FACTORS INFLUENCING THE SELECTION OF DELAY ANALYSIS METHODOLOGIES

Abstract

Delays and disruption to contractors' progress are a major source of claims and disputes in the construction industry. Often at the heart of the matter in dispute is the question of the extent of each contracting party's responsibility for the project delay. Various delay analysis methodologies have been developed over the years as aids to answering this question. This paper reports on a study into the factors that influence analysts' selection from these methodologies. Eighteen factors were identified through literature review and pilot surveys and then ranked on their relative importance based on data collected in a nation-wide survey of UK construction organisations. Factor analysis was used to reduce the factors into 6 group factors: project characteristics, contractual requirements, characteristics of baseline programme, cost proportionality, timing of the analysis and record availability.

Keywords: claims; delay and disruption; extension of time; programming; delay analysis

INTRODUCTION

Delays and disruptions to contractors' progress are a major source of claims and disputes in the construction industry [1, 2, 3, 4]. The matters often in dispute concern the dichotomy in responsibility for delays (project owner or his contractors) partly because of the multifarious nature of the potential sources of delays and disruption.

With increased project complexity and requirements coupled with multiple parties all subject to their performance exigencies, the resolution of such claims and disputes has become a matter of the greatest difficulty [5, 6, 7].

To overcome this difficulty, parties to claims often resort to a wide range of delay analysis techniques [8, 9, 10] for proving or disproving the claims either in the course of the project or after completion under arbitration or some other forms of dispute resolution mechanism. Such a technique is referred to in this paper as "Delay Analysis Methodology" (DAM). Although the applications of these methodologies are analytical in nature, their use is often attended by considerable acrimony not only because of the nature of differences in their inherent approaches, they produce results of staggeringly different levels of accuracy [9, 11, 12], but also because of differences in the way individual analysts deal with the issues often in dispute [13, 14].

The appropriateness of the methodology applied in producing a delay claim is therefore often hotly contested. For example, in *Balfour Beatty Construction Ltd v The Mayor and Burgesses of the London Borough of Lambeth* (2002 1 BLR 288), the defendant challenged the adjudicator's decision in court for, among others, not having given any opportunity to the parties to comment on the appropriateness of the methodology which the adjudicator had adopted in determining extensions of time and to seek their observations as to its use. His Honour Judge Humphrey Lloyd QC stated that the adjudicator ought to have informed either party of the methodology that he intended to adopt and sought their observations on that methodology and refused to enforce the adjudicator's decision. The factors that influence the selection of the appropriate methodologies are therefore a matter of the greatest importance.

Notwithstanding this, the UK courts have not generally gone into any great depth as to what method of proof is acceptable in particular circumstances or, when a method of analysis has not been accepted, the reasons for its rejection [15].

A review of the delay analysis literature disclosed only three major initiatives aimed at developing knowledge and understanding of the way analysts should select from existing DAMs for any given delay problem. Based on a case study, Bubshait and Cuningham [11] assessed the reliability of three of the existing methods and came to the conclusion that none of the methods is perfect and that the best method should be chosen based on the time and resources available and the accessibility of project documentation. In a survey by Harris and Scott [16] on how UK professionals deal with claims, respondents were generally unwilling to indicate their preference to four existing DAMs, with the reason that their choice would be dictated by the conditions of the claims at hand. The study, however did not investigate the conditions that they consider important in this respect. A more recent empirical work is the debate dubbed "Great Delay Analysis Debate" [17], organised by the UK's Society of Construction Law (SCL). It involved four participants each speaking in favour of one of the four common methodologies with reference to a hypothetical construction scenario. Voting was subsequently carried out as to the most appropriate methodology that should be applied to the assumed facts. The result was that there was no consensus reached as to the correct method, with votes splitting into four significant minorities.

Recognising that no single methodology is universally acceptable for any given claim situation, the SCL's protocol [10] has identified a number of factors that analysts should look out for in considering a method. These are: the relevant conditions of contract; the nature of the causative events; the value of the dispute; the time available; the records available; the programme information available and the programmer's skill level and familiarity with the project. Similar factors have also been reviewed recently by Arditi and Pattanakitchamroon [18]. However, the limitation with this approach is that not only does the list appear inexhaustive; it does not go any further to give their relative importance when evaluating the appropriateness of DAM.

It was concluded from the review of the literature that knowledge and understanding developed from the surveyed initiatives need to be extended by a wider empirical study into how those responsible for compiling delay claims make selections from the existing methodologies. This paper reports on such a study, as part of the authors' current research work. It is organised in sections covering: (i) an overview of common DAMs; (ii) study methodology; (iii) discussion of findings of the study; (iv) conclusions.

AN OVERVIEW OF COMMON DAMs

The task of investigating the events that led to project delay for the purpose of determining the financial responsibilities of the contracting parties arising from the delay is referred to as "Delay Analysis" (DA). Various DAMs are available for undertaking DA but the methodologies frequently commented upon in the literature are:

- As-Planned vrs. As-Built
- Impacted As-Planned
- Collapsed As-Built
- Window Analysis

- Time Impact Analysis.

As-planned vrs. As built

This methodology simply compares the activities of the original CPM baseline programme with those of the as-built programme for detailed assessment of the delays that occurred. The main advantages of this methodology are that: it is inexpensive, simple and easy to use or understand [19]. Its limitations include failure to consider changes in the critical path and inability to deal with concurrent delays and other complex delay situations.

Impacted As-Planned

This methodology involves incorporating delays encountered as activities into as-planned CPM schedule to demonstrate how project completion date is being delayed by those delays. The amount of project delay due to each delaying event is the difference between the schedules completion dates before and after the addition [8, 15]. Although this methodology does not need as-built information to operate, it has major drawbacks such as failure to consider any changes in the critical path and the assumption that the planned construction sequence remains valid.

Collapsed As-Built

This methodology first creates an as-built CPM schedule including all the delays encountered. Delays are then removed from the schedule to create a 'collapsed' as-built schedule, which indicates how the project would have progressed but for those delays. The advantage with this approach includes producing results of good accuracy

[19]. Its limitations, however, include: ignoring any changes in the critical path and the great deal of effort required in identifying the as-built critical path [20].

Window Analysis

In this methodology, the total project duration as given by as-built CPM schedule is first divided into a number of time periods. These periods are updated chronologically using as-built information including all delays encountered. The difference between project completion dates resulting from any time period under review and that prior to the review gives the project delay that occurred during that period. The main strength of this methodology is its ability to take care of the dynamic nature of the critical path. However, it is usually more expensive due to the amount of time and effort needed to perform it [20].

Time Impact Analysis

This methodology is a variant of the window technique described above, except that in this, the analyst concentrates on a specific delay or delaying event not on time periods containing delays or delaying events [9]. The approach evaluates the effects of delays chronologically by incorporating each (sometimes using a 'fragnet' or subnetworks) into an updated CPM baseline programme that represents the actual status of the project before the advent of the delay. This approach has significant merit making it probably the most reliable technique [10]. However, it is time consuming and costly to operate, particularly in situations where large number of delaying events are involved.

STUDY METHODOLOGY

The design of a research is largely determine by the nature of the research topic, its aims and objectives and the resources available [21, 22]. This criterion largely informed the methodology adopted in carrying out the authors' current research, part of which is reported in this paper.

The multiplicity of the research's aims and objectives, coupled with the diversity in types and sources of data to be collected, suggested a mixed methods research design as typically described by Tashakorri and Teddlie [23] as the most appropriate methodology to adopt. This involved the collection of data at two different stages. A quantitative research strategy involving the use of a cross-sectional survey was adopted in the first stage to explore current delay and disruption analysis practice, followed by an in-depth qualitative investigation of issues informed by the survey. A major factor that influenced the choice of the survey strategy was the large and diverse nature of the research population as delay claims are prevalent in different forms and in many different types of organizations across the UK. According to Rea and Parker [24], there is no better method of research than a survey for collecting information about large populations. The survey research strategy also makes it possible to generalize the results to the research population while enabling comparisons between target groups to be made [25]. In this study, differences in experiences and attitudes within and across contractors, owners and their Architects/Engineers were of particular interest.

There are two primary modes of obtaining survey data [24, 21]: (1) sending a questionnaire out by post, fax or internet for the respondents to self-administer; (2)

using an interviewer to administer the questionnaire either by face to face or telephone interviews. In the light of the time and resource constraints within which the research had to be completed, the second option was eliminated as inappropriate as it requires more time and cost to conduct. Considering the first option, fax and internet were discarded on account of their poor response rate [24, 25] leaving postal questionnaire survey as the most appropriate. The limitations of this approach were overcome by designing the questionnaire in line with best practice advocated in the literature, for example, by Rea and Parker [24] and Creswell [22].

Questionnaire design

The first stage in the questionnaire design process was an extensive review of the relevant literature. The questionnaire covered a wide range of issues with regard to delay analysis practice but this paper mainly documents the factors influencing the selection of DAM and their relative importance. The part of the questionnaire aimed at collecting feedback from practitioners on these factors required respondents to score, on a 5-point Likert scale (1 for “not important” and 5 for “very important”) the listed factors on their degree of importance in their decision-making as to the appropriate methodology to adopt in any given situation. Provision was also made for respondents to add and rate any other factor (s) they considered important. By this provision, the list of factors was extended to a total of 18 in a pilot survey of acknowledged DA experts in the UK and the US. Table 1 shows this list together with their brief descriptions provided as part of the questionnaire for purposes of clarity of interpretation of the factors.

[Insert table 1 about here]

Sampling

The absence of a specific sampling frame for construction firms with experience of delay claims dictated use of non-probability sampling techniques. The Kompass Register [28], NCE Consultants' file [29], and 2002 RICS Directory [30], which together lists in excess of 5000 providers of construction products and services in the UK, were the starting point of sampling. A sampling frame of 2000 of these organisations of different sizes was compiled and then divided into the six geographical regions of the UK (North East, North West, South East, South West, Midlands and Scotland). Using a combination of quota and purposive sampling as described typically by Patton [31] and Barnet [32], 600 construction organisations (300 contractors and 300 consultants) were selected based on a need to ensure that the outcomes are nationally applicable.

The questionnaires were addressed to the managing directors of the selected firms with an accompanying cover letter, explaining the purpose of the survey and requesting that senior staff members responsible for claims preparation or assessment be encouraged to complete it.

Data analysis

It was found appropriate to analyse the data using non-parametric statistics involving frequencies, relative important index analysis, Kendall's Concordance test and Chi-square because the data was measured at ordinal level. Parametric statistics are unsuitable for such data, unless precarious and, perhaps, unrealistic assumptions are made about the underlying distributions [33].

With the help of Statistical Package for the Social Sciences (SPSS), Equation (1) was used to compute the relative importance index (RI) of each selection factor. This facilitated their ranking with respect to contractors, consultants, and the overall (see Table 6).

$$\mathrm{RI} = \left[\sum_{i=1}^{i=5} w_i f_i\right] \times \frac{100\%}{n} \qquad \text{------------------------------} \qquad (1),$$

where f_i is the frequency of response; w_i is the weight for each rating (given by rating in scale divided by number of points in the scale which is 5); and n is the total number of responses.

The degree of agreement (or consensus) between the two groups in their ranking was investigated using Kendall's coefficient of concordance (W) as defined by Equation (2) [33].

$$W = \frac{12 \times s}{k^2\left(N^3 - N\right)} \qquad \text{----------------------------------} \qquad (2),$$

where s is the sum of square of deviations of ranking sum of the factors from the mean, k is the number of respondent groups, which is 2 in this case and N is the number of factors ranked. The significance of W was tested using a chi-square approximation of the sampling distribution given by Equation (3) with N-1 degrees of freedom [33].

$$\chi^2 = k(N-1)W \quad \text{--------------------------------------} \quad (3)$$

Finally, factor analysis was used to investigate the underlying features interrelating the selection factors for the purpose of reducing the 18 factors into manageable groups, as a preliminary step towards future development of a model for aiding practitioners on DAM selection. Only brief description of the analysis is presented here, as many of the target readers are likely to be practitioners. Readers interested in further details may consult various texts such as the works of Kim and Mueller [34] and Field [35]. The appropriateness of using factor analysis was first confirmed by a number of tests including Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett test of sphericity. Principal component analysis was then employed to extract six group factors with eigenvalues greater than 1, suppressing all other factors with eigenvalues less than 1 based on Kaiser's criterion [35]. To clarify the factor pattern so as to ensure that each variable loads high on one group factor and very minimal on all other group factors, the variables were 'rotated' using varimax orthogonal rotation method.

DISCUSSION OF FINDINGS

Characteristics of the respondents and their organisations

A total of 156 questionnaires were returned of which only 130 (63 Contractors and 67 consultants) were properly completed that could be used for analysis; the other 26 respondents either stated that it was company policy to decline to respond to surveys or have little experience in delay claims analysis. This represents a response rate of 21% and 22% respectively for construction and consulting firms, which is within the expected range of 20-40%, typical of similar surveys [36].

Tables 2 and 3 show the distribution profile of respondents' organisations in terms of type and size and their designations for construction and consulting firms respectively. The size of the organisations is based on their annual turnovers. Whilst this shows that the survey covered a wide spectrum of construction organisations, the distribution of the responses was not uniform. Over 60% of the construction firms had annual turnover of over £26million (i.e. majority were medium to large construction contractors). An opposite profile was observed in the consulting firms.

[Table 2 about here]

[Table 3 about here]

The designation of the respondents covers a wide variety of professions with involvement in DA. Majority of them have been acting as Commercial Managers or Quantity Surveyors for employers and contractors with some occupying senior management positions. Table 4 shows their experiences with regard to a number of relevant functions. As can be seen, the average experience on claims preparation /assessments is the highest (over 16 years). This suggests that most of the respondents have been dealing with claims for considerable number of years and thus were ideally suited to comment on the issues dealt with in the survey. The average years of experience of measurement was higher than planning and programming and site management, reflecting the fact that the largest category of respondents was made up quantity surveyors or commercial managers by profession.

[Table 4 about here]

[Table 5 about here]

Relative importance of factors influencing DAMs selection

Table 6 shows the rankings of the factors relative to their importance in influencing the selection of DAM. The overall results demonstrate that “record availability” ranks first followed by “baseline programme availability”, while at the bottom comes “the other party to the claim” and “applicable legislation”. The ranking of record availability as the most important factor was not unexpected because irrespective of the method adopted, analysts will have to depend on it for the analysis, although the amount of records required varies for the various DAMs. A claimant or defendant will have a difficult time proving the standing of his or her case if documentary evidence is lacking [37, 38]. Factors relating to the contract programme were generally ranked high by the groups and overall, suggesting that programmes have relatively high degree of influence on the method selected for DA. This was not surprising as programmes are now recognised as the main vehicle for analysing delays [39, 40, 26]. A remarkable observation is the high ranking of “The amount in dispute” as 4^{th}, 5^{th} and 3^{rd} by contractors, consultants and overall respectively. The possible reason for this is the fact that analysing delay claims can be costly and time-consuming process particularly when using methods such as Time impact analysis and Window analysis [9, 19]. This makes it necessary to consider the value of the claims in dispute in relation to the cost involved in resolving it to ensure the selection of a cost effective methodology.

Consultants ranked skills of the analyst 4th while contractors ranked it 10th, suggesting that contractors attach relatively less importance to analysts skills' level in choosing a method. Considering that lack of appropriate skills would lead to results likely to be challenged, the relatively low ranking by contractors is surprising and needs further investigation. On the other hand, the high levels of disputes associated with delay may be a reflection of insufficient appreciation by contractors of the importance of delay analysis skills.

[Table 6 about here]

There was a strong consensus among contractors and consultants in their rankings (W= 0.93) and this was statistically significant at 95% confidence level.

Application of factor analysis to the selection factors

The factor analysis extracted 6 group factors. The proportion of variance explained by these factors was 69.18% i.e. percentage of the common variance shared by all the 18 selection factors that is accounted for by the 6 factors. The group factors were appraised to identify the underlying features that the constituent selection factors have in common. This resulted in the construction of the six group factors as follows:

- group factor 1-project characteristics;

- group factor 2- requirements of the contract;
- group factor 3-characteristics of baseline programme;
- group factor 4-cost proportionality;
- group factor 5-timing of analysis; and
- group factor 6-record availability.

Group factor 1: project characteristics

This group factor accounts for 26.5% of the variance and is made up of complexity of the project, the amount in dispute, size of the project, duration of the project, nature of delaying events, number of delaying events and the other party to the claim. The loading together of these factors Was not surprising as theliterature also suggests that they are related. In research by Bennet and Fine [41], complexity of a project activity was viewed as the nature of the combinations of a number of operations involved in the activity or the incidence of roles requiring different kinds of work identified as work packages. These operations are often innovative and conducted in an uncertain or not clearly defined situation [42]. Gidado [43] also identified overlap of phases or concurrency of activities as a component of project complexity.

The identified characteristics of project often impact on the nature of the delays encountered (e.g. serial or concurrent of delays), thereby necessitating the use of certain DAMs to a greater extent than others. Methods involving the use of bar charts are unable to show critical paths, interrelationships and interdependencies between activities and therefore are not suitable for proving delays where changes in the construction logic were experienced and the effects of the delay were not restricted to clearly definable activities [15]. Although methods such as As-Planned vrs As-Built and Collapsed As-Built utilise CPM techniques, they are unable to take into account concurrent delays and any changes in the critical path schedule during the course of the project [9]. These limitations make them unsuitable for delay situations where re-sequencing and acceleration took place in the course of the project.

Group factor 2: contractual requirements

Contractual requirements grouping accounted for 11.7% of the variance and comprised availability of an updated programme, applicable legislation, form of contract and dispute resolution forum. These factors relate to the provisions or requirements of the project contract and can influence the methodology that should be used to analyse delays. For instance, contract clauses relating to programming and progress control requirements may have a bearing on the availability of contract programmes and its updates, which in turn facilitate the use of certain DAM to a greater extent than others. Furthermore, standard forms provisions in respect of providing relief from liquidated damages for employer risk events tend to fall into two main categories, which can influence the choice of DAM [10]. The first category provides that contractors are only entitled to relief (in the form of extension of time) for events that actually cause delay to completion. Under this category, methods that seek to produce actual project delay such as the Collapsed As-Built and As-Planned vrs As-Built may be suitable to use. For the second category, relief are to be granted for the likely effect of the events for the purpose of providing the contractor with a rough but realistic completion date pending final review. In this case, Impacted as Planned or Time Impact Analysis may be appropriate [10].

Group factor 3: characteristics of baseline programme

This group factor is made up of availability of baseline programme and the nature of the baseline programme and accounts for 9.3% of the variance in the selection factors. The baseline programme may not always be available or exist in CPM format, making certain methodologies more appropriate to use than others.

In the absence of an As-Planned programme or where significant part of it lacks sufficient detail, methodologies, which rely heavily on this programme cannot be readily used. In such a situation DAMs based much on As-Built programme may be more suitable. Although the As-Planned programme can be created or corrected retrospectively for the analysis, this hindsight development could easily be challenged on grounds of bias or unreliability [8].

Group factor 4: cost proportionality

This groupfactor includes cost of using the DAM and the skills of the analyst and account for 8.4% of the variance. It is noteworthy that the level of skills required in the application of the methods can influence the expense involved. For example, analysing complex delay claims often require the use of powerful planning software packages which have functionalities and specialist features to facilitate the analysis [26, 44]. These packages are however, known to be relatively expensive, difficult to use, and require considerable effort in maintenance and amendments [45, 46].

A major source of the cost is the carrying out of some form of thorough CPM analysis using the contract programme. In the absence of a reliable programme, retrospective reconstruction of CPM As-Built from project records may be required which is a highly laborious task requiring considerable levels of skills and experience. Although such analyses are costly, they tend to give more accurate results. However, in a situation where the claim values are small compared to the cost involved in using a particular DAM, it may be appropriate to use a simple and less costly methodology for the analysis [15].

Group factor 5: Timing of the analysis

This group factor grouping accounts for 6.8% of the variance in the selection factors and comprises the reason for the analysis and time of the delay. The purposes for analysing delay claims are many including: the resolution of matters concerning extension of time, prolongation cost, acceleration and disruption [39]. These require different nature of proof because of their different requirements. For instance, the effect of disruption is often delay to progress or productivity loss and would only cause delay in completion if the impacted activities lie on the contractor's critical path. As a result methods utilising CPM should be considered when claiming for extensions of time for employer-caused disruptions. Concerning claims for reimbursement of loss or expense, the claimant should be able to prove the actual cost suffered, which warrants an approach based on what actually occurred on the project [47].

The time of the delay refers to the time of its occurrence relative to the stage of the project. In this respect, DA is carried out either prospectively or retrospectively of the delay occurrence. The former refers to analysing delays at its inception for the determination of their theoretical or likely impact on the programme. This is best undertaken using methodologies that largely do not require actual project data for their implementation such as the Impacted As-Planned method. Retrospective analysis, on the other hand refers to delays assessment after their occurrence or after the project is completed and methodologies such as Collapsed As-Built would be suitable as they are able to show what actually occurred.

The loading of reason for the analysis and time of the delay together under one group suggests that they are related. For instance, while extensions of time can be assessed prospectively it may not be appropriate to assess prolongation cost in this manner because many of the standard forms of contract require recoverable prolongation costs to be ascertained and not just estimated. Indeed, the SCL's Protocol [10] emphasised that: ……'compensation for prolongation should not be paid for anything other than work actually done, time actually taken up or loss and/or expense actually suffered…'

Group factor 6: Record availability

Record availability factor is the only selection factor in this group and accounts for 6.5% of the variance in the selection factors. The sources of information that are useful in DA includes contract documents, letters, minutes of meetings, notes, material receipts, supervision and inspection reports, resource data and costs, daily reports, extra work order, photographs, project schedules, and cost reports of a project [15]. The extent of availability and reliability of these records may influence the methodology to be used, with less project information necessitating the use of the less sophisticated DAMs and vice versa [19]. The more reliable methodologies such as Window Analysis or Time Impact Analysis require the availability of more project information to operate and thus would produce less accurate results when important information is lacking.

SUMMARY AND CONCLUSIONS

Parties to construction contract claims often resort to a wide range of DAMs to investigate events that led to project delay for the purpose of determining the financial responsibilities of the contracting parties arising from the delay. The existing methodologies have varying degrees of capabilities in producing accurate results, thus making the question of appropriateness of DAM in any given circumstances an often highly contested issue. Review of the literature suggests that the appropriate methodology should be dictated by circumstances surrounding the claim situation. The knowledge and understanding of these factors as to their relative importance is imperative in deciding on a methodology by the claims parties before proceeding with the DA as recommended by the SCL protocol. However, existing literature on DA does seldom go beyond the mere mentioning of these factors, with very little empirical basis for the assertions.

This paper reports on an empirical a study based a survey of UK construction and consulting organisations. Initial analysis of the results shows that the top six factors influencing the selection of DAM are records availability, baseline programme availability, the amount in dispute, nature of baseline programme, updated programme availability, and the number of delaying events. There was a strong consensus, at 95% confidence level, among contractors and consultants in their rankings of the factors. As a preliminary step towards future development of a model to aid practitioners on DAM selection, factor analysis was used to reduce the factors into 6 group factors by determining the underlying features interrelating the selection factors. These group factors (in order of importance) are project characteristics, contractual requirements, characteristics of baseline programme, cost proportionality, timing of the analysis and record availability.

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Table 1 Factors influencing the selection of DAM

	Source literature							
Factor	Leary and Bramble [13]	Colin and Retik [24]	Finke [25]	Bubshait and Cunningham [11]	Bramble and Callahan [7]	SCL [10]	Pickavance [15]	**Brief description of factors- as a determining factor in selecting a method**
Records availability	✓	✓	✓	✓	✓	✓	✓	Accessibility of project information/data (save the baseline programme and its updates)
Baseline programme availability	✓			✓		✓	✓	Accessibility of project baseline programme
Nature of baseline programme				✓	✓	✓	✓	The format of the baseline programme (bar chart, CPM etc) and its quality
Updated programme availability				✓	✓	✓	✓	Accessibility of regular programme updates
Time of the delay*								The instance of the delay occurrence relative to the stage of the project
Reason for the delay analysis	✓	✓					✓	The purpose of doing the analysis (e.g.proving time extensions, compensation cost, etc)
The other party to the claim*								The attitude/behaviour of the opposing party to the claims
Applicable legislation		✓						The existing laws of the contract that tend to affect the legal aspects of delay analysis
The form of contract		✓	✓			✓	✓	The contract form used whose requirements tend to affect the analysis
Cost of using the technique	✓			✓		✓	✓	The expense involved in implementing the method
Size of project*								The scale of the project in terms of cost
Duration of the project*								The time length of the project

Table 1 cont'd

Factor	Source literature: Leary and Bramble [13]	Colin and Retik [24]	Finke [25]	Bubshait and Cunningham [11]	Bramble and Callahan [7]	SCL [10]	Pickavance [15]	Brief description of factors- as a determining factor in selecting a method
Complexity of the project*								The amount of overlap and interdependency of the construction activities
Nature of the delaying events	✓				✓	✓		Characteristics of the delay events such as their source, length and their interrelation with other delays (e.g. concurrency)
Skills of the analyst	✓				✓	✓		The expertise level of the person to carry out the analysis
The amount in dispute	✓					✓		The value of the claims in dispute.
Dispute resolution forum*								The mechanisms or method adopted for resolving the claims
The number of delaying events			✓		✓			The amount of delay events in the analysis

*Factors obtained from pilot survey.

Table 2 Construction organisations

Type of organisation	Percent*	Annual Turnover (£m)	Percent*	Designation	Percent*
Building contracting	27.0	<5	7.9	Planning Engineer	15.9
Building and Civil Engineering	39.7	5 - 25	25.4	Commercial Manager /Quantity Surveyor	50.8
Civil Engineering contracting	33.3	26 - 100	30.2	Project/Site manager	9.5
		>100	36.5	External Claims consultant	6.3
				Managing Director	11.1
				Contracts Director	6.3

* of the total response from construction firms

Table 3 Consulting organisations

Type of organisation	Percent*	Annual Turnover (£m)	Percent*	Designation	Percent*
Firm of Architects	9.0	<5	43.3	Planning Engineer	3.0
Firm of Engineers	14.9	5 - 25	32.8	Project Quantity Surveyor	35.8
Firm of Quantity Surveyors	41.8	26 - 100	9.0	Project Architect/ Engineer	25.4
Firm of claims consultants	34.3	>100	14.9	External Claims consultant	29.8
				Managing Director/ Partner	6.0

* of the total response from consulting firms

Table 4 Experience of respondents from construction organisations.

Function	Years of experience						Mean years	Std. dev
	0	1-5	6-10	11-20	21-30	>30		
Estimating	12	22	16	5	5	3	8.0	9.3
Planning and Programming	12	12	20	9	8	2	9.7	9.2
Site Management	11	10	22	8	8	4	10.7	10.1
Measurement	9	17	6	11	13	7	13.4	11.9
Claims preparations	0	7	12	24	15	5	16.6	9.1
Contacts Management /Legal support	8	4	10	23	10	8	15.6	10.7

Table 5 Experience of respondents from consulting organisations

Function	Years of experience						Mean	
	0	1-5	6-10	11-20	21-30	>30	years	Std. dev
Estimating	14	17	17	9	5	5	9.4	10.2
Planning and Programming	7	21	18	12	5	4	9.9	9.4
Site Management	19	22	18	4	3	1	5.7	7.1
Measurement	15	10	15	14	5	8	11.6	11.3
Claims preparations/ assessments	4	9	12	19	14	9	16.3	10.4
Contacts Management /Legal support	4	7	9	25	15	7	16.5	9.4

Table 6 Relative importance of DAM selection factors

Selection Factor	Contractors		Consultants		Overall	
	Important index	Rank	Important index	Rank	Important index	Rank
Records availability	99.7	1	95.5	1	97.5	1
Baseline programme availability	85.4	2	83.1	2	84.1	2
Nature of baseline programme	73.3	3	69.8	6	71.5	4
Updated programme availability	64.7	5	76.7	3	69.8	5
Time of the delay	58.4	11	65.4	11	62.0	14
Reason for the delay analysis	60.6	9	67.2	8	61.8	10
The other party to the claim	47.1	15	42.5	18	44.7	17
Applicable legislation	38.7	17	53.7	16	36.5	18
Type of contract	50.7	13	67.2	8	59.2	11
Cost of using the technique	52.4	12	63.3	13	58.0	12
Size of project	42.3	16	59.1	14	50.9	15
Duration of the project	37.5	18	52.2	17	45.1	16
Complexity of the project	64.7	6	66.9	10	65.8	7
Nature of the delaying events	64.4	7	64.7	12	64.6	9
Skills of the analyst	54.0	10	76.1	4	65.3	8
The amount in dispute	71.5	4	74.7	5	73.1	3
Dispute resolution forum	50.5	14	58.3	15	54.4	13
The number of delaying events	64.4	8	67.7	7	66.1	6

Test Statistics

Kendall's W = 0.93

$\chi^2_{critical}$ = 27.59 (α=0.05); df = 17; χ^2_{sample} = 31.7