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Comparison of construction costs on motorway projects using measure and value and alternative tendering initiative contractual arrangements

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This paper reports the outcome of an investigation into the construction costs in 11 motorway projects. The projects formed one length of road and were of identical specification; five of the projects were undertaken by a traditional design, tender, construct method, and five were undertaken by a procurement system by which the contractor bid a lump sum for the work and so absorbed potential risks and benefits from changes in prices of resources or fluctuations in quantities of work necessary for the completion of the work. One project was undertaken by a design and build method. The results of the analysis indicate that in roadworks the construction cost per kilometre of road is some 11% less expensive when lump sum contracts are used. This benefit appears to be more pronounced in the case of bridge structures incorporated into the motorway. Of greater significance is the cost certainty that is afforded using the lump sum methods. The research showed that lump sum projects were much more likely to be completed within the budget. Finally the lump sum methods required less management by the client organization and delivered more harmonious working relationships between the client and contractor.

Keywords: Procurement, tendering, construction costs, variations, value for money

Introduction

The theme of risk allocation in procurement methods has become a critical issue in the placing of construction contracts. Latham (1994) invigorated the debate in the UK by noting that clients often prematurely selected procurement methods without consideration of the appropriate division of risks. The risk involved could, of course, be physical in nature but is more likely to be mercantile. This view reinforced the argument put by Taylor (1993), who suggested that consideration of the risks at the procurement stage could save money and time and improve quality.

Smith (1995) confirmed that inappropriate risk management could lead to higher costs for the client. Yet often the procurement choices are made, according to Hibberd *et al.* (1990), where 'without an effective means of judging the success of previous decisions regarding procurement advice clients can be influenced to change their approach upon supposition and not hard factual evidence'.

Not only are procurement issues a factor influencing risk but, as Uff and Odams (1995) noted, contractual risks are seldom analysed and quantified. Thus the evidence seems to point to the importance of clients selecting appropriate procurement routes and contractual strategies which fit client ambitions for a project. Invariably these will include, amongst other factors, achieving 'value for money'!

Research reported in this paper seeks to provide evidence of the comparative outturn of costs of two procurement methods used in motorway construction

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of identical specification and quality using the criterion of 'value for money'.

The research problem

The research problem may be simply put. Do clients get better value for money when using traditional measure and value methods of contract when compared to contracts which are let on a fixed lump sum basis with little or no scope for recovery of additional costs arising from fluctuations in price or quantity?

The problem may be a surrogate measure for risk management. In the traditional contract the majority of cost overruns are borne by the client whereas in the case of the lump sum bids – known as Alternative Tendering Initiative (ATI) schemes by the client – the performance risk is shifted to the contractor. The characteristics of the ATI approach are described later.

The pattern of risk sharing due to aleatoric factors (those due to chance) is unlikely to be changed as both arrangements would permit the usual range of claims for unforeseen events. However, sharp differences may be seen in risk situations which may be defined as epistemic (which relates to the knowledge base of those taking the risks). So, for example, a contractor who perceives a particular item of work to be particularly high (or low) risk will price that item accordingly since it sees its knowledge base and hence its ability to manage the risk as different to that of its competitors. For example, a contractor considering the risk of delay and additional cost due to excavation through rock would include in the assessment any special knowledge of the geology of the area (and consequently the risk of there being rock to hit) and any specialist expertise, rock-cutting equipment, etc. the contractor has developed, which places it in a superior state of readiness to deal with rock. In such situations risks, over which the contractor has a superior knowledge base, provide opportunities for competitive advantage.

Economists agree that those who take over or bear the risk have to be rewarded for doing so. Begg *et al.* (2000) comment:

> Many economic activities consist of the more risk-averse bribing the less risk averse to take over the risk.

This would suggest that a simple shift of risk to the contractor would result in increased prices. There is an argument, based on the field of moral hazard, that the contractor, knowing that the major risks on the project were carried by the client might be less than diligent in managing the works in such a way as to deal effectively and economically with risky items.

The process of arbitraging risk will be central to the tendering and adjudication strategies of contractors operating in lump sum tendering environments. In measure and value contracts more of the risk will remain with the client.

This risk shift was amplified by the willingness of the client to accept contractor alternatives to bids in the ATI schemes. These alternatives would be driven by cost reductions, programme benefits, increased constructability or timeous procurement of components or materials. The client categorized the ATI as being a suite of alternative contractual arrangements with the overall objective of driving effectiveness into the procurement methodology.

Any efficiencies gained should be rewarded and any benefits that road users gained from, say, early completion, should be considered when assessing tenders. These factors led the client to consider the following options when seeking tenders:

1. Conforming tender with tenderer's own time for completion.
2. Conforming tender + tenderer's own time + fixed price lump sum for the whole of the works.
3. Tenderer's own time + alternative design of components at fixed price lump sum + conforming bid for remainder of works.
4. Tenderer's own time + alternative design of components + fixed price lump sum for the whole of the works.
5. Tenderer's own time + alternative design for whole of works + fixed price lump sum for whole of works.

Behind this list of alternatives is a primary client objective to obtain better 'value for money. In some ways this is an ambiguous concept. Early attempts at defining this concept was attempted by Burt (1978) who collapsed the definition to cost cutting rather than its broader approach in respect of quality or utility.

The former UK Department of the Environment (1991) saw value for money as being multi-faceted; their definition combined economy, efficiency, and effectiveness. Economy was the task of minimizing resources used, whilst efficiency was seen as an input/output function – minimized inputs for maximized outputs. Effectiveness was the satisfaction of objectives.

The research reported here used the economy dimension as a pointer to achievements in other areas. For example, if the ATI projects were seen to deliver lower outturn costs then economy had been gained but also efficiency will have been improved since ATI projects will have required fewer managerial inputs by the client. Equally, effectiveness will have been achieved since the client has had delivered a scheme which moved traffic earlier than scheduled. Drivers in Scotland will have noted the boast on bridges over new roads 'completed x months ahead of schedule'.

The costs quoted in this research are those paid by the client. The actual contractors' costs are out with the scope of this study. Consequently, our measures for value for money are informed by the evaluation of tender costs and outturn costs.

The research problem was defined to take into account comparisons of cost performance at two points in the construction process, first the tender costs per kilometre length of roadway and second the outturn costs after allowance had been made for accepted claims. For major structures, costs were compared per square metre of bridge deck and for minor structures (culverts) per linear metre.

The data set

The data were collected from 11 projects, which composed the A74/M74 upgrading carried out between April 1990 and October 1995. The 11 projects provided a unique sample for comparison of the measure and value projects and lump sum projects. All projects were designed with an identical specification for carriageways and encountered similar climatic, geographical and geological conditions. Major and minor structures are obviously bespoke and certain aspects of the groundworks are project specific. However the research design took into account the particularities of each project.

The projects used in the study are disguised and have been identified by a project letter.

Projects A, B, C, F, K

Measure and value contract based upon The Institution of Civil Engineers (ICE) Conditions of Contract (5th amendment).

Projects D, E, G, H, J

Lump sum fixed price based on ICE Conditions of Contract (5th amendment) with major amendments.

Project I

Design and Build based upon ICE Conditions of Contract (5th amendment) with substantial amendments.

The Design and Build project was included in our analysis but given that it is a 'one-off' it has not been included in the analysis of this paper.

Data collection

Obtaining the data for the analysis was a time consuming activity. The data, whilst primarily quantitative were supported by qualitative evaluation. Most of the data were historical in nature but were supplemented by subjective reviews of situations which appeared ambiguous during the data analysis. The data were held by a variety of sources and the framework identified by Browers (1994) was used to evaluate the data.

Corporate

Data dispersed through the client organization.

Project team

Data possessed by individuals in several organizations contributing to the project.

External

The knowledge held by the research consultants.

Data from all of these sources was captured and used in the analysis.

The corporate data were primarily the priced bills of quantities and final accounts for each scheme used in the study, with a copy of the post-project evaluation report. This was supported by interviews with resident engineers, contract advisers and consultants. Regular contact was maintained with the client's representative who was able to provide a well informed, yet dispassionate, explanation for ambiguous data.

Project durations, carriageway lengths and dimensions of structures were provided by the engineering consultants. Finally the research team inputted their skills and knowledge concerning construction processes, construction costs and tender price indices as well as a detached, impartial overview of the data.

The methodology used was to establish the average cost of each major element of the works in the measure and value projects. This data were then used as a benchmark against which costs in the ATI set of projects could be compared.

The following set of comparisons were made:

Roadworks overall
Preliminaries
Roadworks
Pavement
Side roads
Motorway communications
Statutory bodies

Major structures built in:

- in-situ concrete;
- pre-cast concrete;
- steel/concrete.

Minor structures:

- corrugated steel culverts.

Each item had three levels of analysis applied:

1. Outturn costs per kilometre (in the case of the roads items).
2. Outturn costs per kilometre which had been adjusted for inflation.
3. Growth in costs between the tender price and outturn costs.

In the case of the structures the unit of comparisons was m^2 of bridge deck and linear metre for culverts in the case of minor structures. This paper uses the data from the inflation adjusted tender and outturn costs.

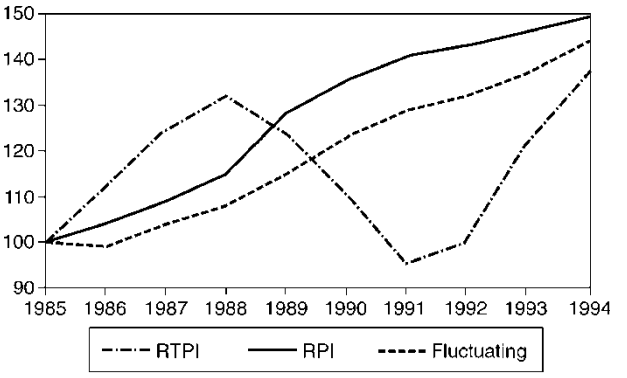

Figure 1 Comparison of measures of cost movement

Indexation

As the projects spanned the period April 1990–October 1995 it was recognized that some effort would be required to eliminate the effect of cost inflation over this period. Three measures of cost movement were examined to establish the most appropriate. These measures included the use of Road Tender Price Index (RTPI), the Retail Prices Index (RPI) and the use of the Price Adjustment Formulae for Civil Engineering Contracts (Fluctuations). In the case of the last of these the cost profile of a 'typical' motorway contract was estimated and used as a basis for the model.

Figure 1 indicates considerable fluctuation in the Road Tender Price Index. After discussion it was considered that the price movements represented in this index were too widely varying and not closely associated with the relatively more stable road construction situation in Scotland and was consequently discarded as a useful measure. The RPI and the Price Adjustment Formula derived fluctuations were fairly consistent and were seen to be almost parallel over the period of the duration of the construction projects. It was considered that between them these measures represented a reasonable model of cost inflation over the period of work. As the RPI is a measure which is externally derived and is not subject to any assumptions regarding the cost profile of motorway projects the decision was made to adopt the RPI as the measure of cost inflation for the research project.

A base month was selected to minimize the magnitude of cost fluctuation. This was achieved by examining the overlapping durations of the projects and finding the period during which most work was being carried out (3rd Quarter 1993). This was then established as the base for indexation.

Results

The data was broken down into roadworks, major structures and minor structures. Graphs showing the comparisons of the major elements are included in the text for ease of reference. Table 1 indicates the results of the comparison between the cost of each element in each of the Lump Sum projects against the average cost of each of these elements for the Measure and Value projects. Each element is reviewed in turn. Table 2 shows the growth between tender and outturn (or final) cost for each element of all the Measure and Value and Lump Sum projects.

Table 1 Comparison between each ATI project and the average of the Measure and Value projects

Element of cost	Average of Measure and Value projects outturn costs £/km	Outturn costs of the ATI projects £/km					
		Lump Sum					Design & Build
		D	E	G	H	J	I
Roadworks (overall)	4 087 312	3 190 111	2 839 965	4 386 536	5 790 999	3 618 586	4 171 097
Preliminaries	652 446	484 915	536 643	632 197	2 018 865	256 253	1 159 614
Roadworks (carriageways)	958 747	762 631	403 697	565 514	848 903	963 489	855 324
Pavements	855 649	698 934	875 017	827 735	977 763	1 056 028	963 354
Side roads	285 345	265 779	263 702	212 095	306 227	313 569	364 614
Motorway communications	138 427	87 361	72 309	56 996	106 057	94 296	104 058
Statuory bodies	23 908	16 185	15 355	1 988	12 693	48 234	35 539

Table 2 Percentage growth between tender costs and outturn costs

Element of cost	Percentage growth for each project										
	Measure and Value projects					All projects					
						Lump Sum					Design & Build
	A	B	C	F	K	D	E	G	H	J	I
Roadworks (overall)	32.70	22.66	37.87	47.05	18.31	7.19	4.20	14.01	1.69	0.32	0.94
Preliminaries	75.76	22.86	35.05	141.38	–7.38	3.22	1.35	–1.21	–1.82	0.00	–1.26
Roadworks (carriageways)	35.18	26.09	75.26	20.94	49.40	5.64	2.51	0.57	1.08	0.31	0.82
Pavements	4.62	3.17	2.88	3.13	9.10	4.83	3.13	5.95	5.57	0.00	0.00
Side roads	1.12	25.13	–7.32	–10.76	7.83	5.34	11.04	8.05	11.05	0.00	4.15
Motorway communications	37.93	26.30	82.53	36.75	20.06	14.37	15.21	7.84	30.60	0.00	10.79
Statuory bodies	80.45	65.86	186.01	98.54	29.04	0.00	58.10	–35.04	6.56	21.18	30.81

Roadworks overall

The data collected for this comparison included all aspects of the motorway other than the structures. Figure 2 shows the average outturn cost for the measure and value projects as being just over £4m per km.

Inspection of Figure 2 indicates that three of the five ATI projects are below the measure and value average. One project which distorts the picture is project H which was predominantly a bridge project with a short length of road (1.66 km) and as such it is outwith the normal pattern of road lengths. Despite the inclusion of this outlying project the average outturn cost per km for the ATI projects was £3 965 219 per km.

Figure 3 shows the striking comparison between the procurement routes when the issue of cost growth between tender and final out-turn cost is considered. The Measure and Value projects (shown as MV on the chart) show cost growths of between 18.31% and 47.05%, whereas the ATI Lump Sum projects (shown as LS on the chart) show cost growths of between 0.32% and 14.01%. The figure for the Design and Build project (shown as DB on the chart) was included for comparison but cannot be taken as representative.

Preliminaries

The Preliminaries comparison is particularly interesting in that it is often in this section that contractors build-in

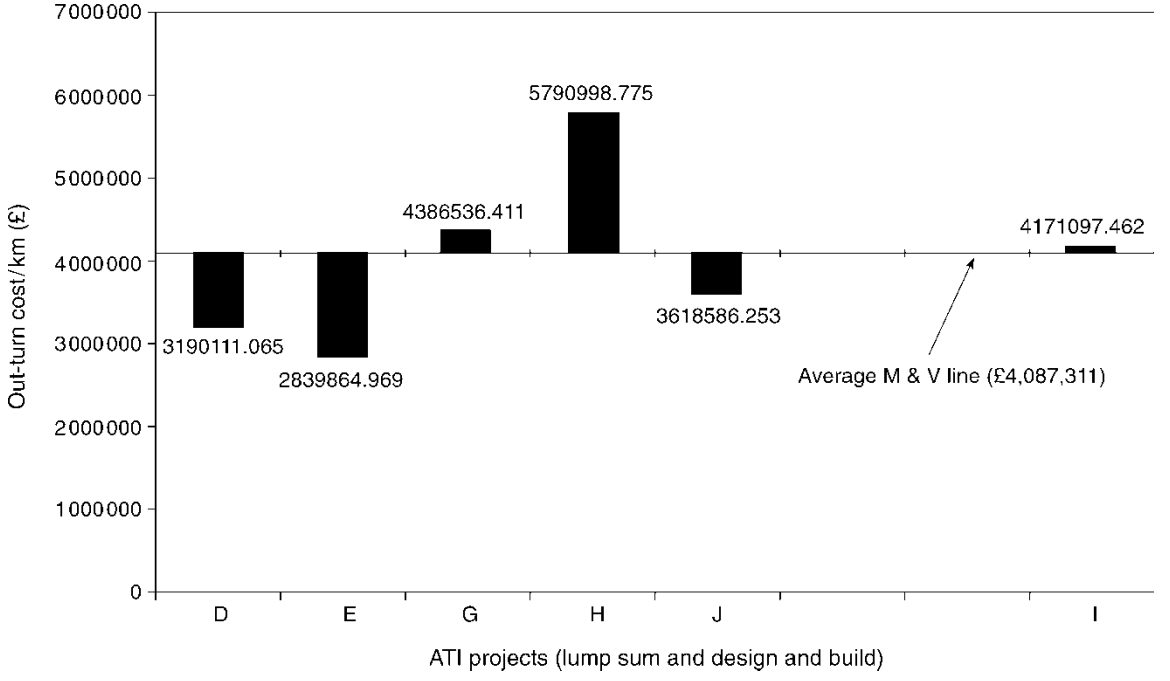

Figure 2 Average measure value outturn cost/km v. ATI outturn cost/km (index adjusted)

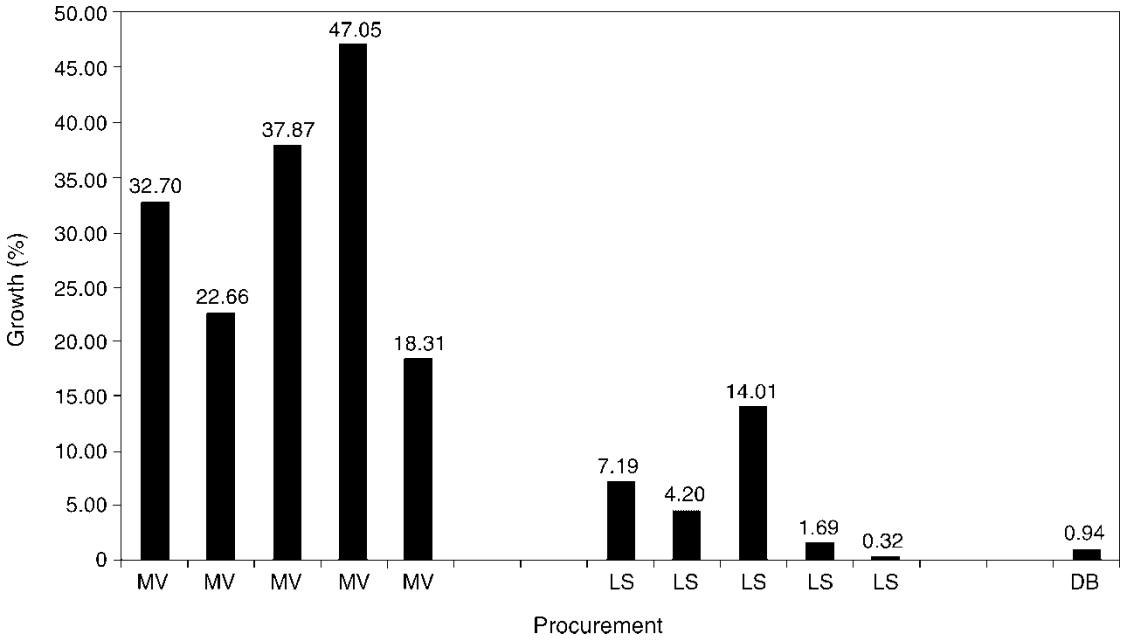

Figure 3 Percentage growth – total tender to outturn cost/km

allowances to cover risk-related items. After index adjustment only one project showed a Preliminaries cost per km higher than the Measure and Value average and that was the project referred to earlier as predominantly a bridge project with a short section of road attached.

The cost growth on Preliminaries, as shown in Table 2, indicates the relative stability of the ATI group when compared with Measure and Value projects. In the former the outturn cost of Preliminaries fluctuates from between –1.83% to 3.22% whereas the latter fluctuated between –7.38% and 141.38%.

Roadworks (carriageway)

This data covers the carriageway works alone and is a subset of the roadworks (overall) data described earlier. The analysis of the Roadworks (carriageway) section (shown in Table 2) shows that, apart from one project which was in excess of the average cost per km of £958 747 for Measure and Value projects by £4741, all of the other projects were substantially lower than the Measure and Value projects. The analysis also shows that the cost inflation was also very much lower in ATI projects.

Pavement

The comparison between the procurement routes with regard to Pavements shows that the average costs were similar and that they both experienced a similar (if modest) degree of cost inflation

Side roads

The analysis in the case of side roads shows three out of the five ATI Lump Sum projects had a lower cost per km than the average for Measure and Value projects but as Table 2 shows they had a greater tendency towards cost inflation. This runs contrary to the general pattern of the research. In four out the five ATI projects the cost increased between the tender and outturn whereas in four out of the five Measure and Value projects the cost reduced between tender and out-turn.

Motorway communications

The evidence shows that the cost of communications on Lump Sum projects was considerably lower than that found on Measure and Value contracts. All of the Lump Sum projects had lower costs that the average for Measure and Value contracts. The variance between tender and outturn costs was also found to be lower on Lump Sum contracts.

Statutory bodies

With regard to the cost of work in connection with Statutory Bodies the study found that in four out of the five Lump Sum contracts the costs were considerably lower and that there was an appreciably lower level of cost inflation. Care must be taken however in respect of comparisons where Statutory Bodies are involved as the work is likely to be highly project-specific.

Analysis of structures

In-situ concrete

There were 36 major structures over the eleven projects; 20 on the traditional Measure and Value, 14 on the ATI Lump Sum and two on the ATI Design and Build projects. The research showed that out of 14 structures of this type on the lump sum projects, 11 had statistically significantly lower costs per square metre than the average for Measure and Value projects (Figure 4). The study also clearly indicated a statistically significantly reduced level of cost inflation on ATI Lump Sum projects than that found on Measure and Value work (Figure 5).

Pre-cast concrete

In pre-cast structures the analysis shows that, of the eight structures of this type on the ATI projects, all but one had a lower cost per square metre than those of the Measure and Value projects. The data also indicates a striking comparison with regard to cost inflation. In the ATI projects only two suffered some cost inflation (of just over 1%) whilst all the Measure and Value projects experienced variation in cost, some very considerably (Figure 6).

Steel

Of the four Steel Structures on the ATI projects all had much lower costs than on the Measure and Value contracts. Some of these savings were substantial. They also experienced much lower cost escalation than on the Measure and Value projects.

Corrugated steel culverts

In five out the six minor structures of this type on the ATI projects the costs were lower than the average of the Measure and Value projects. In only two cases did Lump Sum projects experience some cost inflation, whereas all eleven of such structures on the Measure and Value projects experienced some cost variation (from –17.92% to 20.50%) (Figures 7 and 8).

Conclusions

In the realm of construction procurement for major works prototypicality is the norm. Rarely is it possible for a client to construct the same structure to the same specification using the same contractor, same ground conditions, etc.; changing only one variable at a time in the same way as a laboratory researcher can, allowing them to claim with confidence that by changing one variable they can predict a change in the outcome. In this research it was the intention of the client to attempt this. It set out to measure the effect of the ATI procurement initiative on final cost in both absolute terms and in terms of cost certainty. This section of motorway was carefully divided into sections where the specification,

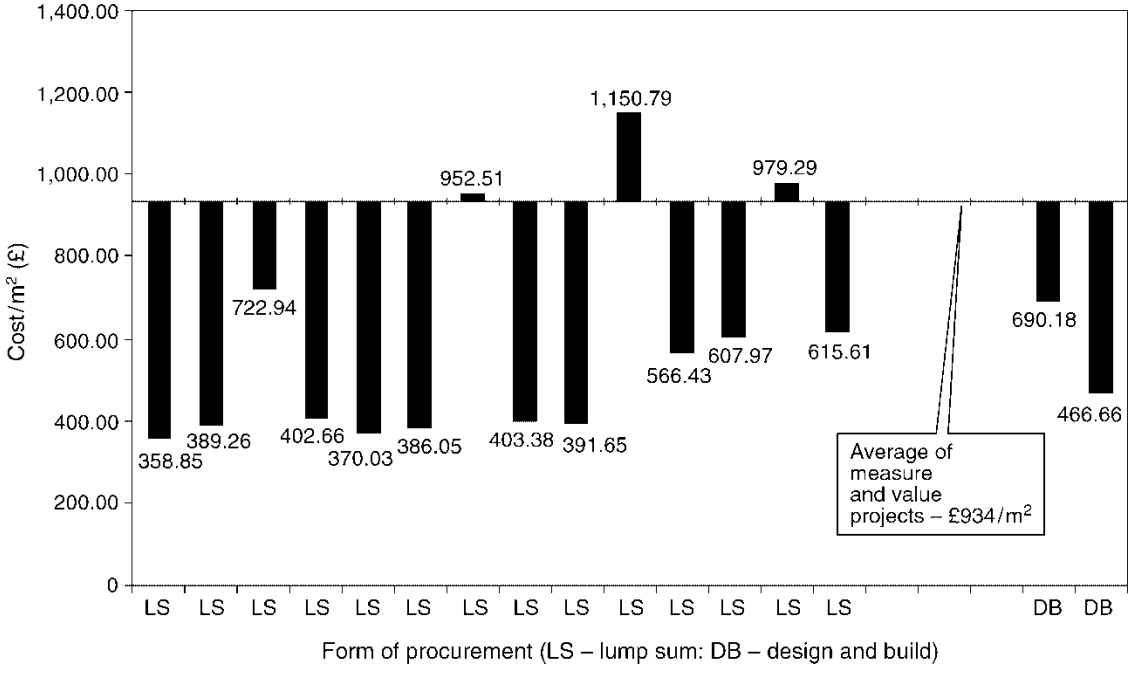

Figure 4 Major structures – in-situ concrete: ATI cost/m² v. average measure value cost/m² (index adjusted)

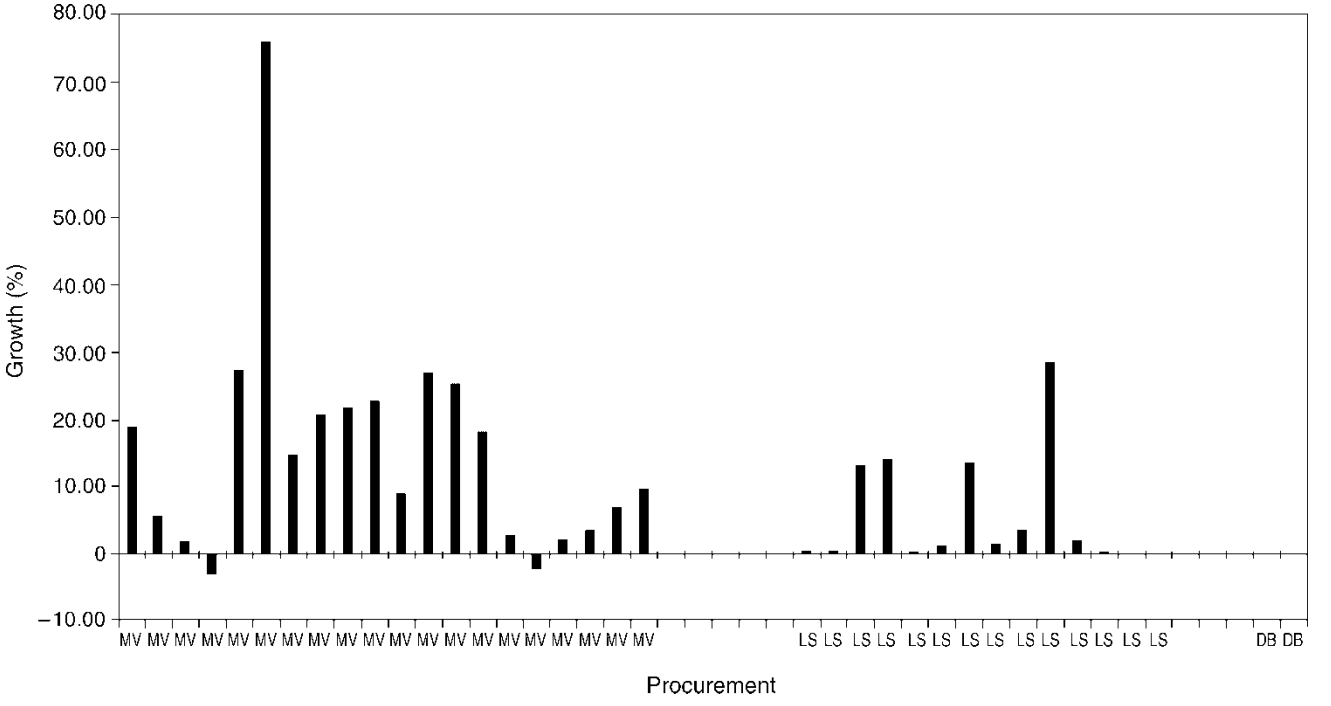

Figure 5 Percentage growth – tender to outturn cost/m^2 (major structures: in-situ concrete)

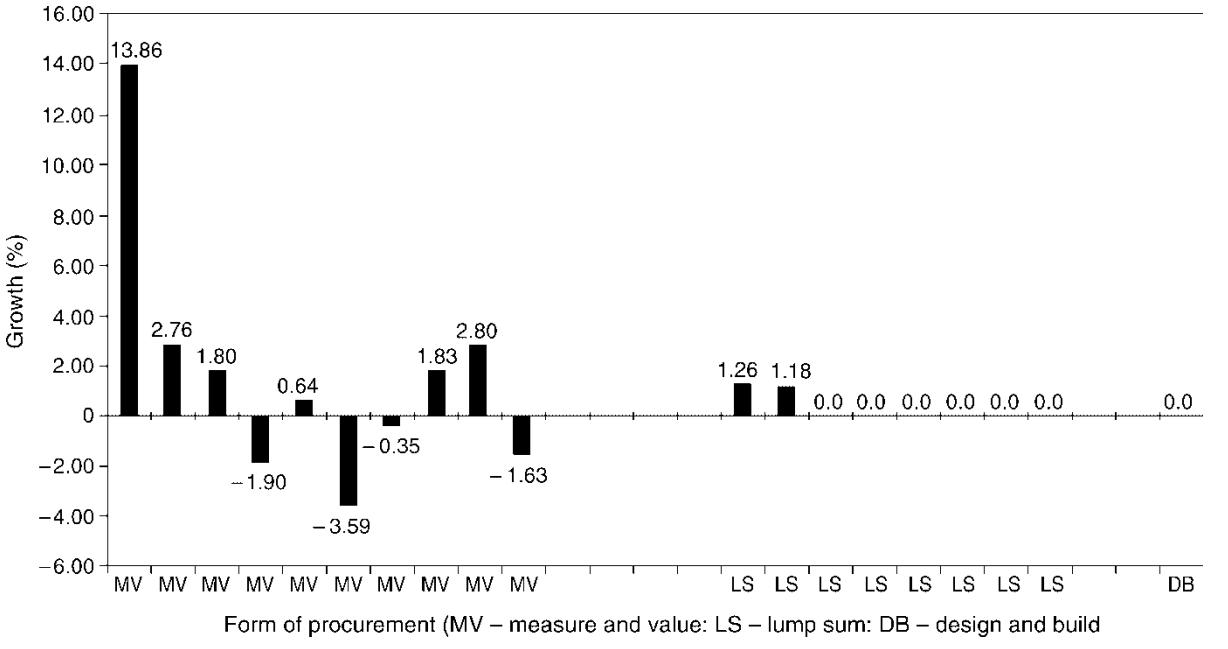

Figure 6 Percentage growth – tender to outturn cost/m^2 (major structures: pre-cast concrete)

terrain, 'in-line' working, etc. were similar. Clearly due to the competitive nature of the bidding process the identity of the contractor could not be predicted in advance.

In launching the Alternative Tendering Initiative it was noted (Innes, 1996) that contractors had enthusiastically embraced innovations which helped them to improve their own performance. Moreover, where contractors could demonstrate better performance then this should be recognized in the tender sum. The most common option used in the Alternative Tender Initiative was a conforming tender and tenderer's own time and fixed price ATI for the whole of the works.

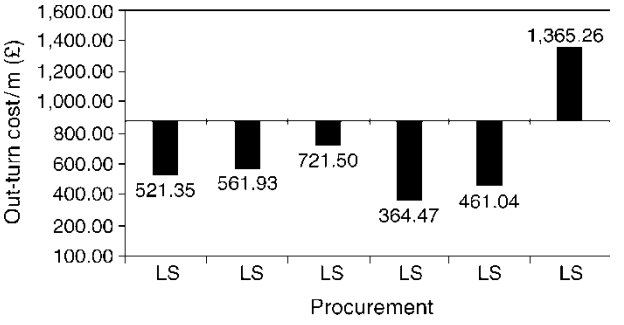

Figure 7 Minor structures – corrugated steel culverts: average measure value cost/m v. ATI cost/m (index adjusted)

The research has demonstrated that where the ATI is applied then cost savings are enjoyed. In terms of the roadworks part of the projects, some £122 092 per km is saved. This figure, whilst not statistically significant, is sufficiently attractive to public sector clients who are continually under pressure to deliver projects which are verifiably delivering value for money. Perhaps of greater significance is the cost certainty that ATI methods deliver.

Careful examination of the results show that in areas where uncertainty is high (Preliminaries, Roadworks, Communications and to some extent Statutory Bodies) the initial bid is high and the cost inflation is also high. The pattern of risk assessment shown by the contractors is remarkable consistent. In the areas of the Measure and Value projects which were subject to variation they all tended to increase (albeit by differing amounts) and on the rare occasions where the outturn costs were less than the original bids (e.g. Side Roads) four out the five contractors followed the same pattern. The deviating contractor (project K) in this case was also out of step on the bidding of Preliminaries where it was the only contractor to experience a reduction on its outturn cost. It is reasonable to conclude that contractors, experienced in the traditional Measure and Value system, would be able to predict those areas likely to be increased and to 'load' their bids accordingly. It can also be observed that in areas where the risk of variation to the work to be carried out is low (pavements, etc.) the average costs are not significantly differentiated as are the extents of cost inflation.

With respect to structures, the average cost of major structures and to a lesser extent the minor structures was lower on the ATI projects and that the variability on the tender to outturn costs was very much reduced. Discussions with contractors suggests that one reason for this was the freedom given to the contractors to design and construct these structures to suit formwork techniques with which they were expert rather than being constrained by an external consultant's design.

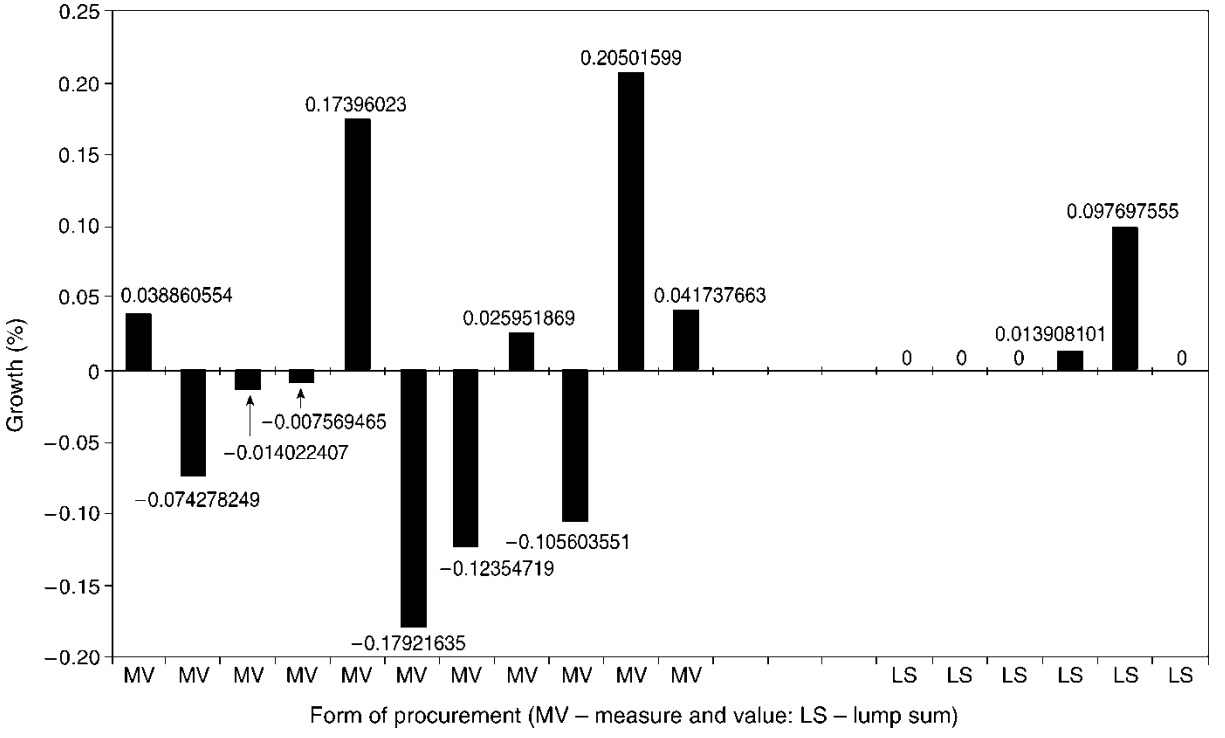

Figure 8 Percentage growth – tender to outturn cost/m (minor structures – culverts)

The research suggests that where motorway projects comprise carriageway and structures then the use of ATI contracts is more cost effective than the Measure and Value method and carries with it higher degrees of cost certainty.

Other benefits may also be observed. Innes (1996) pointed out that cost saving is only one objective for the responsible client. Others will focus upon reducing the confrontation between the parties to the contract; early engagement of the contractor's skills and providing them with incentives would be secondary but nonetheless important criteria in evaluating project success. The contractors record that these have been achieved and this was confirmed by discussions held with the principal actors during the research project. This evidence is largely anecdotal but nonetheless the objectives of the research are believed to have been achieved.

Other savings may also be observed but as yet have not been quantified. For the client the costs of close supervision necessary on the Measure and Value projects were reduced by the engagement of more autonomous and self-reliant contractors. For the contractor, the need for large numbers of surveyors to measure and remeasure the work was reduced and so a portion of overheads able to be removed.

Like most innovations the changes that are involved are sometimes uncomfortable and now more detached, and often reduced, roles have had to be learned by the client and the resident engineers. For contractors' staff there is a need to manage more fully the direction of the works – the role may be moved from 'construction contractor' to a more professional role of 'the client's construction expert'. Of course it may be premature to sound such good tidings, not every project lends itself to the fixed price approach. Where risks may be best carried by the client, the traditional approach may deliver better cost performance.

Some projects will just carry too much risk for a contractor to be comfortable about handling it and as yet data on life cycle costs of the two approaches are not available. However the work undertaken in this research project provides some convincing evidence of the benefits of the ATI.

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