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RESEARCH ARTICLE

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## THE ROLE OF PROJECT PROGRAMMING IN MINIMIZING DELAYS AND IMPROVING CONSTRUCTION PROJECT DELIVERY: EVIDENCE FROM THE UK

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### ABSTRACT

Delays are one of the most critical challenges in construction projects, often resulting in cost overruns, disputes, and reduced productivity. This study investigates the role of project programming in minimizing delays and improving project delivery. The research combines a literature review and a questionnaire survey distributed to 96 project managers in Greater Manchester, with a response rate of 25%. Data analysis revealed that the most critical causes of delay include rework, ineffective planning, poor site management, and adverse weather conditions. These factors are strongly correlated with disputes, arbitration, and cost and time overruns. Findings also indicate that construction practitioners rely heavily on traditional planning tools such as Gantt charts and CPM, while modern optimization techniques remain underutilized. The study concludes that project programming plays a strategic role in reducing delays. Key recommendations include strengthening training in advanced planning techniques, adopting innovative scheduling methods, and integrating programming at early project stages. These measures can significantly enhance project performance and reliability in the construction industry.

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## INTRODUCTION

At the time this study was conducted, the construction industry was a major contributor to the UK economy, generating over £100 billion in output in 2010 (Office for National Statistics, 2011). More recent ONS data indicate that the sector reached a record £139 billion in new work output in 2023, underscoring its continued economic significance despite cyclical fluctuations. Many studies have been undertaken to improve its efficiency. Achieving excellence, 1999, modernizing construction, 2001, constructing excellence 2005, Egan 'never waste a good crisis', 2009 etc... Despite its economic significance, the industry continues to face persistent delays that undermine timely and cost-effective project delivery. In construction, delay could be defined as the time overrun either beyond completion date specified in a contract, or beyond the date that the parties agreed upon for delivery of a project (Assif & Al-Heiji, 2005). Such delays not only have financial implications for stakeholders but also frequently result in revenue loss for the owner and may also cause higher overhead costs for the contractors. Traditional scheduling methods such as Gantt charts and the Critical Path Method (CPM) are widely used; and, these methods often fall short when applied to resource-constrained scenarios, as they fail to account for dynamic resource limitations. However, their limitations in dealing with complex, resource-constrained, and repetitive projects have been well

documented (Amol & Sachin, 20225). This research aims to evaluate the role of project programming in avoiding occurrence delays and improving project delivery. Specifically, the study seeks to: (i) Identify the most significant causes of delays; (ii) Assess different planning practices and their adequacy; (iii) Examine the correlation between planning and project performance.

## MATERIALS AND METHODS

The study followed a mixed-method approach combining literature review and empirical research.

**Development and Distribution of the Survey:** The survey was carried out between July 2011 and August 2011. A total of 96 questionnaires were distributed to project managers in medium and large construction firms across Greater Manchester, of which 24 projects managers completed the survey and formed the basis for this analysis. This amounted to answer frequency of 25%. The questionnaire was structured into four sections: respondent profile, delay factors, planning practices, and project performance. The first part of the questionnaire is related to general information for respondent. They were inquired about their professional qualification, educational level and organizational role.

Part II) were concerned with delays, it includes a list of identified causes of delay in construction project: disputes, delay in progress payments, change order, rework, ineffective planning, inadequate unclear drawing details, delay in material delivery, equipment breakdown, weather, accident, poor site supervision and low productivity. For each cause factor two questions were asked: What is the frequency of occurrence for this cause? And what is the degree of severity of this cause on project delay? Both frequency of occurrence and severity were categorized on a five-point scale. Frequency of occurrence is categorized as follows: always, often, sometimes, rarely, never (on 5 to 1 point scale). Similarly, degree of severity is categorized as follows: extreme, great, moderate and little (on 4 to 1 point scale). This helped identify delay factors and weigh their importance in UK construction industry.

Part III) investigated planning practices being used in respondents' organizations. They were asked about the planning tools used in their organization; and given options to choose from: Network based, time scheduling, resource driven technique, graphical method, or PERT. It informed the subject on scheduling techniques being used in practice. The last part of the questionnaire was entirely dedicated to project performance.

**Approach to analysis:** Empirical analysis would then be generated on numbers given by the questionnaire using the rating scale measurement method. This is a commonly used research technique to analyze the results of survey tools in which participants provide their assessments of an object using a pre-defined numeric scale.

**Frequency index:** A formula was used to rank causes of delay based on frequency of occurrence as identified by the participants

$$\text{Frequency Index (F.I.) (\%)} = \sum a (n/N) * 100/5 \quad (1)$$

Where a is the constant expressing weighting given to each response (ranges from 1 for rarely up to 5 for always), n is the frequency of the responses, and N is total number of responses.

**Severity index:** A formula was used to rank causes of delay based on severity as indicated by the participants.

$$\text{Severity Index (S.I.) (\%)} = \sum a (n/N) * 100/5 \quad (2)$$

where a is the constant expressing weighting given to each response (ranges from 1 for little up to 4 for severe), n is the frequency of the responses, and N is total number of responses. Importance index: The importance index of each cause was then calculated as a function of both frequency and severity indices, as follows:

$$\begin{aligned} \text{Importance Index (IMP.I.) (\%)} \\ = [\text{F.I. (\%)} * \text{S.I. (\%)}] / 100 \end{aligned} \quad (3)$$

**Key performance measures** were ranked based on their importance as indicated by participants.

$$\text{Key performance index (K.P.I.) (\%)} = \sum a (n/N) * 100/5 \quad (4)$$

Where a is the constant expressing weighting given to each response (ranges from 1 for little up to 4 for severe), n is the frequency of the responses, and N is total number of responses. Respondents there inquired to indicate which planning tools were employed (such as bar charts, critical path networks, and probabilistic PERT analysis) by their firms in planning their projects. The frequency distribution of the responses was used to assess the prevalence of scheduling technique used in the construction industry. Other questions were treated similarly by either determining importance indexes or frequency distribution.

## RESULTS

**General characteristics of respondents:** Respondents included mainly individuals involved with project management. Most

participants were professionally qualified. The qualifications listed comprised ICE, ISTRUCTE, CENG, RICS. They were HND, Bsc, or Msc holders. Respondents were not asked about their experience in the industry.

**Identification of delay factors:** This section was useful in determining the importance of delay factors identified through literature review; causes of delay that are site related were prioritized over other delay factors, as this study seeks to determine the role of programming in avoiding occurrence of delays. Other delay factors that are design related, or owner related cannot be controlled through scheduling. Respondents' experience has been very helpful in informing the research. Their direct involvement in projects within the construction industry was a valuable asset to this study. The most frequent causes of delays are unclear drawings, ineffective planning, disputes, rework, delay in material delivery, poor site management. Unclear drawings, dispute, material delivery are factors that planning has little or no control over. However, project participants could ensure that design documents are produced on time, and that caution is taken to avoid mistakes and discrepancies in design documents. Delay in material delivery and disputes are greatly dependent on project participants' ability to work as a team. Other delay factors relate to project planning.

**Severity of delay factors:** Causes of delay impact differently on project performance. The most severe causes of delay are rework, ineffective planning, weather, poor site management. These factors are site related and can be controlled through project planning. However, findings show disparity between occurrence of delays and their effect. Thus, a further step was required to determine the importance of delay factor. This was achieved by calculating the importance index of causes of delay. Based on their importance the main key delays ranked from the highest to the lowest affecting the construction industry are shown in Figure 1.

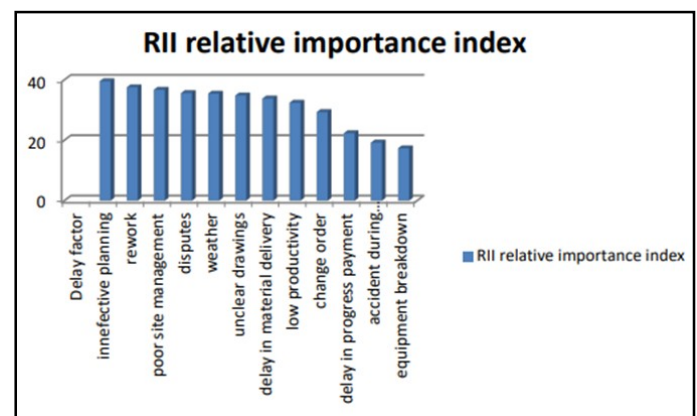


Figure 1. Importance of delays factors identified

According to respondents the most important delay causes are ineffective planning, rework, poor site management, disputes and weather. They are mainly site related and can be controlled through programming; provision could be made for weather. This shows that project planning has an important role in achieving project goals and delivering project on time.

**Effect of construction delays:** The literature points out that delay could lead to six different outcomes, if not contained; they are time overrun, cost overrun, dispute, arbitration, total abandonment, or litigation. This section investigates how often those effects of delay occur in construction projects.

Effects of construction delay were then ranked based on frequency of occurrence. According to respondent's own judgment, delays are more likely to translate in dispute, arbitration, or time overrun. However low frequency indexes for other effects of delay such as total abandonment, and litigation indicate that they occur rarely.

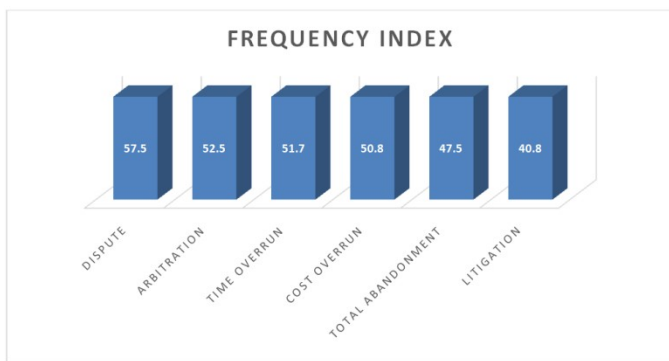


Figure 2. Effects of construction delay on construction projects

**Planning practices:** Participants were inquired about planning tools being used in their organizations. 75% of respondents are familiar with time scheduling, 37% have used network based scheduling technique, and 25% have used graphical method. However it appears that most respondents are unfamiliar or have not used resource driven technique. (12.5% of participants are familiar with resource driven technique). Moreover question 11 was designed to investigate respondents' familiarity with resource constrained project scheduling technique (scheduling technique which aims to optimize project duration). Only 15% of participants gave a positive answer. It can be deduced that this scheduling technique is not widely spread in the industry. Question 10 tested respondents' knowledge regarding the limitations of traditional techniques. Thus they were asked to rank traditional tools' adequacy for maintaining a target production rate, maintaining continuity of work, balancing resource between activities, resource utilization; they are identified in the literature as limitations of traditional scheduling techniques. Respondents answers are presented in Table 1, each option is associated with its RII (relative importance index).

Table 1. Traditional planning tools' limitations

Traditional Planning Tools adequacy for:	RII
Maintain a Target Production rate	74,4
Maintain Work continuity	75,2
Balancing Resources	75,2
Satisfy work interruption	64,8
Resource Utilization	73,6

High RII shows that respondents believe that scheduling techniques being used in their organization are adequate for maintaining a target production rate, maintain work continuity, balancing resources and resource utilization. These findings that suggest practitioners are confident that traditional scheduling techniques being used in their organization are satisfactory for attaining positive project performance.

**Project Performance:** Respondents unanimously admitted that an increased level of pre-project planning could yield increased predictability of schedule, reduced probability of project failures, improved operational performance, and better achievement of goals; however they are divided regarding the achievement of cost predictability (54% agreed), and the reduction of scope changes (50% said yes). It is understandable that respondents doubted that pre-project planning could minimize scope changes, since it is solely dependent of owners' needs or requirements. Question 14), 15), 16) and 17) looked into how practitioners perceived the relationship between time, cost and quality. 62.5% of respondents believe better quality implies more time to complete a project; 37.5 % believe better quality implies higher cost, and that reducing time required to complete a project implies higher costs; according to 25% of respondents reducing time required to complete a project implies lower quality. This shows that practitioners adhere to the idea that project could be delivered on time, and budget, however the majority are certain that quality is a function of time; better quality would impact on the completion time. The final question relates to key

performance indicators; its purpose was to find out how respondents prioritized the following key performance measures: predictability-cost, predictability-time, construction time, and productivity. Key performance indicators in accordance with their RII (relative importance index) are represented in Figure 3 as follow:

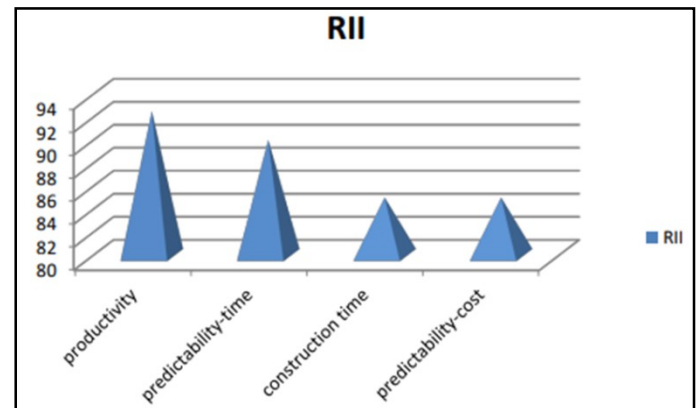


Figure 3. Key performance indicators RII

The High importance indexes hint that practitioners value all the key performance measures presented in the table as being important. It appears that respondents prioritize productivity and predictability-time over construction time, and predictability cost. On the other hand the literature review hints that recent development in scheduling practice guarantee high performance (in accordance with those indicators).

## DISCUSSION

A questionnaire was developed to capture project managers' perceptions of the relative importance of delay factors, and to examine how project planning could contribute to minimizing the occurrence of delays. However, an important step in the questionnaire development process was omitted, a pilot study. According to (Gillham, 2000), conducting a pilot study is a critical step, as it allows researchers to test a proportion of the questions in advance in order to identify ambiguous, confusing, or unreliable item. In addition, a pilot survey enables the assessment of other key aspects of questionnaire design, including the clarity of instructions provided to respondents, the wording and tone of accompanying letters, and the overall length and structure of the questionnaire. Similarly, (Devaus, 2002) emphasizes the importance of evaluating questionnaire design in terms of validity and reliability, redundancy of questions, and the discriminatory power of individual items. If all respondents provide identical answers to a question, its analytical value is limited, as the primary purpose of a questionnaire is to capture the diversity of perspectives on a given subject. These methodological recommendations have been implemented in comparable studies. For instance, (Sambasivan & Soon, 2006), in their investigation of the causes and effects of delays in the Malaysian construction industry, conducted a pilot study prior to the main survey. The pilot phase aimed to verify the completeness and relevance of the questionnaire in capturing the required information, and the respondents confirmed its adequacy, resulting in no subsequent modifications. Despite the absence of a pilot study in the present research, its overall impact on the quality of the questionnaire appears to be limited. Most of the feedback received from respondents highlighted the simplicity of the questionnaire, although several noted that greater clarity could have been achieved through the use of simpler vocabulary. The questionnaire was administered by post; however, the relatively low response rate (25%) raises concerns regarding the effectiveness of this data collection method. As pointed out by (Dillman, 2007), low response rates are often associated with difficulties in reaching the intended respondents. In the present study, initial contact with organizations was frequently made through administrative staff or personal assistants, who in many cases did not forward the questionnaire to the targeted project managers, thereby limiting

participation. To mitigate this limitation, several alternative strategies could have been adopted. First, greater effort could have been made to clearly identify the most appropriate respondents and to develop multiple channels of contact to ensure direct access. Second, a mixed-method approach could have been implemented, combining postal questionnaires with other modes of communication such as email or telephone follow-ups. Finally, on-site interviews could have been conducted to improve response rates and enhance the depth and reliability of the collected data, as recommended by (Dillman, 2007).

Furthermore, sample elements were selected randomly, which makes it hard to achieve high response rate. This limitation is illustrated by the previously cited study that achieved a 75% response rate by employing a non-probability sampling strategy, whereby respondents were selected through convenience sampling and referral networks. Such approaches, while potentially introducing bias, often facilitate greater participation and access to targeted professionals. Overall, the research methodology adopted in this study was appropriate and generated sufficient data to support the analysis. Nevertheless, alternative methodological approaches could have been employed to establish a more direct and objective relationship between project programming and the occurrence of delays. For example, (Al-Momani, 2000), in his investigation of construction delays in Jordan, analyzed archival data from contract files associated with five categories of public projects, including residential buildings, administrative offices, medical centers, and communication facilities. Similarly, (Yu-Ren Wang & Edward Gibson J., 2008) relied on empirical data from 62 industrial projects and 78 building projects to assess early planning practices in the construction industry. Such data-driven approaches are generally considered more reliable, as findings are based on objective project records rather than perceptions. However, access to this type of information remains challenging due to confidentiality concerns and organizational reluctance to share sensitive project data. The analytical approach adopted in this study, based on frequency, severity, and relative importance indices, has been widely used in construction management research. Similar methods were applied by (Aibinu & Jagboro, 2002); (Arshi Shakeel Faridi & Sameth Monir El-Sayegh, 2006), (Sambasivan & Soon, 2006), to cite a few. This approach is particularly suitable for analyzing Likert-scale data, as it allows for the systematic ranking and comparison of delay factors based on respondents' perceptions.

**Delay factors:** The analysis identified the ten most important causes of delay as follows: rework (RII = 62.5), ineffective planning (RII = 62.5), adverse weather conditions (RII = 61.5), poor site management (RII = 61.1), disputes (RII = 59.4), low labor productivity (RII = 56.3), delay in material delivery (RII = 56.3), change orders (RII = 53.2), unclear drawings (RII = 47.5), and delay in progress payments (RII = 46.9). These findings are consistent with those of (Odeh & Battaineh, 2002), who examined the most significant causes of delays in construction projects under traditional contract arrangements. Their study identified subcontractor-related delays, slow decision-making processes, improper planning, and low labor productivity among the most critical delay factors. The convergence of findings across different geographical and contractual contexts reinforces the robustness of these results. Notably, the most critical delay factors identified in the present study are closely associated with operational performance, particularly rework, ineffective planning, and poor site management. These issues may be attributed to contractors' inadequate experience, insufficient coordination among project participants, and the lack of systematic schedule updates during construction. Although work schedules are generally required for construction projects, they are often prepared as high-level summaries and rarely updated to reflect actual site conditions. However more contractors are making the effort to adopt advanced method and technique; there is clear need to educate professional construction managers and invest in planning and control (Odeh & Battaineh, 2002). Disputes, change orders and delay in progress payment can be grouped as client related factors. These issues are linked to financial issues and owner interference.

The findings indicate that construction delays are most likely to result in disputes, arbitration, and time overruns. However, their adverse cost and schedule impacts can be mitigated through the acceleration of site activities and the inclusion of contingency allowances in pre-contract cost estimates to cushion potential cost overruns (Aibinu & Jagboro, 2002). Also literature provides substantial information regarding innovative techniques that could be implemented to complete project in a shorter duration at minimum cost.

The findings suggest that project programming plays a critical role in preventing the occurrence of delays and mitigating their adverse effects on project performance. However, the results also reveal a notable gap between the recognized importance of programming and the actual planning practices adopted by construction practitioners. Although 75% of respondents reported familiarity with conventional time-based scheduling techniques and considered them adequate for maintaining target production rates, work continuity, resource balancing, and utilization, this apparent satisfaction contrasts with evidence from prior studies highlighting the limitations of traditional planning tools in complex and resource-constrained project environments (Odeh & Battaineh, 2002) (Sambasivan & Soon, 2006) (Aibinu & Jagboro, 2002). This paradox may partly explain why planning-related factors—such as ineffective planning, rework, and poor site management—emerged as the most significant causes of delay in this study. If the planning tools currently employed were indeed sufficient to address operational complexity, non-operational factors (e.g., client- or design-related issues) would be expected to exert a greater influence on project delays. Instead, the prominence of planning-related delay factors reinforces arguments in the literature that traditional scheduling techniques often fail to adequately support dynamic decision-making, resource optimization, and proactive delay mitigation (Al-Momani, 2000) (Yu-Ren Wang & Edward Gibson J., 2008).

## CONCLUSION

This study confirms that project programming plays a pivotal role in minimizing delays and improving overall construction project delivery. The findings indicate that the most significant delay factor, namely ineffective planning, rework, poor site management, and adverse weather conditions, are largely operational in nature and can be substantially mitigated through enhanced planning practices. Based on these results, several recommendations emerge. First, there is a clear need to strengthen the training of project managers in advanced scheduling and optimization techniques. Second, project programming should be fully integrated from the earliest stages of project development to improve predictability and proactive decision-making. Third, the adoption of innovative planning tools, such as resource-driven scheduling and 4D modeling, should be encouraged to better manage complexity and resource constraints. Finally, improved collaboration and coordination among project stakeholders remain essential to reducing externally driven causes of delay. In conclusion, project programming should be viewed not merely as a monitoring mechanism, but as a strategic function that underpins efficiency, reliability, and long-term success in the construction industry.

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