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Article

Approaches to Delay Claims Assessment Employed in the UK Construction Industry

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Abstract: Construction project delays emanates from multiplicity of different sources of risk events. This, combined with high uncertainty in cause-effect relationships between the events and their impacts on project completion dates, have created immense difficulties in apportioning project delay responsibilities amongst contracting parties. This challenge is now dealt with by various delay analysis approaches, yet delay claims settlement continues to be a troublesome undertaking. Empirical research on these approaches as to their application in practice is limited, although such studies provide important reference sources to practitioners and researchers. As a contribution to addressing this gap, this paper reports on practitioners' views on the approaches based on a UK nation-wide questionnaire survey of construction and consulting companies. The key findings of the study include: (1) delay claims are often resolved late and not close in time of occurrence of the delay events, creating more difficulties; (2) simplistic delay analysis approaches are widely used in practice and form the basis of successful claim resolutions, although they have major weaknesses; (3) the sophisticated approaches, although are more robust, are generally not popular in practice. To promote the use of these reliable approaches and help reduce or avoid disputes amongst claims parties, programming and record keeping practices must be improved as they do not facilitate the use of the approaches.

Keywords: claims; delay and disruption; extensions of time; planning and programming

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1. Introduction

Construction and engineering projects commonly overrun their contractual completion dates [1], resulting in significant costs to all project parties [2,3]. To ensure equitable adjustment to contract price or time to perform the project, on account of project delays, contractors are often required to present delay claim submissions to project Employers (or their representatives, usually consulting Engineer or Architect) for subsequent assessment of the claims. However, as modern projects have become increasingly complex with multiple parties involvements, all subject to their own performance exigencies [1,2], so project delays have been generally caused by numerous events whose risks are borne by several parties [4,5]. In view of this complexity, it is often difficult to isolate the actual causes of delay suffered by a given project for purposes of deciding on the right amount of time and/or cost compensations amongst the parties, as typically required by most forms of construction contracts [4,6–8].

The need to address this challenge has generated considerable efforts from academic researchers and industry practitioners, aimed at enhancing smooth delay claims settlement to reduce the high level of disputes often associated with the resolution process. Most of the research studies so far have largely focused on addressing key issues relating to the improvement needs of delay analysis approaches. They include studies focusing on: resolving cases of concurrent delays [9–12]; accounting for migration of the critical path [13–18]; and dealing with the effects of acceleration [19], float ownership [20], productivity losses [21], and resource allocations [22]. Initiatives in the form of "good practice" documents for providing guidance to practitioners on, *inter alia*, the application of existing delay analysis approaches have also been developed. Two notable initiatives are the "Delay and Disruption Protocol" [7], developed by the UK's Society of Construction Law (SCL), and the "Recommended Practice on Forensic Schedule Analysis" by the Association for Advancement of Cost Engineering International [23] of the USA. These developments have brought about some sanity into the way delay claims are now resolved, including promoting (within the construction industry) a much clearer contract conditions regarding float ownership, concurrent delay and the determination of compensation for prolongation [24], than hitherto was the case [1]. However, despite the commended advice of the SCL protocol, many of its recommendations have not been embraced by the UK construction industry [25]. The reasons responsible for this are quite difficult to tell since there is very little empirical research reported on this issue, except the few mixed receptions some practitioners gave to the protocol (see for e.g., [26–29]). Recently, the seminal publication entitled, "Guide to Good Practice in the Management of Time in Complex", the first of its kind, published by the UK's Chartered Institute of Building (CIOB) [30], has also expressed disappointments at the poor take-up of the protocol's recommendations by the industry, noting that: "*…notwithstanding the obvious advantages* (with following the recommendations), *the industry did not take this message at heart. Contract drafting bodies ignored it…*".

In spite of the various contributions, delay and disruption claim resolutions continue to be plagued with more disputes than other heads of claims [3,5,7]. A major reason contributing to this unfortunate state of affairs is the fact that most UK construction contracts rarely specify the approach that contractors and project supervisors should use to analyze the claims [1,7,13]. Claim parties therefore usually adopt their own approaches to preparing or assessing delay claims, which are likely to be those

that are going to suit their respective positions or capable of casting their case in the best light. This practice has been a potential source of disputes, not only because the existing approaches tend to produce different results of varying levels of accuracy for any given claims situation [31–33], but also the fact that no industry-wide agreement exists on which approach is the most appropriate approach or otherwise [1,7,23]. Not surprisingly, the SCL protocol [7] strongly recommends that, if possible, contracting parties should agree on a common method, amongst the existing approaches, for the claims' analysis. Another example that highlights the crucial need for parties to rely on these approaches when substantiating or assessing delay claims is found in the recent Australian case court case of *Alstom Power Ltd* vs. *Yokogawa Australia Pty Ltd (No. 7) [2012] SASC 46*. The judge in this case rejected outright the claimant's novel resource-based approach used to prepare its delay claims, not on its merits, but rather because the approach is not mentioned in both the SCL protocol and the leading text on this subject [1], as one of the recognized acceptable approaches for delay analysis.

In view of the important role that existing delay analysis approaches play, a good knowledge and understanding of their use and practitioners' attitude towards them in practice are quite essential to promoting relevant recommendations for enhancing their efficacy and popularity in industry. To date, very limited empirical research on this aspect of the approaches has been undertaken. As an attempt to fill this gap, this paper reports on a study conducted to establish how construction practitioners involved with delay claims resolution perceive these approaches in practice. The study was based on a nation-wide questionnaire survey of construction organizations (contractors and consultants) in the UK.

The remainder of the paper is organized as follows. The next section presents a brief overview of the existing approaches and past research carried out on this subject, followed by a description of the research methodology adopted in carrying out the study. The following section following presents analyses of the results obtained and discussions. The final section presents the key conclusions drawn from the study and their implications.

2. Overview of Existing Approaches to Delay Analysis

The existing approaches for analyzing delays all seek to determine the impact that delay risk events experienced during the course of a project have on the contractual completion date of the project. They also share the common concept that delay is measured from project completion date rather than an interim activity's dates [1,31]. They, however, differ primarily on the type of programme used as the baseline or reference schedule (such as, the as-planned programme, as-built programme, and an updated programme) for measuring the amount of delays and also on the form in which the schedule was presented in [e.g., bar chart, critical path method (CPM), *etc*.].

The most common approaches (known by different names) and their brief application procedures as reported in the literature are presented in Table 1. The approaches have evolved over the years as the need for more effective methods for solving delay claims continue to grow. Other relevant details of the approaches such as their strength and weaknesses can be obtained from the cited references. Their application processes, as briefly enumerated in Table 1, sound simple to implement but in real life situations the running of delay analysis can, at best, be a difficult undertaking to pursue [1,8,14]. Instigated by this challenge and the need to address the various shortcomings of the approaches,

considerable research has been carried out over the years with the aim of improving the analysis and resolution of delay claims in practice. The research includes those briefly discussed in next section.

Table 1. Brief description of the approaches to delay analysis.

Delay analysis approach	Literature	Analysis procedure
Global Impact Method	[8,31,34]	• Plot all the delay events on bar chart, showing their start and finish dates; • Total project delay is determined as the sum total of durations of all the delaying events.
Net Impact Method (or Bar chart analysis, as-built bar chart)	[8,31,34]	• Plot all delay events on the project's as-built bar chart showing only the net effect of all the events; • Total project delay is then determined as the difference between the as planned completion date and the as-built completion date.
As-Planned vs. *As-Built* (or Impacted as-built CPM, adjusted as-built CPM)	[1,33,35,36]	• Depict delay events as activities and linked them to their respective activities in the project's as–built CPM schedule; • Determine the critical path for the as-planned CPM schedule and the as-built schedule; • The difference between the completion dates of these two schedules represents the amount of project delay incurred by the delaying events.
Impacted As-Planned (or what if, baseline adding impacts, as-planned CPM)	[1,7,8,35,36]	• Insert all delaying events into the as-planned CPM schedule in a chronological order; • The impact of each event, shown one at a time, demonstrates how project completion date is being delayed; • Project delay amount is the difference in completion dates between the schedules before and after each insertion.
Collapse As-Built (but-for, as-built subtracting impacts, as-built but-for, as-built-minus analysis)	[1,7,8,12,33,36,37]	• Develop CPM as-built schedule based on periodic programme updates or contemporaneous project documentation; • Remove delaying events, chronologically, from the as-built schedule to create a collapse as-built schedule; • Compare the completion date of this schedule with the original as-built completion date to establish the impact of the events on the actual project duration.
Window Analysis (or snapshot, contemporaneous period analysis, periodic update analysis)	[1,7,10,13–15,36]	• Using CPM schedule, the total project duration is divided into a number of time periods usually based on major delays or project milestones; • As-built information for any time period under review is used to update this period of the schedule, while maintaining the as-planned schedule beyond; • Project completion date given by this time period analysis is compared with the as-planned completion date prior to the analysis to determine the project delay experienced in this time period; • Total project delay is obtained by summing up all the delays from the snapshot periods considered in succession.

Table 1. *Cont.*

Delay analysis approach	Literature	Analysis procedure
Time Impact Analysis (or chronological and cumulative approach, end of every delay analysis)	[1,7,8,31]	• The CPM as-planned schedule is first updated up to the occurrence of a delay event whose impact is in question; • The schedule is updated again following the delay occurrence (sometimes by incorporating a "fragnet"); • The impact of the delay is calculated by subtracting the pre-delay update schedule completion date from that of post-delay update schedule; • Similar process is repeated for all of the remaining delay events.
S-Curve (or dollar-to-time relationship)	[6]	• Develop a time/cost S-curve for the original plan together with the S-curve representing actual income; • The actual S-curve must exclude any cost for additional works so that comparison of the two curves is valid; • The amount of delay at any point along the actual curve is the horizontal distance between these curves at this point.

3. Previous Research on Delay Analysis

Kraiem and Diekmann [9] developed an approach for dealing with instances of concurrent delays on parallel critical paths. It involves, first, developing an As-planned and As-built schedules, followed by identifying all types of concurrent delays, as portrayed by the As-built schedule. Each type is then removed successively from the schedule and the completion date of the resulting adjusted schedule compared to that of the As-built schedule (prior to the removal) to obtain the amount of project delay caused. The problem with this approach lies in establishing and manipulating the As-built schedule. In addition, it fails to account for changes in the sequence of work or the critical path [9]. A similar approach was proposed by Galloway and Nielsen [32], however, the latter was based on the Window Analysis technique, which, among others, addresses the issue of critical path dynamics. The approach involves ten systematic steps wherein the analysis focuses on each of the "window", created by periodic programme updates. Although this approach gives an objective and fair analysis of concurrent delays, its main challenge is that it requires complete project records, making it unsuitable for situations where adequate project data is lacking. Another drawback is the high time required for the analysis, which can be uneconomical for claims in which the money at stake is small.

Another contribution that was directed towards the analysis of concurrent delays is the work of Arditi and Robinson [11]. This approach involves, first developing a list of all possible scenarios that represents concurrent delays by systematically considering all possible delay types, their timings, and sequences. The main shortcoming of this approach is that there are no well-acceptable legal remedies for delay damage entitlements for the scenarios contemplate about [7], making the approach unfeasible to employ in practice.

In an attempt to address the limitations of delay analysis approaches, Alkass *et al.* [31] proposed a technique known as Isolated Delay Type. It provides a systematic and objective approach based on real time CPM. The analyses are carried out sequentially on updated schedules whose periods are based on either major delaying events or after a series of delays have occurred. Using the As-planned schedule

as the starting point the analysis is carried out separately for owner's point of view and for contractor's point of view. The main shortcoming of this technique is that there is an inconsistency in the process of apportioning delays between the contractor and the employer, which results in unfair greater amount of owner-caused delays [5]. In addition, the analysis assumes that the delays occur in isolation although they sometimes occur concurrently.

Based on the Time Impact technique, Kartam [14] developed a generic methodology for analyzing delays, of which the process involves 14 conservative steps. This approach also requires sufficient availability of project data and thus may be difficult to use if adequate records are not available to reconstruct statuses, *etc*.

Lee *et al.* [21] proposed an approach that incorporates lost productivity (on account of the delays) into the analysis through use of a construction productivity data model. Mathematical equations were used to develop a model of work duration as a result of lost productivity loses. A data model was also developed for the recording and keeping of information on lost productivity. This method requires the maintenance of considerable volume of project data in uniform and consistent manner, which can be very difficult to implement in practice.

Shi *et al.* [38] developed an approach that, *inter alia*, seeks to circumvent the need to update schedules before performing delay analysis. The approach is based on activity variation analysis, from which a set of equations that can easily be coded into a computer programme for speedy access to project delay information and the contributions of individual activities. The main drawback of this approach is the fact that it is not based on the critical path analyses, which is now a requirement for delay analysis.

A category of the research has also focused on the development of computer-based systems for aiding the delay analysis process. These systems are mostly based on the existing approaches but their main objective is to speed up the process. A computer software, called Delay Analysis System, was developed by Yates [39] for determining the possible causes of project delays and suggesting alternative courses of actions to prevent further delay. Alkass *et al.* [34] developed a computer system for assessing delay claims analysis based on the Isolated Delay technique. Part of this system can be integrated with existing project management, database management, and spreadsheet software. The system also has an expert system tailored to the specific expertise of the construction claims to facilitate the decision-making process. In addition, Abudayyeh [40] developed a multimedia system for construction delay management. His work shows how a variety of data types and information related to delay, including pictures, videos, and audio should be acquired, stored and processed, and presented in an automated manner to improve the delay analysis process.

Whilst the various research efforts have generally contributed, in one way or another, to improvements in delay claims analysis/resolution, very little has been reported in the literature as to practitioners' practical experience with employing existing delay analysis approaches. The knowledge of this experience could provide, among others, insights into the actual usefulness and difficulties of using the approaches in practice and which aspects of them require improvements. Furthermore, most UK construction contracts and case laws have largely remained silent on matters relating to the principles and applications of the approaches [1], leaving much to the often subjective judgment of disputing parties and thus much on which to disagree on during delay claims resolutions. The need to address this problem so as to help promote common understanding amongst practitioners regarding the

applications of the approaches has however attracted limited research attentions in the UK [41–43]. The few studies undertaken include the study by Scott [41], which concerns how contractors prepare delay claims and how supervisors assess them, but was limited to examining how practitioners view contentious issues such as the right to finish early, claims for extended overheads and extension of time awards for adverse weather, with no coverage on delay analysis approaches. A similar study was later on carried out by Scott and Harris [42], but based on a much larger sample. Harris and Scott [43] also investigated how UK professionals deal with delay claims, including the methods used for assessing or preparing delay claims. The methods they examined were: the global method, network analysis, critical path alone, and use of fragnets, of which the respondents were asked to state their preference for using them to analyze delays. The limitations of this study include the fact that many other issues about the approaches were not examined such as their success and reliability information. In addition, the industry has moved on, in terms of the approaches for analyzing delays, since the study was conducted over a decade ago. This represents the gap in literature for which the author's research has sought to contribute an up-to-date knowledge and understanding of practitioners' practical experience with existing delay analysis approaches.

4. Research Methodology

The appropriate research strategy for any study is dictated by the nature of the research problem or questions to be addressed [44–46]. The author's research purported to answer a number of questions concerning the existing approaches to analyzing delay claims in practice, including, what their level of awareness and extent of use amongst practitioners are? Their reliability in terms of facilitating claims settlement without disputes that otherwise would require third party resolution? The extent to which delay claims are resolved during the currency of a project? and, what are the obstacles that make it difficult to apply the approaches and the general problems impeding the resolution of delay claims at large? To address these questions, various research strategies were carefully considered to help ensure the selection of the most appropriate one(s) to use.

Accordingly to research methodologists [45–47], the most appropriate research strategies for answering "what" questions are experiment, surveys, analysis of archival records, and case studies. The confidential nature of the research topic, on account of the sensitive nature of delay claims information, made archival records and case-studies unsuitable to use and so were discounted. For instance, these strategies require access to materials on records of actual delay events (e.g., activity durations, expenses, *etc*.) and disputes materials, which most organizations will be unwilling to release. Experiments in the context of social sciences are field-based that require extensive time and cost to undertake [45,46] than this research could afford. This approach was, thus, also considered unsuitable, leaving surveys as the only appropriate options to rely on. Delay claims are pervasive and involve many different organizations [1,8], making the research population quite large and diverse, and therefore the choice of survey strategy more appropriate. Rea and Parker [47] note that no better method of research exists than the sample survey process for determining, with a known level of accuracy, information about large populations.

Among the methods available for carrying out surveys (viz, sending questionnaire by post, fax, and e-mail; conducting personal interviews and telephone interviews), postal questionnaire survey was

selected as the most suitable. The rationale behind this choice was based mainly on the relatively short time and less resource required by this method. Two separate questionnaires of similar outline were used for the survey; one for contracting organizations and the other for consulting organizations. They were carefully designed following an extensive review of relevant literature and then reviewed through a pilot survey with acknowledged delay analysis experts in the UK and the US, to ensure clarity and relevance of the questions to contemporary thoughts on the subject.

4.1. Sampling and Response Rate

Given that no specific sampling frame exists in the UK for construction organizations with experience in delay analysis, the use of non-probability sampling technique was found appropriate [48,49]. This technique involved, first, compiling a list of 2000 construction organizations of different sizes from the Kompass Register (a company search engine at gb.kompass.com), the New Civil Engineer (NCE) Consultants File, and the Royal Institute of Chartered Surveyors (RICS) Directory, which together contain in excess of 5000 providers of products and services in the UK construction industry. Secondly, the list was divided into the six geographical regions of the UK (North East, North West, South East, South West, Midlands, and Scotland). Finally, a combination of quota and purposive sampling techniques, as typically described by Patton [48] and Barnet [49], we employed to select 300 contractors and 300 consultants, based on a need to ensure that the outcomes are nationally applicable.

Out of the total 600 questionnaires dispatched by post, 156 were returned of which only 130 (comprising of 63 from Contractors and 67 from consultants), were properly completed that could be used for 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% as typical of similar surveys in the construction industry [50].

4.2. Data Analysis

The questionnaire mainly required respondents to respond largely by scoring on a 5-point Likert scale to reflect their views on the awareness of the existing delay analysis approaches (listed in Table 1), extent of their use in practice, *etc*., as highlighted before. As the resulting data were measured on an ordinal scale, the most appropriate method for analyzing them is to use non-parametric statistics [51], which in the case of this study involved using descriptive statistics, relative index analysis, Kendall's Concordance and Chi-square tests for the analysis. The Statistical Package for the Social Sciences (SPSS) was first used to calculate the valid percentage scores of the various methodologies, which were then input in Equation (1) to calculate their rank indices (RI).

$$\mathrm{RI} = \left[\sum_{i=1}^{i=5} w_i f_i \right] \times \frac{100\%}{n} \tag{1}$$

where f_i is the frequency of response; w_i is the weight for each rating; and n is the total number of responses.

Kendall's coefficient of Concordance (W), which provides a measure of agreement between respondents within a survey on a scale of 0 to 1 ("0" indicating no agreement, and "1" indicating perfect agreement), was employed to assess the degree of agreement or consensus between the two

main groups (contractors and consultants) in their rankings. This coefficient is quite suitable for non-parametric data and is calculated using Equation (2) [51].

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

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, and N is the number of methodologies ranked.

The statistical significance of W was further tested to confirm the extent by which the degree of agreement did occur by chance. Equation (3) with $(N - 1)$ degrees of freedom is used for testing this hypothesis at a given level, for $N > 7$ [51]. Calculated χ^2 value greater than its counterpart table value implies that the W was significant at the given level of significance and as such the null hypothesis of disagreement is not supported and thus has to be rejected.

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

5. Characteristics of the Respondents and Their Organizations

Relevant details about study respondents and their organizations form essential background information of any research undertaking [45,47]. Such details were therefore solicited from the respondents and the results obtained are as presented in the following sections.

5.1. Type and Size of Respondents' Organizations

The percentage breakdown of the type of organizations that participated in the survey is as shown in Figures 1 and 2, respectively.

Figure 1. Types of construction organizations.

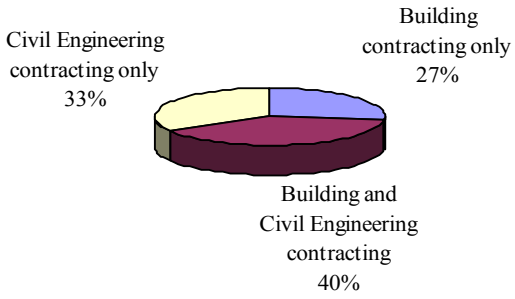
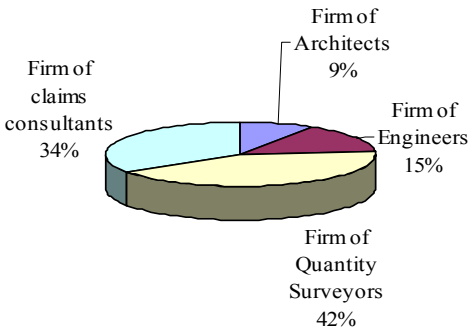


Figure 2. Types of consulting organizations.



Their sizes in terms of annual turnovers are shown in Figures 3 and 4. The average annual turnover of the organizations was £55 m, suggesting that the views sought were from medium to large construction organizations.

Figure 3. Size of construction organizations (in millions of £).

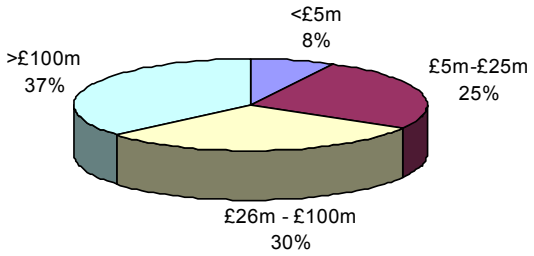
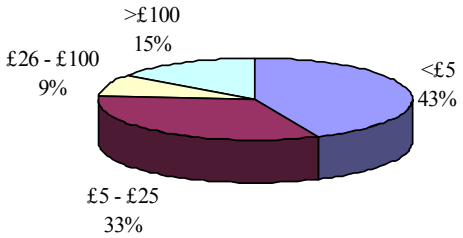


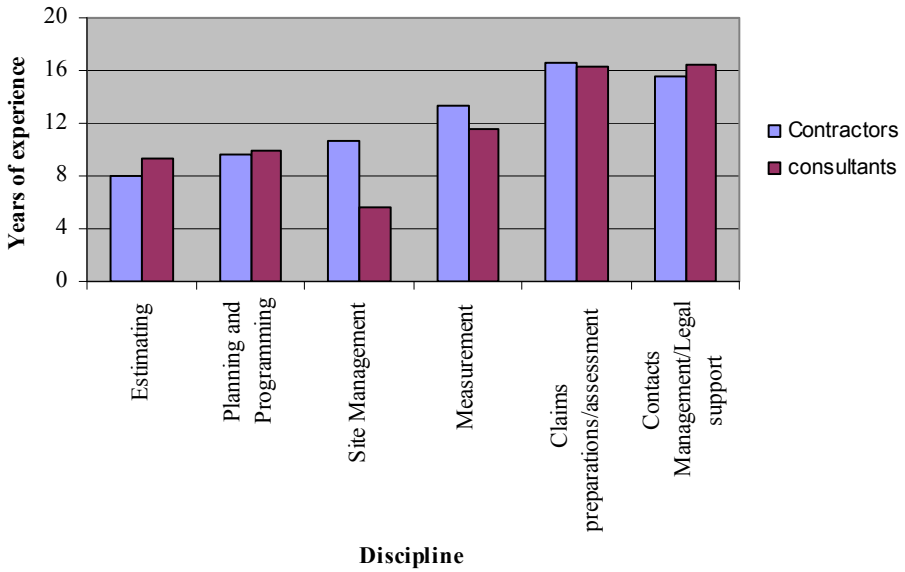
Figure 4. Size of consulting organizations (in millions of £).



5.2. Years of Experience of the Respondents

Figure 5 shows the years of experience of the respondents with regard to a number of functions that are relevant to the preparation and assessment of delay claims. The average years of experience on claims preparation/assessments was high (over 16 years), suggesting that most of the respondents have been dealing with claims for a considerable number of years and thus were ideally suited to comment on the issues dealt with in the survey.

Figure 5. Respondents' years of experience.



5.3. The Role of Respondents in Their Organizations

The respondents play different roles in their respective organizations. Figures 6 and 7 present these roles and the percentage of respondents for each category. As can be seen, their designations consist of a variety of professions that are relevant to delay claims analysis. Majority of them act as Commercial Managers or Quantity Surveyors for employers and contractors, with some occupying senior management positions.

Figure 6. Roles of construction organizations' respondents.

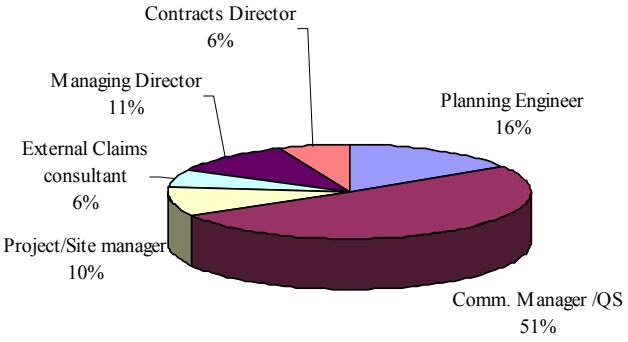
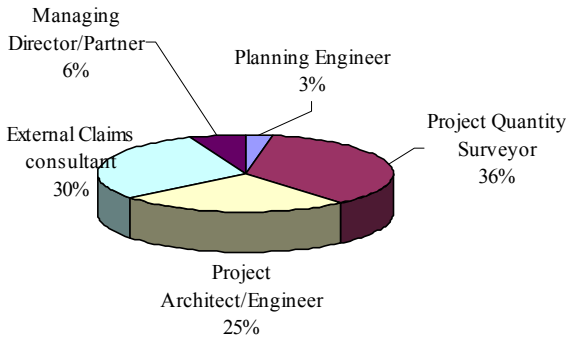


Figure 7. Roles of consulting organizations' respondents.



6. Timing of Delay Claims Submissions and Assessment

Timely submission of delay claims by contractors and their quick assessment by employers (or their representatives) in the course of the project or as close in time to the occurrence of the delaying events is often recommended as a good practice [1,7,8,52]. To investigate the extent to which this practice is observed by contracting parties, respondents were asked to score their level of agreement with the proposition: *"the analysis and resolution of most DD claims are left unresolved until nearer the end of the project or after completion before resolving"*; using a 5-point Likert scale (where "1" = disagree, to "5" = agree).

Table 2 shows the results, which indicates that over 60% of the respondents from either construction or consulting firms are in agreement with this proposition. This suggests that, by and large, contracting parties are unable to deal with delay claims at close in time as possible to the occurrence of the delaying events during the course of the project. With such practice, the facts leading to delay are likely to be distorted by time, as memory fades in the course of the project, increasing the possibility of the claims becoming complicated and unmanageable to resolve. Furthermore, this

practice reduces the opportunities for contracting parties to management and mitigates the delay risk events [53], as required in most forms of contract.

Table 2. Extent of agreement on proposition that delay claims are resolved late.

Extent of agreement scale	1.1.1. Construction		1.1.2. Consulting	
	Percent	Cumulative percent	Percent	Cumulative percent
Strongly disagree	3.2	3.2	7.5	7.5
Disagree	9.5	12.7	9.0	16.4
Neutral	12.7	25.4	14.9	31.3
Agree	42.9	68.3	44.8	76.1
Strongly agree	31.7	100.0	23.9	100.0
Total	100.0	-	100.0	-

In an attempt to understand the reasons that encourage such practice, respondents were asked in a follow-up question to indicate the key obstacles that tend to make it difficult for them to deal with delay claims early on as they arise. The results of this question are as shown in Table 7 (under Section 7.5), which suggests that lack of adequate contemporaneous records represents the key reason that hinders early delay claims assessment. This finding is also supported by a number of previous studies. Gorse [54] investigated the current practices adopted by project managers for collecting and monitoring of project records and revealed that basic information required for developing delay claims at this stage are not collected. The type of information found to suffer most from this deficiency was changes to schedules, particularly those caused by project managers" own work as they were hardly recorded and monitored [54].

Gorse *et al.* [53] explored the matter further, in considerable depth, using focus groups. Among the findings, the groups' participants highlighted three main issues which are quite central to (and do affect) the validity and reliability of information that practitioners relied on to assess delays prospectively. First, they raised concerns over the practice of treating planning information as a factual data in delay analyses, although such information is used subjectively in construction planning process. Secondly, doubts were expressed about whether construction programmes that are usually submitted by contractors are ever really checked properly before being accepted by employers or their representatives (the Engineer/Architect). Finally, the participants noted that there is often little information available for the accurate estimation of task durations. These problems were, thus, acknowledged by the groups as posing great obstacles to early or prospective delay analyses and hence, tend to necessitate later analyses once the full extent of the delays and relevant information become known.

7. Perceptions on Delay Analysis Approaches

The knowledge of practitioners' views on existing approaches to analyzing delays regarding their awareness level, extent of use, and their efficacy in facilitating successful settlement of the claims are quite essential, as mentioned earlier on. The following sections discuss the responses obtained on these issues.

7.1. Level of Awareness of Delay Analysis Approaches

Important to proper understanding of the extent of use of existing approaches, is the need to first find out their awareness level amongst practitioners. The respondents were therefore asked to rank their level of awareness for the approaches on a five-point scale from "unaware" (= 1) to "very aware" (= 5). Table 3 shows a summary of the results obtained, which indicates a high and significant degree of agreement among contractors and consultants in their rankings.

Table 3. Level of awareness of the approaches.

Approaches	Contractors		Consultants		Overall	
	Awareness index	Rank	Awareness index	Rank	Awareness index	Rank
As-planned *vs.* As-built	86.4	1	86.3	1	86.3	1
Impacted As-planned	79.6	3	77.6	3	78.6	2
Global	79.9	2	75.7	4	77.8	3
Net Impact	72.9	4	74.5	5	73.8	4
Collapsed As-built	59.6	5	70.3	6	65.1	5
Time Impact Analysis	46.4	6	78.2	2	62.9	6
S-curve	40.9	7	68.8	7	55.2	7
Window Analysis	40.0	8	67.2	8	54.0	8

Notes: Test Statistics: Kendall's $W = 0.87$; $\chi^2_{critical}$ ($\alpha = 0.05$) = 14.07; df = 7; χ^2_{sample} = 791.7.

The As-planned *vs.* As-built ranked as the most popular approach amongst contractors, consultants and overall, whilst the least popular is the Window analysis. On the whole, the approaches categorised as simplistic in the literature [31,34,37], namely, Global, Net Impact and As-Planned *vs.* As-Built are more popular than the sophisticated approaches (Impacted As-Planned, Collapsed As-Built, Window Analysis, and Time Impact Analysis).

7.2. Extent of Use of Delay Analysis Approaches

Using the 5-point scale, respondents were asked to rank the approaches on their extent of use in practice from "low" (= 1) to "high" (= 5). Summary of the results are as presented in Table 4, which show high and significant degree of agreement among the groups in their rankings.

The As-planned *vs.* As-built ranked as the most widely used approach amongst contractors and overall, although consultants ranked it third. Consultant's found Collapsed As-built as rather the most widely used approach. The simplistic approaches, generally, appear to be widely used amongst construction firms than consulting firms. An interesting finding is that Time impact analysis and Window analysis are largely not commonly used despite their high praise in the literature as being the most rigorous approaches [7,22,33]. Although the less awareness of these approaches is a potential reason for their less use in practice, there is also the problem of poor record keeping culture [7,55,56],

which hinders any desire to use these approaches as they require detailed project information to implement. Their low rate of use could also result from the relatively high level of skills/knowledge they require and significant cost involved in employing them [7,32,35,52]. Unfortunately, the growth in training, education and skills levels of the industry in the use of time management techniques has not kept pace with the technology available, according to the more recent comprehensive study in the UK [30]. Ninety-five percent of the respondents of this study thought that the standard of education and training in the management of time was unsatisfactory.

Table 4. Extent of use of the approaches in practice.

Approaches	Contractors		Consultants		Overall	
	Usage index	Rank	Usage index	Rank	Usage index	Rank
As-planned *vs.* As-built	81.9	1	56.3	2	65.7	1
Impacted As-planned	70.2	2	54.1	3	59.4	2
Collapsed As-built	47.1	5	63.0	1	54.8	3
Time Impact Analysis	37.5	6	52.5	4	48.2	4
Net Impact	51.7	4	39.7	6	45.7	5
Global	54.6	3	36.7	8	45.5	6
Window Analysis	31.4	7	48.9	5	40.2	7
S-curve	30.2	8	37.2	7	33.8	8

Notes: Test Statistics: Kendall's $W = 0.50$; $\chi^2_{critical}$ ($\alpha = 0.05$) = 14.07; df = 7; $\chi^2_{sample} = 455.0$.

7.3. Level of Success with Delay Claims Settlement Based on the Approaches

Due to their different strengths and weaknesses, the approaches are capable of producing results of varying reliability and therefore able to facilitate (or otherwise) the settlement of delay claims at different degrees. To appreciate the position of each delay analysis approach in this respect, respondents were asked to rank them, using the 1–5 scale ("1" representing low, and "5" is for high), on their level of success with claims settlement without disputes. A summary of the results is shown in Table 5. The degree of agreement among contractors and consultants in their rankings was significant.

The results show that As-planned *vs.* As-built was ranked by both contractors and overall as the approach that most frequently lead to successful claim resolutions, followed by the Impacted As-planned approach. This finding was not to be expected as these approaches are often criticized by researchers and commentators for having numerous weaknesses (see for e.g., [7,31,33]). The possible explanation for this inconsistency is probably because these approaches are the most widely-used approaches (as evident in Table 4), they are likely to be those to be relied upon in finally resolving most claims. On the other hand, Time Impact Analysis followed by Window analysis were ranked as approaches that most frequently lead to successful claim resolutions by Consultants. This finding reflects the views on these approaches in the literature [14,22,31].

Table 5. Level of success with delay claims analyzed using the approaches.

Approaches	Contractors		Consultants		Overall	
	Success index	Rank	Success index	Rank	Success index	Rank
As-planned *vs.* As-built	80.3	1	53.6	3	66.0	1
Impacted As-planned	67.7	2	51.1	5	59.2	2
Collapsed As-built	49.6	4	52.2	4	50.9	3
Time Impact Analysis	37.9	6	60.3	1	49.8	4
Window Analysis	30.9	7	57.8	2	45.2	5
Net Impact	54.1	3	33.5	7	43.4	6
Global	45.8	5	32.8	8	39.2	7
S-curve	27.1	8	33.6	6	30.5	8

Notes: Test Statistics: Kendall's $W = 0.45$; $\chi^2_{critical}$ ($\alpha = 0.05$) = 14.07; df = 7; χ^2_{sample} = 409.5.

7.4. Extent of Challenge from Opposing Parties to Claims Analyzed by the Approaches

In addition, respondents were asked to rank the approaches on the extent of challenge opposing parties pose to claims analyzed using a similar scale from "never" (= 1) to "always" (= 5). The findings seek to complement those obtained in respect of the extent of success with the approaches, as measured in the previous section. Summary of the results obtained are presented in Table 6, which also indicate significant degree of agreement among contractors and consultants in their ranking.

Table 6. Extent of challenges from opposing parties to claims analyzed by approaches.

Approaches	Contractors		Consultants		Overall	
	Challenge index	Rank	Challenge index	Rank	Challenge index	Rank
Global	90.9	1	82.6	1	86.6	1
Net impact	75.3	2	78.4	2	76.9	2
As-planned *vs.* As-Built	67.6	3	72.9	3	70.4	3
Impacted As-planned	64.7	4	67.3	6	66.0	4
S-curve	52.0	6	71.8	4	62.3	5
Collapsed As-built	54.1	5	65.4	8	60.0	6
Time Impact Analysis	46.9	8	67.6	5	58.3	7
Window Analysis	48.5	7	66.0	7	57.9	8

Notes: Test Statistics: Kendall's $W = 0.85$; $\chi^2_{critical}$ ($\alpha = 0.05$) = 14.07; df = 7; χ^2_{sample} = 773.5.

The findings suggest that claims analyzed using the Global method, the Net Impact and the As-planned *vs.* As-built are most prone to challenges by opposing parties. Conversely, the sophisticated methods were ranked as less prone to such challenges. These findings corroborate commentaries on the approaches [1,7,33,36].

7.5. Obstacles to the Use of Existing Delay Analysis Approaches

A number of commentators tend to explain the low usage rate of delay analysis approaches, especially with the sophisticated ones, by pointing at some prevailing factors as being obstacles to their successful implementation during project execution or after completion. To investigate the validity of such commentaries and the relative frequencies of the perceived factors in hindering the use of the approaches, the respondents were asked to score these factors (as identified from literature) in this regard, using a 5-point Likert scale (where "1" = not frequent, "5" = very frequent). Respondents were also asked to add and then rate any other relevant obstacles they know from experience but were not included in the questionnaire's list. Table 7 shows the rankings of the obstacles as obtained from analysis of the results. As indicated by the test statistics, the degree of agreement among the respondents in their ranking was generally strong and significant.

Table 7. Obstacles to the use of existing delay analysis approaches.

Factors	Contractors		Consultants		Overall	
	Frequency index	Rank	Frequency index	Rank	Frequency index	Rank
Lack of adequate project information	75.9	1	76.4	1	76.1	1
Poorly updated programmes	74.4	3	73.0	2	73.7	2
Baseline programme not in CPM network format	67.5	5	69.9	3	68.7	3
High cost involved in their use	66.3	6	67.5	4	66.9	4
Difficulty in the use of the approaches	66.0	7	62.1	6	64.0	5
Lack of familiarity with the approaches	75.0	2	53.5	8	63.8	6
Unrealistic baseline programme	57.5	9	60.0	-	-	-
High time consumption in using them	52.0	10	64.5	5	58.6	8
Lack of skills in using the approaches	69.9	4	44.1	10	56.3	9
Lack of suitable programming software	65.7	8	47.5	9	56.2	10

Notes: Test Statistics: Kendall's $W = 0.72$; $\chi^2_{critical}$ ($\alpha = 0.05$) = 16.92; df = 9; χ^2_{sample} = 842.4.

On the whole, "Lack of adequate project information" ranked as the number one top obstacle, followed by "Poorly updated programmes" and then by "Baseline programme not in CPM network format". Interesting, "Lack of familiarity with the approaches" was rated starkly different by the two groups of respondents, contractors and consultants, with ranking of 2 and 8, respectively. The likely reason for this factor being perceived as more of an obstacle by contractors than it is for consultants is probably due to the specialist nature of the tasks involved in preparing delay claims submissions.

The highest rank attained by "Lack of adequate project information" corroborates with the construction industry's poor track record of maintaining adequate project records, as observed by previous studies [55,56]. This problem has continued to persist over the years in spite of the many

recommendations calling for improvements in record-keeping practices [7,57,58]. The respondents of the more recent study by Gorse *et al*. [54] were, for example, quite cynical about progress reports. They raised concerns over the persistent poor culture of not maintaining project records and that *"…false progress reports were the norm rather than the exception…"*. These findings are very much in line with those of the more recent CIOB study [30]. The majority of the respondents in this study did not only regard progress recording as a matter of guess work, they also indicated that progress is often not reported in meetings or in correspondence.

In addition, "Poorly updated programmes" and "Baseline programme not in CPM network format", were identified as issues of grave concern by the CIOB research [30]. Over half of the respondents in this study indicated that they used only master programmes with no short-term planning, and that the programmes were normally bar charts without linked sequencing. Moreover, the programmes were more often than used solely as a political tool to protect companies and management from accusations of blame for delays instead of serving as regularly updated tools used for purposes of managing sequence and progress and to minimize the consequence of delays [30].

7.6. General Comments on the Problems Responsible for Delay Analysis Difficulties

To confirm and identify further sources of difficulties that affect the proper application of delay analysis approaches and the resolution of delay claims at large, respondents were asked to provide general comments (in free text form) on what they think are the key factors responsible for such difficulties. Although not all the respondents replied to this open question, the majority who answered did so enthusiastically by stating at least two problems. The comments offered are summarised and grouped under eight headings as tabulated in Table 8. Similar views were expressed by both the contractors and consultants.

As can be seen, the main problems identified relate to poor record keeping, inadequate programming practice, unhelpful attitude of employers and lack of expertise with relevant skills and experience for dealing with delay claims. These findings largely concur with the earlier results on the obstacles that affect the application of delay analysis approaches in practice, confirming that inadequate record-keeping and poor programming practice represent the major sources of problems responsible for the difficulties. These do not enhance the standard of proof required of delay claims assessment and resolutions as the existing approaches rely very much upon reliable project information maintained contemporaneously throughout the currency of the project. Lack of such records makes delay analysis at a uniform level impossible and thus allows for some delays to be concealed, distorted or overemphasised, resulting in inaccuracies in the claims apportionment.

It is clear from the results that much still need to be done, particularly with regard to improving record-keeping practices, if effective and efficient assessment of delays, either prospectively or retrospectively, are to be enhanced. In order to deal with this issue appropriately, it is important to first establish or conceptualise the source of the problems that have continued to render difficulties in keeping up with appropriate record-keeping practice. One of the often-mentioned problems relates to an intrinsic feature of the construction industry itself, by way of its highly fragmented, peripatetic, non-collaborative, and distinctly unique nature [58]. Such characteristics often create barriers to

integrated and structured communication channels that would otherwise facilitate smooth flow and sharing of information [59].

Table 8. Problems responsible for poor resolutions of delay and disruption claims.

Problem	Frequency	Problem category
Lack of clear, accurate/reliable and adequate contemporaneous records	22	Project records
Difficulties on agreeing on the level of information needed	4	
Lack of productivity norms for individual contracting organisations	2	
Lack of attention to facts with too much emphasis on the type of analysis to be used	2	
Poor information by subcontractors	1	
Inability to keep up with the logistics of keeping accurate records	1	
Lack of understanding from the client of disruptive effects of changes	6	Attitude of project employer/owner
"All risk" contracts not properly expressed	3	
Basic dislike of "claims" by client	2	
Reluctant by client teams to recognised liability because of budget constraints	2	
Client does not want to be shown lacking	1	
Parties having entrenched views and protecting their perceived positions	7	Adversarial relationship between parties
Parties' failure to acknowledge their contribution to DD and accept responsibility	4	
Lack of commitment to seeking recompense due to client relationship risk	1	
Lack of experience, knowledge and skills of claims resolvers	8	Personnel and expertise to deal with claims
People/staff leaving construction companies	2	
Lack of consistency in approach within the industry	2	
Employers team not versed in contract requirements	1	
Lack of timely decisions by Architects/Engineers regarding delays	6	Attitude of employers' Architect/Engineer
Architects/Engineers do very little in mitigating delays	3	
Insufficient thought given to the outcome or likely outcome of changes	2	
Lack of proper planning and management of the project	5	Planning and programming
Contractor's baseline programmes not reliable/realistic	3	
Most contractors do not update their programmes	2	
Delay and disruption claims are usually left unresolved until the end of the project	3	Delay and disruption notice
Lack of timely notifications by contractors	2	
Lack of resources to risk-manage claims on site	2	Resources
Cost of employing delay analysis experts	2	

Another source of barrier lies with the rigidity of most contracts and conflicts of interests between contracting parties [60], who tend to show adversarial relationships towards each other [58]. With these barriers at play, a situation is often created where not only are the project information kept in an *ad hoc* manner, their flow and dissemination are also rendered slow and arduous, resulting in conflict, errors, delays and losses [59]. Unfortunately, most information management systems (both paper and IT-based) utilised in the construction industry to deal with these barriers, are not designed to

support conflict/claims situations [56,57,59]. It is, thus, not surprising that construction organisations still find it quite challenging to efficiently manage the huge amounts of real time information that accumulate over the life of a project for the purposes of assessing delays effectively. Lack of contractual requirements on project records maintenance in UK-based projects remains one of the key reasons exacerbating the situation [57].

8. Summary and Conclusions

Various approaches, mostly based on construction project programming techniques, are often relied on as tools for preparing and assessing delay claims raised by contractors. Although much research has been directed towards improving the use of these approaches, the continuing difficulties associated with such claims suggest the need for further empirical investigation into the extent of use of the approaches, their success rates in dealing with delay claims resolutions and the obstacles affecting their appropriate implementation in practice. This paper reports on such a study based on an industry-wide questionnaire survey of UK construction organizations.

Resolving delay claims early, as and when delay risk events are experienced, in the course of a project is an often recommended practice that is quite crucial to preventing disputes. The results of this study however show that this recommendation is hardly adhered to in practice. The results, coupled with findings from previous studies, suggest that lack of adequate project records is the top contributory reason for the inability to deal with delay claims early on (as close in time to the time of occurrence of the delaying events), ultimately resulting in claims being dealt with rather long after the event or project completion, when records are hard to compile.

By and large, the As-planned *vs.* As-built, Impacted As-planned, Global Method and the Net Impact Technique are the most well-known and widely used delay analysis approaches, in spite of their numerous weaknesses that have been reported in the literature. The study also revealed that these approaches are relied on to successfully resolve delay claims, although they frequently expose delay claims submissions and assessments to challenges from disputing parties. Conversely, the more sophisticated approaches, namely, Collapsed As-built, Time Impact Analysis, and Window Analysis, which are often regarded as being more robust in literature, are not widely used in practice, although they are relatively quite popular amongst consulting firms than in contracting organizations. These approaches were however perceived as more reliable and capable of facilitating delay claims resolution.

Significant degree of agreements or consensus were found between contractors and consultants on the aspects of delay analysis approaches investigated, which is an indication that the main protagonists of delays claims have common views on those aspects. It thus suggests that these aspects can form the basis of a common understanding between contracting parties during delay claims resolution if the process is to be standardized to facilitate amicable claims settlement with less chances of disputes.

The low popularity of the robust approaches in practice is due to deficiencies in programming practice and inadequate project records perpetuated by poor recording-keeping culture in construction firms, as evidenced by the results of this study and findings from earlier research work. To facilitate their use in practice so as to ensure robustness in the analysis of claims with less chances of degenerating into disputes, it is therefore recommended that further studies be devoted to help identify the key issues affecting effective recording keeping and how this could be improved.

Conflicts of Interest

The authors declare no conflict of interest.

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