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Public sector comparators for UK PFI roads: inside the black box

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Abstract A public sector comparator (PSC) represents the hypothetical, risk-adjusted cost of a project—such as a road scheme—when that project is financed, owned and implemented by government. A PSC is commonly used in public procurement decision-making as a yardstick against which private investment proposals are evaluated. Using original material released by the UK Highways Agency for the first time, the author recreated the PSCs used for the evaluation of the first eight road projects to be promoted under the UK's private finance initiative (PFI). Alternative assumptions regarding project risks were modelled using different levels of optimism-bias uplift, and the impact on value-for-money of using different discount rates was evaluated. Public sector comparators have attracted considerable attention in the literature as they retain a pivotal role in the policy decision to use—or not use—private finance. However the fact that their detail is usually kept confidential by public sector procuring agencies—because of commercial sensitivities—has restricted informed discussion and open debate. Now the architecture of these comparators is laid bare for critical examination. It has generally been assumed that any reduction in the discount rate used in PSC calculations will favour conventional procurement over PFI-type contracting arrangements. The research reported in this paper demonstrates that the relationship between the discount rate and the attractiveness of using private finance is not as simple as has been assumed, and the outcome in terms of value-for-money is not as predictable as has previously been reported.

Keywords Private finance initiative · Public sector comparator

Introduction and methodology

A public sector comparator (PSC) is the hypothetical, risk-adjusted cost of a project—such as a road scheme—when that project is financed, owned and implemented by government. A PSC is commonly used in public procurement decision-making as a yardstick against

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which private investment proposals are compared. Countries that currently use PSCs include the UK, Australia, Canada, the Netherlands and South Africa. If, when converted into present values, the private costs are lower than the PSC, then the proposal is deemed to be more efficient than conventional public-sector procurement. Thus, PSCs are central in the decision-making process about where, when and how to use privately-financed infrastructure solutions—such as those encouraged under the UK's private finance initiative (PFI) (HM Treasury 2003).

This paper examines the PSCs compiled for the first eight UK PFI roads.[1] The PFI was launched in 1992 with the objective of increasing the involvement of the private sector in the delivery of public services. Road projects were at the vanguard of the initiative. Under the PFI, the private sector designs, builds, finances and operates facilities based on output specifications. In return, the public sector pays the PFI contractor a stream of revenue payments over a contract period of typically 30 years.

The PSCs are re-created using original data and the findings are summarised. Until now the Highways Agency has regarded this detailed data as being commercially sensitive and has not released it into the public domain. However it is now over 10 years since the early PFI road PSCs were created and the data is less sensitive today. Only the output numbers from the PSC benchmarking process (the summary net present values[2] of the future cash flows required to support the public and the private sector procurement options) have previously been published by the National Audit Office (NAO 1998). Two sets of NPVs are in the public domain: a set calculated using the first-recommended discount rate of 8% and a subsequent set recalculated using the later-recommended rate of 6%. Discount rates are discussed later, however the point of note is that, despite the pivotal role that PSCs play in public policy decision-making, the architecture of these comparators—and, importantly, the assumptions embedded within—have not been available for public scrutiny until now.

The purpose of the research reported here was fourfold: to understand the general PSC formulations, to examine the figures used, to explore the assumptions behind these figures and to assess the impact of alternative assumptions on the output NPVs (and, ultimately, on the procurement-route decisions themselves). The PSCs were recreated in spreadsheets for each road. For comparison purposes, the resulting NPVs were contrasted with the NPV of the stream of revenue payments due to be made to the PFI road operators by the Highways Agency[3] (as published by HM Treasury on its website[4]).

The comparators were constructed using a discount rate of 8%. They were then recalculated using 6%. These results were checked for consistency with the previously-published figures before today's recommended discount rate of 3.5% was applied to assess

[1] The first eight PFI roads were the A30/A35, the A50, the A19, the A1(M), the A419/A417, the A69, the M40 and the M1-A1. Under the PFI contracts, private sector concessionaires designed, built, financed and operated the road projects for 30 years, during which they received compensation in the form of a revenue stream from the UK Highways Agency based on the number and type of vehicles using the roads (shadow tolls).

[2] NPV is net present value. Typically, in the economic appraisal of transport projects, NPV is the difference between the present value of the costs associated with the project and the present value of its benefits. In the PSC-related literature reviewed here, however, NPV is used to refer to the present value (PV) of future costs.

[3] Only the annual 'unitary charge' payments due (per project) are published. No breakdown of the PFI payment figures is provided.

[4] http://www.hm-treasury.gov.uk/ppp_pfi_stats.htm.

its impact on individual schemes and on the early PFI roads programme as a whole. Preliminary analysis of the published data suggested that the progression of the NPVs from 8% discount rate to 6% was non-linear. Simple linear extrapolation could not, therefore, be used to derive the NPVs at a discount rate of 3.5%. The only way of calculating the NPVs at 3.5% was to recreate the PSCs from first principles.

The analytical treatment applied to each of the project roads was identical. To save space, this work is not replicated here in full. Instead, the PSC for one road is examined in some detail for illustrative purposes. That road is the A1(M)—selected because it was broadly representative of the rest of the programme. Following on from the illustrative example, the paper presents key findings from the other early PFI roads, before concluding with a discussion of the issues raised by the research.

PSCs in the literature

The construction of a public sector comparator requires a number of simplifying assumptions to be made about values and probabilities which remain uncertain. The valuation of risk is challenging and requires resources, yet remains subjective and, to an extent, arbitrary. This is especially the case where few or no comparable facilities exist which can be used for benchmarking purposes (PAC 2000)—although this is less of a constraint in the case of roads. However the numbers used in the assessment process remain 'soft number', leaning heavily on professional judgement and "…hence vulnerable to rebuttal" (Heald 2003). Heald suggests that:

> Even disinterested policy analysts, operating with different assumptive worlds about public versus private performance, are likely to generate different numerical answers.

Compounding this anxiety, Heald highlights the fact that the individuals involved in the assessment of PFI projects are not necessarily disinterested parties (or "neutral referees", as he describes) but are "interested players". This exposes the process to possible gaming and/or abuse to legitimise a predetermined or preferred decision.

The specific values employed in some public sector comparators have also attracted criticism (such as tax assumptions and the on-going public sector costs associated with PFI project monitoring and management)—where, rarely, these comparators have been made public. Usually, however, they remain hidden from public scrutiny because of concerns about commercial confidentiality.

Some authors have questioned the like-for-like comparison of a PFI option with a public sector alternative which, in terms of expected performance (and, hence, subsequent risk-adjustment), reflects the worst of historical practice—see Heald (1997), PAC (2003) or Unison (2005). This assumes that the public sector has learned nothing from previous experience and is incapable of improving its conventional procurement record. Benchmarking against contemporary (non-PFI) infrastructure procurement—rather than some hypothetical construct—may have a role in this context. Other authors have challenged the basis upon which historical practice, regarding public sector construction cost and time overruns, has been measured; suggesting that project samples have been small and/or unrepresentative (Pollock et al. 2007).

Sussex (2001) and Unison (2005) point out that poor historical procurement performance—typically focussed on cost and schedule overrun—is exacerbated when outturn figures are compared with initial estimates made years earlier, not at late stages such as financial close. It is further exacerbated when the impacts of scope change are included in measures of public sector inefficiency. Cost (or, rather, estimate) escalation is not the same as cost overruns and overruns caused by 'scope creep' are not the same as those caused by inefficient management. Although these distinctions are important, however, they are unlikely to detract from the central message that the conventional public sector procurement process for large infrastructure projects is commonly exposed to (often significant) upwards cost pressure (Flyvbjerg et al. 2003).

Notwithstanding its limitations, rounded criticism has ensued in cases where the comparison of a PFI project with a public sector alternative was not undertaken (see, for example, NAO 1997). For this reason alone, it seems likely—and it remains important—that some form of quantitative assessment, such as the construction and use of a PSC, will continue to play a central role in procurement decisions about whether or not to use privately-financed infrastructure solutions.

Over the years, PSCs have attracted considerable academic attention, however—largely because of the confidentiality issues mentioned earlier—few authors have described and critiqued their composition in any detail. This paper aims to contribute to the literature by addressing this deficiency.

Example: the A1(M) public sector comparator

The A1(M) Alconbury to Peterborough PFI road project was part of a broader programme of works to upgrade all of the existing A1 between London and Newcastle to motorway standard. The project involved 21 km of motorway construction between Alconbury and Peterborough, and the subsequent operations and maintenance of the project road for 30 years. As noted earlier, until now, public domain information has been restricted to the outputs from the PSC evaluation process only. These outputs for the A1(M), the present values of future cash flows required to support the PSC and the lowest-bid PFI option, are summarised in Table 1.

The outputs from the evaluation process suggested that the PFI procurement route represented best value-for-money (VfM), with a saving of £50 million at the original discount rate of 8%. The PFI remained the preferred procurement choice when later tested at a discount rate of 6%, albeit with a reduced value-for-money differential (£30 million). The following paragraphs describe the composition of the A1(M) PSC. Construction costs and construction risk are considered first. Next, operations and maintenance (O&M) costs—and associated risks—are examined. This information is then combined in the PSC. By recreating the PSC in a spreadsheet based on its disaggregated costs (and the precise timing of these costs), a series of discount rate sensitivity tests could be applied, including the use of 3.5%. The results from these sensitivity tests are presented at the end of this illustrative example.

The constituent components of the undiscounted PSC construction cost for the A1(M) are presented in Table 2.

Table 1 A1(M) public sector comparator outputs

Discount rate (%)	PSC NPV (£m)	PFI NPV (£m)	Difference (£m)
8	204	154	50
6	222	192	30

Source: National Audit Office

Table 2 Construction cost components

Capital cost components	Cost (£m)	% of Total
Structures	39.6	25
Main carriageway	38.7	24
Preliminaries	26.6	17
Earthworks	15.8	10
Side roads and interchanges	13.8	9
Signs, markings, lighting and communications	7.0	4
Fencing/barriers	6.2	4
Statutory undertakers	4.5	3
Horticulture, archaeology etc.	3.3	2
Accomm. works and maintenance compounds	1.4	1
Site clearance	1.3	1
Total	158.2	100

Note: In the UK, ‘statutory undertakers’ are various companies and agencies (such as utilities, telecoms and rail operators) with legal rights and duties to carry out highways works

The PSC report from which Table 2 was compiled states that the construction cost component estimates were based on the rates from three road construction contracts tendered in 1991/1992 (the M1-A1 Link, widening of the M25 and dualling of the nearby A11). In common with the findings from analysis of the other PFI road PSCs, structures, the main carriageway (alternatively labelled ‘roadworks’ or ‘pavements’ in other PSC reports), preliminaries and earthworks accounted for the majority—over three-quarters—of total construction cost. The cost profiling, presented later, converts the total capital cost of £158.2 million (April 1995 prices) to an NPV of £141.8 million when discounted at 8%.

The PSC report states that the construction cost NPV for the A1(M) had been revised upwards by some £18.5 million (an estimate of £123.3 million had earlier been adopted). This change—attributed to revised estimates, updated indexation and refined assumptions about the phasing of costs—highlights the fact that cost estimation is not a one-off, point-in-time exercise. Cost estimation is a process that evolves in response to factors such as advancements in a scheme’s design, design compromises, cost inflation, the introduction of new standards and more detailed information becoming available to the estimators. Attention returns to this issue at the end of this paper.

Limited detail is provided about how monetary values were attributed to construction-related risks, except for a statement saying that they had been calculated with reference to historical cost overrun data. A percentage risk adjustment was attributed to each of the capital cost components. The total risk allowance is the sum of those percentages applied to the respective component costs. This information is presented in Table 3.

In terms of the possible risk of cost overrun, statutory undertakers and earthworks scored highly. In terms of risk cost, however, structures and earthworks were the main contributors. Indeed, the risks associated with four cost components (structures, earthworks, statutory undertakers and the main carriageway) accounted for 70% of the total cost overrun risk uplift incorporated in the A1(M) PSC. In total, construction risk added 22% to the overall construction cost. This level of risk adjustment is within the observed range—albeit towards the lower end—of cost overruns described elsewhere in the literature (summarised below in Table 4).

Table 3 Construction cost risk allowance

Cost component	Cost (£m)	Risk element (%)	Risk cost (£m)
Statutory undertakers	4.5	86	3.9
Accom works/maint compounds	1.4	50	0.7
Earthworks	15.8	45	7.1
Fencing/barriers	6.2	38	2.4
Horticulture, archaeology etc.	3.3	33	1.1
Signs, markings, lights, comms	7.0	32	2.2
Site clearance	1.3	25	0.3
Structures	39.6	23	8.9
Side roads and interchanges	13.8	15	2.1
Main carriageway	38.7	10	3.7
Preliminaries	26.6	6	1.6
Total/average	158.2	22	34.1

Table 4 Alternative estimates of cost overruns (roads)

Extent of cost overrun (%)	Source
27	NAO (1992)
24–40	NAO (2001)
3–44	Mott MacDonald (2002)
20	Flyvbjerg et al. (2003)

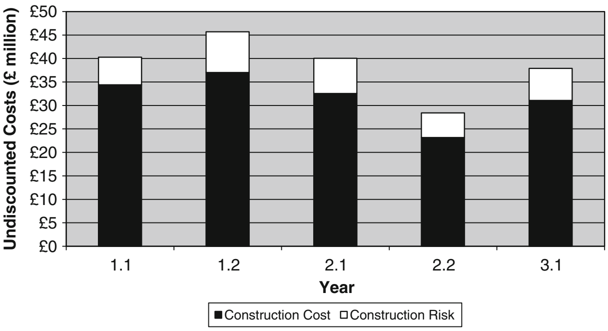


Fig. 1 A1(M) PSC construction cost profile

The construction cost and risk profile associated with the A1(M) PSC is presented in Fig. 1.

The cost profile was calculated on a semi-annual basis (1.1 is the first half of year one, whereas 1.2 is the second half). 1.1 is equivalent to the period April–September 1996. The discounted values for construction cost and risk were £141.8 million and £30.5 million, respectively, giving an NPV sub-total of £172.3 million.

The constituent operations and maintenance (O&M) costs are presented (undiscounted) in Table 5 for two pavement options: a rigid pavement and a flexible pavement. Rigid pavements are surfaced with cement concrete whereas flexible pavements use bituminous

Table 5 A1(M) PSC O&M costs

O&M cost component	Rigid pavement		Flexible pavement	
	Cost (£m)	% of Total	Cost (£m)	% of Total
Periodic maintenance: resurfacing	36.8	40	24.5	23
Periodic maintenance: strengthening overlay	–	0	27.5	26
Non-periodic maintenance	26.4	29	26.4	25
Structures	11.4	12	11.4	11
Lighting	8.0	9	8.0	8
Telecoms	8.8	10	8.8	8
Total	91.4	100	106.7	100

(or asphalt materials). The Highways Agency concluded that the construction costs associated with both options were similar. However the maintenance costs differed. The rigid pavement option was selected for the PSC because of the maintenance cost savings it offered.

The cost estimates were reported to have been drawn from recent experience on similar road contracts in the Midlands region. Some detail is provided in the PSC report to justify the use of particular figures. However the striking fact is the extent to which the reported outturn costs varied contract by contract. The observed ranges for some cost components were significant and this has to impact on the subsequent accuracy of estimates drawn from past experience—a further issue discussed at the end of this paper. Take resurfacing, for example. Outturn costs for resurfacing a D3M (dual 3-lane motorway) were reported to vary from £0.24 million to £0.70 million per km. In this case—and other examples—a mid-point figure was used (£0.47 m/km). This put the total cost of resurfacing the 8 km D3M section of the project road at £3.8 million. However, at £0.70 m/km, the total cost would have been £5.6 million—an increase of nearly 50%.

Similarly, the outturn costs associated with strengthening that are reported [and used as the basis for the estimate for strengthening on the A1(M)] were drawn from a sizeable range. A mid-point value was again employed. However, use of a value from the upper end of the observed range would have inflated the estimated costs of strengthening the D4M section of the project road by over 45%.

Returning to the PSC, when discounted using 8% (against the cost profile described later), the O&M cash cost of £91.4 million becomes an NPV of £25.4 million. As with the construction cost estimate discussed earlier, these O&M costs had also been the subject of some revision. The PSC report notes that the NPV of O&M costs had earlier been estimated at £52.2 million (over twice the revised estimate). Reasons reported for the revision included the use of improved cost estimates based on most recent experience, changes made to the cost profiles and correcting errors discovered in earlier calculations. Notwithstanding the reasons provided, the fact remains that both the construction and the O&M cost estimates had changed—significantly, in the case of the O&M estimate—as the estimation process evolved, with no consistent trend. Construction costs increased; O&M costs decreased.

Periodic Maintenance (alternatively labelled 'capital maintenance' or 'structural maintenance' in other PSC reports)—resurfacing the carriageway—accounted for the

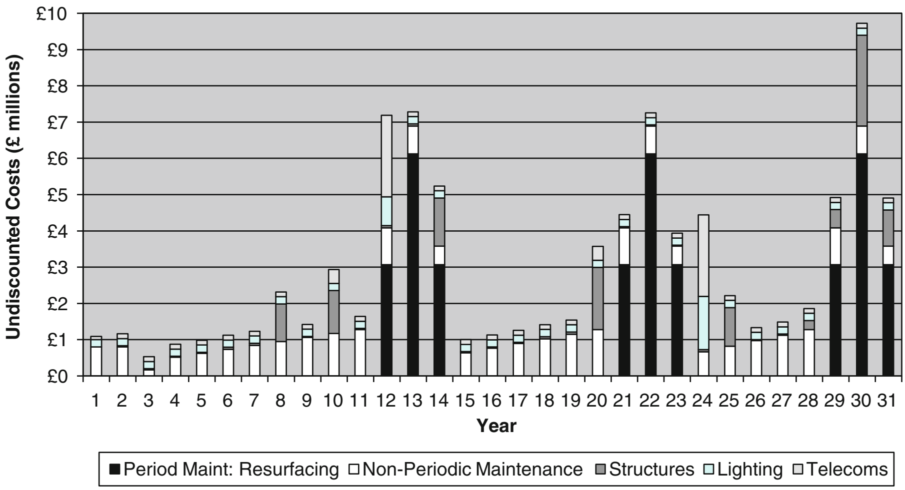


Fig. 2 A1(M) PSC O&M cost profile

majority of O&M costs. It was assumed that resurfacing work would be required every 10 years, with the costs being phased over 3 years (25, 50, 25%)—hence the periodic maintenance peaks evident in Fig. 2.

In the PSC material reviewed, no detail is provided about the assumptions underlying the O&M risk uplift calculation for the A1(M), save for a statement that the allowance is "…based on an assumed uplift of 25%" and that it was "…derived from an analysis of historic data." In undiscounted terms, 25% equates to £22.9 million.

When discounted at 8%, the O&M costs of £91.4 million and O&M risks of £22.9 million give NPVs of £25.4 million and £6.3 million, respectively. These figures are carried forward to the PSC calculation summarised in Table 6 below.

The PSC formulation is heavily weighted towards the construction obligations in this project. The NPV of the A1(M) PFI road scheme reported by the National Audit Office (1998) at 8% was £204 million (my spreadsheet calculations also suggested £204 million). At 6%, the NAO reported an NPV of £222 million (Bain = £219 million). The small discrepancy—largely due to rounding errors—suggests that the recreated PSC is a valid platform from which to calculate the A1(M) NPV at alternative discount rates. These sensitivities are shown in Fig. 3.

Table 6 The A1(M) PSC (@ 8%)

PSC cost component	NPV (£m)	% of Total
Base construction cost	141.8	70
Construction risk	30.5	15
Total construction cost	172.3	84
Base O&M cost	25.4	12
O&M risk	6.3	3
Total O&M cost	31.7	16
Total cost	204.1	100

Fig. 3 The A1(M) PSC at alternative discount rates

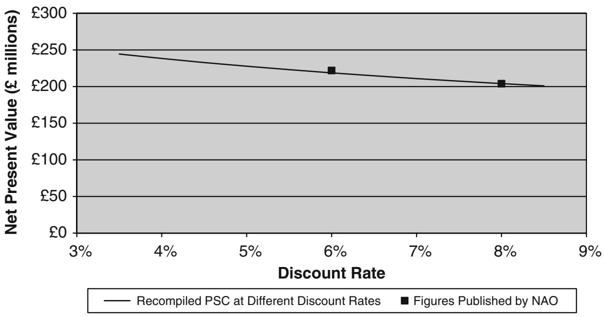
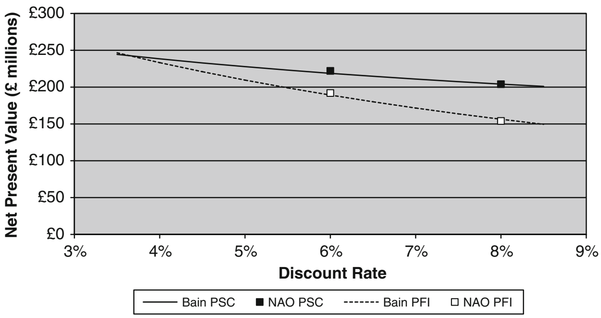


Table 7 PSC versus DBFO at different discount rates

	PSC NPV (£m)	PFI NPV (£m)	Difference (£m)
NAO @ 8%	204	154	50
Bain @ 8%	204	156	48
NAO @ 6%	222	192	30
Bain @ 6%	219	189	30
Bain @ 3.5%	244	247	-3

Fig. 4 A1(M) VfM comparisons at different discount rates



The PSC at alternative discount rates could now be compared with the PFI option (future cash flow obligations as reported in the Treasury's database) at alternative discount rates—for example, at today's recommended discount rate of 3.5%. The results from that comparison are summarised in Table 7.

At a discount rate of 3.5%, the PFI option becomes more or less equal to the PSC. This suggests that, if the A1(M) was evaluated today, *ceteris paribus*, it would be marginal for conventional procurement to be preferred over a PFI scheme. A graphical illustration of the discount rate sensitivity tests is presented in Fig. 4. The non-linearity of the relationship between the discount rate and the resulting NPVs is subtle, but evident.

Recreated PSCs for the other PFI roads: summary

The analysis reported above was replicated in full for the other early PFI project roads—with the exception of the M1-A1 (discussed later). Key findings are reported below, followed by a separate description of the treatment applied to the (more limited) M1-A1

Table 8 The A30/A35 PSC (@ 8%)

PSC cost component	NPV (£m)	% of Total
Base construction cost	90.0	60
Construction risk	27.6	19
Total construction cost	117.6	79
Base O&M cost	28.4	19
O&M risk	3.1	2
Total O&M cost	31.5	21
Total cost	149.1	100

data set and a round-up of the results across all eight PFI roads, before the broader discussion of issues that concludes this paper.

The A30/A35 public sector comparator

The PSC for the A30/A35 is summarised in Table 8.

As before, earthworks, pavements, structures and preliminaries accounted for the majority (over 80%) of the construction cost. Construction risk added around 30% to the total construction cost. The main risk drivers were reported to be allowances made for design contingencies, contractor claims, unforeseen ground conditions and protestor action. The O&M costs related to routine and winter maintenance (51%), capital maintenance (45%) and unavoidable lane closure charges (4%). O&M risk was assumed to be small, 80% of which was attributed to higher HGV usage than anticipated and the potential for (and possible magnitude of) O&M cost overruns. Having reconstructed the PSC, the NPV was recalculated using different discount rate assumptions (see Fig. 5).

The previously-published NAO figures suggested that the value-for-money benefits gained by procuring the A30/A35 via the PFI were marginal at 8%. At 6%, the PFI did not represent value-for-money, and at 3.5% the NPV differential had swung in favour of conventional procurement by £44 million (see Table 9).

The A50 public sector comparator

The A50 PSC is summarised in Table 10.

Construction risk added around 25% to the total construction cost. The main risks on this project were assessed to relate to contractors' claims, design contingencies and unforeseen ground conditions. At 8%, the allowance made for O&M-related risks on the

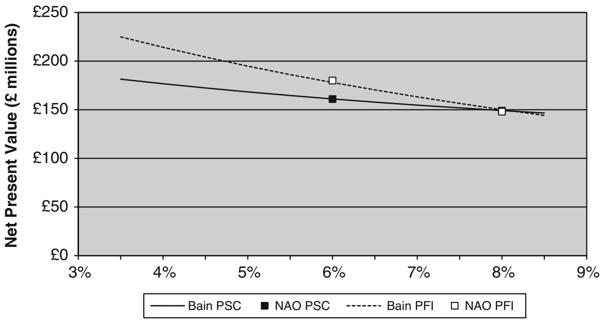


Fig. 5 A30/A35 VfM comparisons at different discount rates

Table 9 PSC versus DBFO at different discount rates

	PSC NPV (£m)	PFI NPV (£m)	Difference (£m)
NAO @ 8%	149	148	1
Bain @ 8%	149	150	−1
NAO @ 6%	161	180	−19
Bain @ 6%	161	178	−17
Bain @ 3.5%	181	225	−44

Table 10 The A50 PSC (@ 8%)

PSC cost component	NPV (£m)	% of Total
Base construction cost	27.3	35
Construction risk	6.6	8
Total construction cost	33.9	43
Base O&M cost	41.8	53
O&M risk	3.5	4
Total O&M cost	45.3	57
Total cost	79.2	100

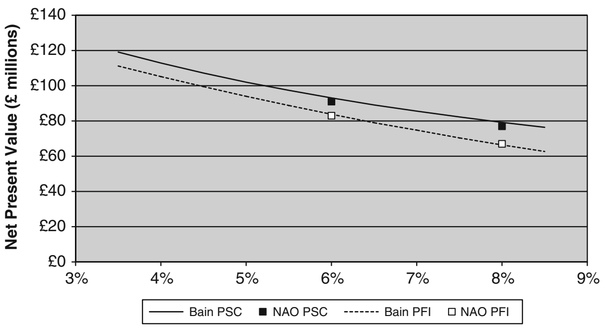


Fig. 6 A50 VfM comparisons at different discount rates

A50 project was not dissimilar to the uplift assumed for the A30/A35 project (9%). This PSC is more heavily weighted towards the O&M responsibilities embedded in the project. The ratio of construction costs to O&M costs is 43:57. In the A30/A35 project, that ratio was 79:21 (and it was even higher in the A1(M) project at 84:16). In part, this reflects the fact that the Highways Agency had specifically selected road projects with different characteristics to trial the PFI (National Audit Office 1998). The value-for-money comparisons at different discount rates are illustrated in Fig. 6 and are summarised in Table 11.

When using a discount rate of 3.5%, the A50 project remains value-for-money when procured under the PFI. The distribution of scheme costs between construction and O&M activities—with this project's emphasis on O&M activities—does make the NPVs sensitive to alternative discount rate assumptions. However the limited (upfront) construction obligations make the PSC and the PFI 30-year cost profiles more similar and, as such, they move 'in tandem' under different discount rate assumptions. This is demonstrated in Fig. 6 which shows the trend lines running almost in parallel. This project's particular cost profile characteristics serve to effectively insulate the ultimate procurement decision from the choice of discount rate. This is a significant finding. It is often assumed in the literature that a reduction

Table 11 PSC versus DBFO at different discount rates

	PSC NPV (£m)	PFI NPV (£m)	Difference (£m)
NAO @ 8%	77	67	10
Bain @ 8%	79	66	13
NAO @ 6%	91	83	8
Bain @ 6%	93	83	10
Bain @ 3.5%	119	111	8

Table 12 The A19 PSC (@ 8%)

PSC cost component	NPV (£m)	% of Total
Base construction cost	30.7	18
Construction risk	9.5	5
Total construction cost	40.2	23
Base O&M cost	104.9	60
O&M risk	24.3	14
Handback works	4.4	3
Total O&M cost	133.6	77
Total cost	173.8	100

in the discount rate will automatically favour the PSC over the PFI. This finding demonstrates that the relationship is not as simple as has been assumed. In terms of the preferred procurement route, the impact of a reduced discount rate can only properly be evaluated through a thorough examination (and reconstruction) of a project's precise costs and its cost profile.

The A19 public sector comparator

The PSC for the A19 is summarised in Table 12.

The construction risk uplift added 31% to the construction cost estimate. Over 50% of this uplift was attributed to risks falling under the categories of incorrect scheme cost estimates, soil acceptability for reuse, the potential for schedule overruns, pricing risk and preliminaries & supervision. The construction cost of this project was, however, dwarfed by the O&M costs—estimated at £275 million (NPV = £104.9 million). Capital maintenance accounted for around two-thirds of the O&M cost estimate, with routine and winter maintenance accounting for one-third. The O&M risk allowance for the A19 is considerably larger than that assumed for the other PFI project roads. O&M risks added 21% to O&M costs. By way of explanation, a distinguishing characteristic of the A19 project was the inclusion of three major structures in the scheme: the Tees Viaduct, the Hylton Bridge and the Leven Viaduct. Commenting on O&M risks, the PSC report states that "The principal risk area of the A19 project is the major bridges…".

In a departure from the convention followed earlier, the A19 PSC separately considered the costs associated with handback works. These are defined as "…the additional works that would be required, over and above the projected maintenance works, to improve the project road to the standard required in the DBFO contract." Handback works added £13.1 million to the PSC (NPV = £4.4 million). Again, this is a scheme dominated by O&M (as opposed to construction) costs and risks—a characteristic which leads to the PSC and PFI NPVs moving in parallel under different discount rate assumptions (see Fig. 7).

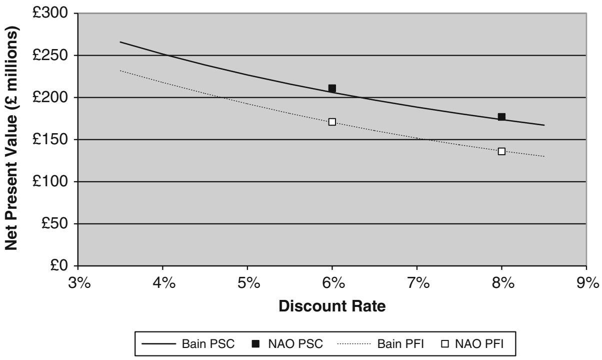


Fig. 7 A19 VfM comparisons at different discount rates

Table 13 PSC versus DBFO at different discount rates

	PSC NPV (£m)	PFI NPV (£m)	Difference (£m)
NAO @ 8%	177	136	41
Bain @ 8%	174	137	37
NAO @ 6%	211	171	40
Bain @ 6%	206	170	36
Bain @ 3.5%	266	232	34

The discount rate sensitivities are summarised in Table 13. As a PFI project, the A19 continues to represent value-for-money at the lower discount rate of 3.5%.

The A419/A417 public sector comparator

The PSC for the A419/A417 is summarised in Table 14.

The A419/A417 project PSC shifts the emphasis back to construction costs. At £29.5 million, the estimated risk allowance increased the undiscounted construction costs by nearly 40%—towards the upper end of the range suggested by Mott MacDonald. Five categories of risk dominate the construction risk uplift: earthworks, sub-contractors/suppliers, protestors, statutory undertakers and roadworks. Together, these represent 97% of the construction risk allowance. Earthworks alone account for one-third of the risk estimate.

In the PSC documentation reviewed, there was little discussion about O&M risks and their underlying assumptions. This is unfortunate as the estimate provided (£15.0 million) added around 21% to the O&M cash costs—higher than that reported for the majority of roads (nearer 10%), save for the A19 with its three major structures. No explanation was provided for this relatively high O&M risk assumption.

The sensitivity of the PSC and the PFI alternate to alternative discount rate assumptions is presented in Fig. 8. The results are summarised in Table 15. Although the PFI option represented better value-for-money at a discount rate of 8%, by 6% conventional procurement appears to be the better solution in terms of value-for-money. The case in favour of conventional procurement is even stronger at 3.5%, with the value-for-money differential growing to £18 million.

Table 14 The A419/A417 PSC (@ 8%)

PSC cost component	NPV (£m)	% of Total
Base construction cost	68.3	56
Construction risk	24.4	20
Total construction cost	92.8	75
Base O&M cost	25.7	21
O&M risk	4.5	4
Total O&M cost	30.1	25
Total cost	122.9	100

Fig. 8 A419/A417 VfM comparison at different discount rates

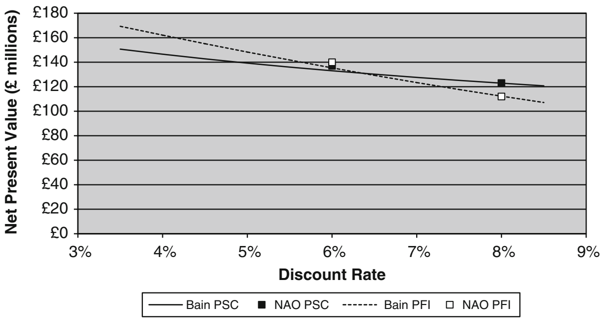


Table 15 PSC versus DBFO at different discount rates

	PSC NPV (£m)	PFI NPV (£m)	Difference (£m)
NAO @ 8%	123	112	11
Bain @ 8%	123	112	11
NAO @ 6%	137	140	−3
Bain @ 6%	133	135	−2
Bain @ 3.5%	151	169	−18

The A69 public sector comparator

The PSC for the A69 is summarised below in Table 16.

The A69 was the smallest of the first eight PFI road projects, with a construction value of just £14.8 million (NPV = £13.0 million). The works involved a short (3.2 km) section of new-build bypass. Structures accounted for half of the construction budget. Construction risk was estimated at £3.85 million (NPV = £3.4 million). Two risks accounted for over 70% of the construction cost uplift: contractual risk (the risk associated with the scheme being switched to a design-build procurement) and protestor action (security-related costs). Construction risk added 26% to construction costs.

O&M costs, on the other hand, totalled £96.8 million (NPV = £35.1 million). Major maintenance costs were the single largest line item (accounting for almost half of the total O&M costs). O&M risks added £7.1 million to the O&M costs (£3.3 million when discounted at 8%). The single largest O&M risk was labelled ‘estimating risks’ (the cost estimates being incorrect). O&M risks added 7% to O&M costs.

Table 16 The A69 PSC (@ 8%)

PSC cost component	NPV (£m)	% of Total
Base construction cost	13.0	23
Construction risk	3.4	6
Total construction cost	16.4	28
Base O&M cost	35.1	61
O&M risk	3.3	6
Total O&M cost	38.4	66
Total before lane closure charges	54.8	95
Lane closure charges	3.0	5
Total cost	57.8	100

In a departure from the material reviewed earlier, the PSC documentation for the A69 specifically identified lane closure charges with an NPV of £3 million—although no detail underpinning this estimate is provided. Lane closure charges are incurred by PFI road contractors during construction and operations, and are subsequently reflected in their PFI payments as deductions. These costs are, therefore, added to the PSC. As can be seen from Table 16, the PSC for the A69 is weighted in favour of the O&M obligations in the PFI contract.

The response of the PSC costs (and the future stream of PFI payments) to alternative discount rate assumptions is represented in Fig. 9 and is summarised, below, in Table 17. This table highlights the fact that, in terms of PSC performance, the A69 is quite different from the other project roads. The PFI option failed the value-for-money test at the original discount rate of 8%. Nevertheless, the scheme was still procured as a PFI project. This underscores the experimental nature of the early PFI roads programme.

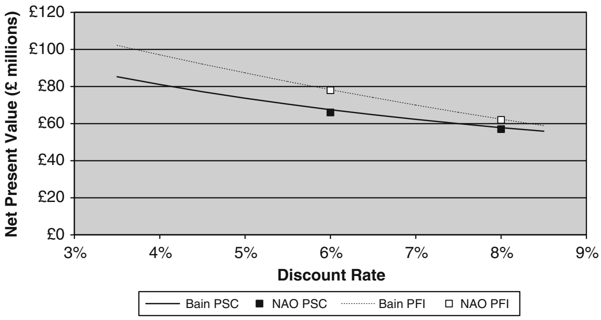


Fig. 9 A69 VfM comparisons at different discount rates

Table 17 PSC versus DBFO at different discount rates

	PSC NPV (£m)	PFI NPV (£m)	Difference (£m)
NAO @ 8%	57	62	−5
Bain @ 8%	58	62	−4
NAO @ 6%	66	78	−12
Bain @ 6%	68	78	−10
Bain @ 3.5%	85	102	−17

Despite failing the PSC test, the A69 was procured under the PFI as (a) the Highways Agency was keen to assess the performance of PFI roads with very different characteristics, and (b) the Agency had a broader—and, in this case, over-riding—objective to foster the development of a private road operating industry in the UK (National Audit Office, 1998). Having failed the PSC test at 8%, it is unsurprising to find that the conventional procurement option becomes increasingly attractive (in economic evaluation terms) as the discount rate reduces through 6–3.5%.

The M40 public sector comparator

The M40 PSC is summarised in Table 18.

Construction risk was assessed to be relatively low, adding only around 10% to construction costs. This reflected the fact that the project was a motorway widening scheme with no elements of greenfield new-build. In NPV terms, construction and construction risk-related costs account for less than a quarter of project costs. It is the scale of the operating and maintenance obligations associated with this project which differentiates it from the others. As most of the M40 opened in 1991, large sections of this heavily-trafficked motorway required resurfacing early in the PFI contract term (around 2001) and strengthening (around 2011). O&M risks added a relatively modest 7% to O&M costs (£36.8 million; NPV = £13.3 million); reflecting the availability of good, historical O&M data for this existing motorway. The discount rate sensitivity test results are presented in Fig. 10, and are summarised in Table 19. Following earlier comments made in relation to the A69 PSC, Fig. 10 further demonstrates the 'parallel line' characteristics of PFI projects with heavy O&M responsibilities.

Table 18 The M40 PSC (@ 8%)

PSC cost component	NPV (£m)	% of Total
Base construction cost	55.7	20
Construction risk	5.4	2
Total construction cost	61.1	22
Base O&M cost	202.1	73
O&M risk	13.3	5
Total O&M cost	215.4	78
Total cost	276.5	100

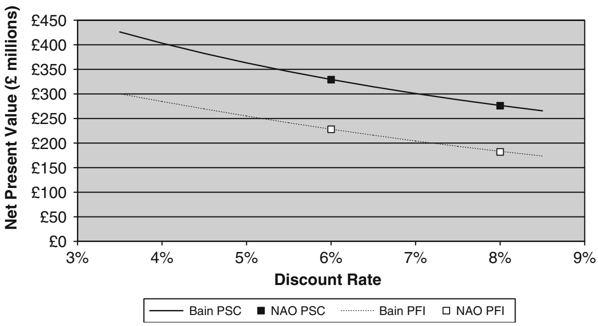


Fig. 10 M40 VfM comparisons at different discount rates

Table 19 PSC versus DBFO at different discount rates

	PSC NPV (£m)	PFI NPV (£m)	Difference (£m)
NAO @ 8%	276	182	94
Bain @ 8%	277	183	94
NAO @ 6%	329	228	101
Bain @ 6%	329	228	101
Bain @ 3.5%	426	300	126

Table 20 The M1-A1 PSC (@ 8%)

PSC cost component	NPV (£m)	% of Total
Base construction cost	205	60
Construction risk	104	30
Total construction cost	309	90
Base O&M cost	30	9
O&M risk	2	1
Total O&M cost	32	9
Total before lane closure charges	341	99
Lane closure charges	3	1
Total cost	344	100

The results summarised in Table 19 suggest that the value-for-money case for procuring the M40 project under the PFI actually *strengthens* as the discount rate is reduced. Once again, this repudiates the notion of a simple, predictable relationship between PFI value-for-money and the test discount rate.

The special case of the M1-A1

The data reviewed for the M1-A1 PFI road was very limited. Although a PSC NPV breakdown was available (see Table 20), there was no information regarding the cost details or the profiling of construction and operations/maintenance costs across the 30-year contract term. Thus it was not possible to recreate this PSC in a spreadsheet from first principles.

Points of note from the PSC calculation are:

- The PSC is very heavily geared towards the construction obligation. In NPV terms, total construction cost is 90% of the total PSC cost;
- Construction risk appears to be particularly high, as the risk allowance is over 50% of the base construction cost[5];
- Operations & maintenance risk was assessed to be low, as the risk allowance is only 7% of the base O&M cost.

In its report, the NAO published the NPV of the PSC at a discount rate of 8% (£344 million) and at 6% (£372 million). Given this limited PSC information, and using

[5] This high risk was attributed to specific scheme complexities (at the Aire Viaduct and the M62 Lofthouse interchange).

data from the earlier PSC calculations, an attempt was made to model the NPV of the PSC for the A1-M1 at a discount rate of 3.5%.

The model was based on the premise that (a) sensitivity to discount rate changes is linked to a PSC's cost profile (across the 30 year term), and that (b) a proxy for that cost profile was the contribution of construction costs to the total PSC figure. Construction costs are, by their nature, front-loaded. All things being equal, it appeared reasonable to expect that PFI projects with extensive construction obligations would be less sensitive to alternative discount rate assumptions than projects with large O&M commitments (which would have a higher proportion of project costs spread across the 30 year contractual period).

Table 21 summarises the results from the PSC discount rate sensitivity tests reported earlier.

The cell in the bottom right-hand corner of Table 21 was the one to be modelled. As can be seen from Table 21 (and the earlier graphs) the progression of the NPVs from 8 to 6% and finally to 3.5% is non-linear. This is why the published PSC NPVs at 8 and 6% could not simply be extrapolated to give the respective NPV figures at 3.5% and why calculation of the 3.5% figure could only be achieved by recreating the entire PSC formulation.

However the curve parameters are different for different projects. The first stage of the modelling analysis was to find out if similar types of curve were associated with projects with similar percentages of construction works. First, the figures in Table 21 were rebased, by setting the respective 8% NPVs to 1.

For comparison purposes, the percentage construction costs were added to the table and the roads were sorted in descending order (of percentage construction cost)—see Tables 22, 23.

The rebased NPVs are shown graphically in Fig. 11.

The trends presented in Fig. 11 looked promising. The curves for the four roads where construction work was <50% of the PSC are relatively steep and are grouped together at the top of the figure. Similarly, the three roads with the higher construction obligations (the A30/A35, the A1(M) and the A419/417) are grouped together but are markedly less steep (less sensitive to alternative discount rate assumptions).

The existence of families of curves relating to the extent of construction works in the projects suggested that it might be worth constructing a multiple linear regression model to calculate (model) the expected value for the M1-A1 PSC NPV at 3.5%. Excel was used to run the regression and derived the following equation with an R^2 of 0.99:

Table 21 PFI road PSC NPVs at alternative discount rates

PFI road	PSC NPVs (£m) at different discount rates		
	8%	6%	3.5%
A30/A35	149.1	161	181
A50	79.2	93	119
A19	173.8	206	266
A1(M)	204.1	219	244
A419/A417	122.9	133	151
A69	57.8	68	85
M40	276.5	329	426
M1-A1	344.0	372	**?**

Table 22 Rebased PSC NPVs at alternative discount rates

PFI road	Rebased NPVs at different discount rates		
	8%	6%	3.5%
A30/A35	1	1.08	1.21
A50	1	1.17	1.50
A19	1	1.19	1.53
A1(M)	1	1.07	1.20
A419/A417	1	1.08	1.23
A69	1	1.18	1.47
M40	1	1.19	1.54
M1-A1	1	1.08	**?**

Note: Thus the rebased A30/A35 at 6% gives a figure of 1.08 (161/149.1)

Table 23 Rebased PSC NPVs with % construction costs

PFI road	% Construction cost	Rebased PSC NPVs		
		8%	6%	3.5%
M1-A1	90	1	1.08	?
A1(M)	84	1	1.07	1.20
A30/A35	79	1	1.08	1.21
A419/A417	76	1	1.08	1.23
A50	43	1	1.17	1.50
A69	28	1	1.18	1.47
A19	23	1	1.19	1.53
M40	22	1	1.19	1.54

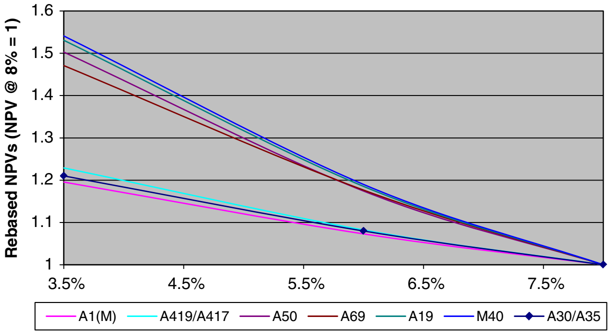


Fig. 11 Rebased PSC NPVs at different discount rates

$$y = -3.8 + 3.2x_1 - 2.2x_2 + 8.6x_3$$

where y = the PSC NPV at 3.5%, x_1 = the PSC NPV at 6%, x_2 = the PSC NPV at 8%, x_3 = % construction.

The result from the modelling exercise is summarised in Table 24.

As can be seen from Table 24, the PFI appears to remain the preferred procurement route for the M1-A1 project at a discount rate of 3.5%, however the value-for-money benefits are half those originally calculated by the Highways Agency. These results are

Table 24 PSC versus DBFO at different discount rates

	PSC NPV (£m)	PFI NPV (£m)	Difference (£m)
NAO @ 8%	344	232	112
Bain @ 8%	342	233	109
NAO @ 6%	372	288	84
Bain @ 6%	375	288	87
Bain @ 3.5%	419	362	57

now carried forward to a consolidated review of the Highways Agency's early PFI roads programme as a whole.

PSCs for the first eight PFI roads

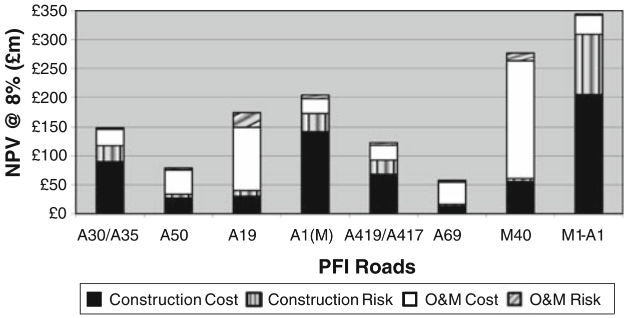
This paper has reported the results of recreating the public sector comparators for the first eight Highways Agency PFI roads. For each road, the key components of construction cost and risk, and operations & maintenance cost and risk were identified and quantified. Once recreated, the PSCs were compared with published data (NAO and PAC figures) to check their accuracy, before being used—in conjunction with discounted future cost data from the Treasury's PFI database—to assess PSC performance at today's recommended discount rate of 3.5%.

As the relationships between the discount rate and the PSC NPVs are non-linear (they can be approximated by polynomial functions) simple extrapolation could not be used to short-cut this exercise. For each project road, only two 'point values' were previously in the public domain (the PSC NPVs at 8 and 6%). Two points can be used to define a straight line—but not polynomial expressions (curves). The only way of recalculating the PSC NPVs at 3.5% was to recreate the public sector comparators for each road from first principles.

The PSCs for each of the PFI roads differed significantly from each other—reflecting the nature of the obligations embedded in the respective PFI contracts. Some were dominated by new works (hence construction cost and risk featured prominently) whereas others were weighted towards operations and maintenance responsibilities. In this respect, Fig. 12 summarises and contrasts each of the first eight PFI roads.

Conventional wisdom suggests that testing value-for-money at lower discount rates effectively raises the hurdle for PFI projects. In comparison with conventional

Fig. 12 PSC cost components for the first eight PFI roads



procurement, the PFI smoothes costs over a 30-year contract period and a lower discount rate reduces the dampening effect on costs incurred towards the end of the contract term. However the analysis presented earlier demonstrated that, although this is the overall trend, at the individual project level this is not always the case. PFI road value-for-money performance at rates of 8, 6 and 3.5% is summarised in Table 25. All other things being equal, only half of the roads (four of the first eight) remain value-for-money at 3.5%.

In Table 26, the aggregate value-for-money from the Highways Agency's first eight PFI roads programme (at different discount rates) is recalculated and the results are summarised.

Table 26 illustrates that value-for-money is reduced significantly (by over 50%; from £314 million to £143 million) when the discount rate is reduced from that recommended in 1995/1996 (8%) to that recommended today (3.5%). Only four of the eight offer value-for-money although, of note, the Highways Agency's overall PFI roads programme still remains value-for-money at 3.5%.

One weakness of the analysis presented here is the fact that recalculations of value-for-money at different discount rates—and the findings—are based on the assumption of fixed private sector bid costs. In reality, this assumption may not hold. Consortia bidding for the early PFI roads were aware of the evaluation criteria being used by the Highways Agency (including the discount rate) and would have tailored their submissions accordingly. The private sector bid costs could possibly have been different if, for example, a discount rate

Table 25 PFI Value-for-money at different discount rates

PFI road	Does the PFI represent value-for-money?		
	DR = 8%	DR = 6%	DR = 3.5%
A30/A35	Yes	No	No
A50	Yes	Yes	Yes
A19	Yes	Yes	Yes
A1(M)	Yes	Yes	No
A419/A417	Yes	No	No
A69	No	No	No
M40	Yes	Yes	Yes
M1-A1	Yes	Yes	Yes

Table 26 The first eight PFI roads—VfM at different discount rates

PFI road	PFI value-for-money (NPV £m)		
	DR = 8%	DR = 6%	DR = 3.5%
A30/A35	1	−19	−44
A50	10	8	8
A19	41	40	34
A1(M)	50	30	−3
A419/A417	11	−3	−18
A69	−5	−12	−17
M40	94	101	126
M1-A1	112	84	57
Total	314	229	143

of 3.5% (instead of 8%) had been publicised back in 1995/1996. It is impossible to estimate the nature or scale of this impact, but is important to point out that, although not acknowledged, the NAO's analysis of PFI road value-for-money differentials at 8 and 6% suffers from the same complication.

Issues for consideration

This PSC-related research has raised a number of issues worthy of further consideration. These are summarised below under the following headings:

- Key project risks
- The process and precision of cost estimation
- Is the PSC benchmark appropriate?
- Limitations of this research

In the literature, construction risk is commonly identified as a key risk for PFI road projects. The importance of construction risk is underscored by the results reported in this paper. On average, construction risk added around 33% to PSC construction costs. O&M risk, on the other hand, added around 10% to O&M costs.

A comparison of the construction risk assumptions applied across all of the first eight PFI road schemes could not be undertaken in any detail. Different PSC reports used different terminology and grouped risks in different ways. Despite this, several construction risk categories (or descriptions) appeared as recurring themes. These were unforeseen ground conditions, estimating risk, statutory undertakers, schedule/delay risk, protestors and contractor claims. Any construction industry initiative that could effectively reduce these risks—particularly the risks associated with earthworks and ground conditions—under conventional public sector roads procurement would reduce the economic argument in favour of PFI-type procurement solutions.

Critics of the PFI have suggested that the risk adjustments made in PSCs—particularly those relating to the potential for public sector construction cost overruns—are based on slim evidence, perhaps manipulated to achieve a desired (pro-PFI) result. Having recreated the PSCs from first principals, it is possible to re-set the construction risk uplifts to zero. In such circumstances, when evaluated at a discount rate of 8% the Highways Agency's PFI roads programme continues to represent value-for-money. At 6%, the programme-wide value-for-money drops to zero. The point of note is that it takes only small assumptions about public sector construction cost overruns for the early PFI roads programme to continue to represent value-for-money.

It was clear from the PSC reports that the main source of information used to prepare the cost (and, indeed, risk i.e. cost-overrun) estimates embedded in the PSCs were historical data. This raises possible questions about the availability and relevance of the data, and its transferability. However the most striking feature from the historical data was the reported variability of observed unit costs. The illustrated example of the A1(M) provided evidence that outturn costs—particularly those relating to construction—varied considerably. Mid-point estimates were used for the purposes of the PSCs, however other unit costs could have been selected, entirely consistent with the observed range, that would have increased the cost estimates by 50%.

It is telling that, when commenting on the ranges of historically observed costs, the PSCs point to specific reasons for unit cost variability. The costs for strengthening a D4M reportedly ranged from £0.7 million to £1.9 million/km. The PSC report comments that:

…outturn costs vary considerably depending on thickness of overlay, the number of structures where reconstruction is required to give adequate height clearance, required work on safety fences, the permitted hours of working, whether maintenance crossing points already exist, and the number of traffic management switches between junctions.

Given this information (and the magnitude of the unit cost variability), it would seem desirable to be able to isolate the individual impact of these cost drivers, such that adjustments could be made to unit costs to ensure that future estimates best reflected the scheme under consideration and narrowed the likely cost range. Disaggregated cost analysis requires large samples, however, and this information may not be available at a local level. This suggests that some national database of estimated and outturn construction costs could have a valuable role to play in improving future cost estimate accuracy.

An alternative would be to undertake sensitivity tests to determine how the PFI option performed against a range of PSC cost estimates. None of the PSC reports reviewed suggested that this form of sensitivity testing was undertaken. Notwithstanding, the reliability placed on the outcome of the PSC evaluation process can never be any greater than the reliability inherent in the data and assumptions used to compile the PSC. Furthermore, it was reported that cost estimates changed (in some cases, by some margin) as the planning process rolled forward. This suggests that careful attention needs to be paid to the issue of exactly when in the planning process the PSC evaluation should be conducted.

Various costs are added to the PSC to make it comparable with the PFI alternate. For example, a strict maintenance regime is imposed on the public sector procurement option (to reflect the whole-life costing approach embedded in and contractually enforced under the PFI) despite the fact that no conventionally-procured road schemes have ever enjoyed ring-fenced maintenance budgets. It could be argued that leaving highway maintenance to the discretion of annual spending settlements has caused the very deterioration in road network which prompted adoption of the PFI by the Highways Agency in the first place. However the move from ‘no ring-fencing’ to (effectively under the PFI) ‘full ring-fencing’—for what remains a relatively small proportion of the UK’s strategic highway network—suggests that there is no middle ground worth exploring; in which some road construction and O&M risks could be reduced but at a cost lower than a full-blown, high-specification PFI solution.

The general results from the discount rate sensitivity tests are summarised in Table 27.

The PSCs for projects with their costs weighted towards their O&M obligations are sensitive to alternative discount rates as their cost profile is more evenly distributed across the 30-year contract period (hence discounting impacts on a higher proportion of overall project costs). This contrasts with the front-loaded cost profile of projects weighted towards construction, which gives discounting less opportunity to ‘dampen’ the resulting NPV figures. However the cost profile of projects with high O&M obligations is more similar to the smoothed distribution of PFI payments and, under such circumstances, discount rate changes are likely to have parallel impacts on the PSC and the PFI option.

Table 27 Summary results from discount rate sensitivity tests

Project costs geared towards…	PSC sensitivity to alternative discount rates	VfM differential between the PSC and the PFI at alternative discount rates
Construction	Low	Changes
O&M	High	Remains unchanged

The value-for-money differential between the PSC and the PFI is generally maintained and hence the resulting procurement decision remains unchanged under alternative discount rate assumptions. The critical issue is the size and shape of the cost profiles and how they compare—in detail—with the schedule of PFI payments. The only certain way of knowing what impact an alternative discount rate would have on a particular procurement decision is to recreate the PSC from first principles and re-run the evaluation process.

It is important to emphasise the fact that the analysis reported in this paper has been based on a selection of PSC summary reports and their contents. A number of these reports reference other material—earlier reports, supporting documents, technical data and independent reviews—which have not been available for examination. As such, PSC-related issues which appear to have attracted modest attention (or no attention at all) may have been the subject of extensive consideration elsewhere. A good example is the central topic of project risk. Although the PSC reports provide a deeper insight into the identification and quantification of PFI road construction and O&M risk than has previously been published, in places they undoubtedly fail to tell the full story in terms of all the underlying assumptions, their foundations and their justification.

Conclusions

The eight PFI road projects considered here were at the vanguard of the UK's PFI initiative. Procurement policy was still evolving, as were many related issues such as what risks to transfer and why, what evaluation methodologies to use and when, and so forth. Indeed, the first eight highway schemes were specifically selected to test the PFI at a time when policy-makers were keen to kick-start the Initiative, have it build momentum and learn early lessons. The evaluation process used for PFI roads today retains the use of a PSC and shares many of the characteristics of the methodology described above, yet it has evolved. Nevertheless, here—for the first time—the architecture of the early comparators is laid bare and the performance of the PSCs has been tested against some key alternative input assumptions.

Important conclusions include the fact that, although the use of today's recommended test discount rate of 3.5% reduces the value-for-money from seven of the first eight PFI roads, the programme as a whole remains value-for-money from the public procurement perspective. Similarly, value-for-money continues to be demonstrated when construction cost optimism-bias uplifts are significantly reduced. This new evidence suggests that the policy of procuring these early roads by the PFI appears more robust than many authors have previously claimed.

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