{1/(1-\alpha)}) > 0$

Labelling $(\alpha^{\alpha/(1-\alpha)} - \alpha^{1/(1-\alpha)})$ as A we obtain:

$\sigma^2(\beta_G - \beta_C) + A(\beta_C/w^{\alpha})^{1/(1-\alpha)}$

Appendix 2

At most the contractor can reduce the uncertainty to 0 with maximum effort $\underline{e}$ i.e. $\beta_C(\sigma^2 - \underline{e}^{\alpha}) = 0$.This means that it bears no uncertainty, but still faces a monitoring cost $w\underline{e}$, which is rational as long as the uncertainty eliminated causes more disutility than the cost control ($\beta_C\sigma^2 > w\underline{e}$). Implying that at effort level $\underline{e}$ we get a negative net effect:

$-\sigma^2\beta_C + A(\beta_C/w^{\alpha})^{1/(1-\alpha)} = -\beta_C(\sigma^2 - \underline{e}^{\alpha}) - w\underline{e} = -w\underline{e} < 0$

As $\beta_C(\sigma^2 - e^{\alpha}) > 0$ for $e < \underline{e}$ the negative sign holds generally.

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