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ECONOMIC IMPORTANCE INDEX: A NEW APPROACH TO QUANTIFY AND IDENTIFY CRITICAL DELAY FACTORS IN CONSTRUCTION PROJECTS

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Abstract : In the ever-evolving landscape of construction projects, the effective identification and quantification of critical delay factors play a pivotal role in project management. This research introduces a novel tool, the Economic Importance Index (EII), designed to address the limitations of existing methodologies. Unlike traditional survey-based approaches, EII offers a more nuanced and precise measure, considering not only the importance but also the impact and duration of delay factors. Through a comprehensive literature survey, this study identifies the need for a standardized method in delay quantification. The project aims to bridge this gap by developing the concept EII, providing a robust foundation for decision-making in the face of construction delays. The paper explores the methodology, application, and advantages of EII, and future research scope contributing to the refinement of delay analysis tools in the construction industry.

Keywords **– Delays, Delay quantification, Economic Importance Index (EII), Construction Project Scheduling**

I. INTRODUCTION

The construction industry, a crucial pillar of modern infrastructure development, faces persistent challenges, with delays emerging as a recurrent and multifaceted concern. The efficient management of construction projects demands a nuanced understanding of the factors influencing delays. Existing insightful methodologies, such as the Relative Importance Index (RII) and survey-based approaches, contribute significantly to decision-making processes but often lack precision in quantifying the financial impact of delays.

To address this limitation, our research introduces a novel framework—the Economic Importance Index (EII)—aimed at providing a more robust and objective measure of the criticality of delay factors in construction projects. The EII is designed to go beyond traditional survey-based tools by incorporating considerations of both the frequency and duration of delays, offering a more nuanced understanding of their economic ramifications. This paper explores the gap identification, development of EII, and its applications, positioning it as a valuable addition to the toolkit for construction project managers seeking data-driven insights into the economic implications of delays.

This research is driven by recognition of the need for a quantitative and objective approach to delay factor analysis in construction, acknowledging that the financial impact of delays extends beyond individual perceptions. By introducing the EII, we aim to contribute a comprehensive and adaptable methodology that aligns with contemporary demands for precise decision support in the dynamic realm of construction project management.

II. LITERATURE SURVEY

The delay in construction projects refers to the extension of time or time overruns in completing the project or late completion compared to the planned schedule. Delays can be defined on the basis of time and cost overruns. The owner defines delay as the increase in cost and contractor delay as overworking period. Delay is defined as the slowing down of labor without stopping construction completely and which can result in time overrun both past the contract date and past the date that the parties have agreed for the delivery of the project.[6] Since delay is associated with cost and time overrun, the phenomenon of delays has been a matter of concern for construction professionals as well as a topic of study. Some researchers have studied the reasons for delays and others studied the results of project delays in the construction sector. [18]

Delays in construction project leads to following negative impacts [1,2]

- Cost and time overrun
- Productivity losses
- Disputes and conflicts
- Contract termination

Available literature shows no standard method or framework to identify critical causes of delay and assess its impact on the construction project. The use of ambiguous phrases and unstructured identification of causes has resulted in the ineffectiveness of the study findings. Therefore, this study has developed a framework to identify critical causes of delay through a systematic approach. This systematic approach helps to identify critical causes of delay in a standardized format. The framework categorically sequences causes of delay and connects them to the responsible party. From the obtained data, three hundred thirty-five critical causes of delay were extracted, categorized into 14 groups, and summarized into 48 major critical causes presented in tables. This study provides a comprehensive list and reference of the critical causes identified in the past 10 years. The study also quantitatively analysed the collected data presented in tables. The developed framework and approach minimize alternate and ambiguous phrasing, enhance study findings application in practice, and increases the research outcome's consistency.[3]

It was found that the critical delay factors are identified by ranking given to each factor based on its Relative Importance Index (RII).

(M. Zadeh Et. Al. 2013) [4] A questionnaire was distributed among 52 experts working in the South Pars project, and the data were analyzed by descriptive and factor analysis methods. Descriptive analysis revealed that "Inflation and escalation of material prices and human resources salaries", "Unrealistic contract duration and requirements imposed" and "Political situation" were the most significant delay factors. Meanwhile, factor analysis indicates that "Improper construction methods", "Shortage of experienced and skilled labor" and "Long acceptance process (shop drawings, permits, tests and samples)" were the most important causes of delay.

(B. Ismaeli Et. Al. 2022)[5] the questionnaires were distributed to experienced project parties such as the owner, contractor, consultant and other parties. The relative importance method was used to analyze the results of the questionnaire to obtain the highest ten or five factors with the highest rank which cause delay. The results showed that the groups of contractor and owner have the highest percentage and were repeated several times compared to the rest of the groups. The top five factors causing delay of construction projects in Arab countries are, problems of cash flow and financial by owner, difficulties in financing the project by the contractor, Poor site management and supervision of the contractor, selecting the contractor who has the lowest bid and ineffective planning and scheduling by contractors.

(F. Tahmasebinia el. at. 2022)[6] Poor planning, scheduling, and material delivery are the top ten causes of construction delays in Cambodia, and collaborating among contractors, consultants, and owners is crucial for improving the industry.

(S. Mohamed el. at. 2022)[7] The proposed shop drawing framework effectively reduces delays in the submittal/approval process in construction projects by addressing top causes like rework due to errors, suspension of work due to changes, delays in sub-contractors' work, coordination problems in design drawings, and unrealistic schedules.

Relative Importance Index (RII)

R.H. Hooker and G.U. Yule discovered the relative importance index in 1906, while other researchers like Prance et al., Phillips and Gentry, Budescu, and Johnson developed variations of the concept in later years.[8, 9, 10].

The discovery of relative importance index aims to improve weight differentiation, provide a meaningful index for predictors in multiple regressions, and determine the importance of components for system reliability.[11, 12].

Relative importance indices, such as dominance analysis and relative weights, are effective tools for evaluating predictor importance in multiple regression analysis.[13]

Studies suggest that RII is used in construction projects for assessing contractor selection criteria, analyzing data for planning and management, and identifying factors influencing productivity, safety, quality, and sustainability. RII can be used for selecting contractors in civil engineering projects include managerial capability, technical ability, financial soundness, competitive tender/bid price, and health and safety policy/performance, which improve project success and minimize risks [14]. Resource availability, individual learning, decision making, proper work design, and resource allocation are the most influencing management factors in construction projects, which can be identified using RII [15]. Delays in construction projects in Hargeisa are mainly caused by payment delays, underestimation of project costs, and work scope changes. These delay factors are ranked using RII and then critical delay factors are identified.[16]

RII is calculated with the following equation [17],

$$RII = \frac{\sum W}{(A \times N)}$$

Where,
RII = Relative importance index
W = Weighing given to each factor by respondents
A = Highest weight assigned
N = Total number of respondents

Other analytical techniques

(M. Kumar el. at. 2022) [11] The results of this study with other developing countries indicated that relative importance index, frequency index, severity index, spearman's coefficient are observed to be the most famous data analysis techniques in different growing countries. All techniques are survey based.

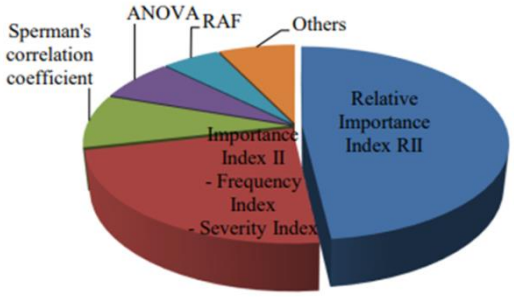

figure 1. delay analysis techniques used[11]

III. RESEARCH METHODOLOGY

Gap Identification

The prevalent use of ranking systems like the Relative Importance Index (RII) and other subjective methodologies in construction project research has brought to light a significant gap. These approaches, often rooted in surveys and subjective opinions, lack the solid foundation of objective Key Performance Indicators (KPIs). The resultant rankings are susceptible to individual biases, psychological factors, and varying perspectives within the industry. Recognizing the limitations of these existing methods, our research endeavors to bridge this gap by introducing a more precise and data-driven framework.

Limitations of using survey based methodology for quantitative analysis

RII and various methodologies prove effective in decision-making processes, contractor selection, and forecasting uncertainties. However, relying solely on survey-based tools for quantitative analyses, particularly in measuring the impact of delays or other parameters, may introduce inherent imprecision due to underlying logical constraints.

i. **Ambiguity**: It is the major limitation of these methodologies. Ranking is based on importance, but it is not specifically mention whether it is regarding intensity of impact or frequency of that delay factor. Additionally, the duration of delay, a crucial measure, is not explicitly addressed. Varied durations, even for less frequent delays, can significantly impact the project's economic aspects or vice versa.

ii. **Limited Scope**: Surveys typically have predetermined questions, limiting respondents' ability to provide nuanced or detailed information. This can restrict the depth of understanding regarding the impact of delays.

iii. **Subjective responses**: Respondents' perspectives are inherently subjective, influenced by their professional background, field of knowledge, and project-specific experiences. This subjectivity affects accuracy in responses.

iv. **Bias**: Respondents with positive experiences may downplay the impact of a delay factor, while those with negative experiences might emphasize its significance. Consider a delay due to "weather conditions"; individuals working in regions with frequent adverse weather may assign a higher importance ranking compared to those in areas with stable climates.

v. **Experience in field of knowledge**: Individual with broader period of experience will provide more insightful and valuable responses compared to less experienced individual.

vi. **Psychological factors**: Highly positive or highly negative state of mind of respondent can create unnecessary biases and influence their ability to respond precisely.

Concept of EII

"The Economic Importance Index (EII) is a quantitative measure that assesses the financial impact of various delay factors, often in the realm of project management, decision-making, or system analysis. It involves assigning numerical values or weights to different factors based on their economic implications. The EII provides a structured way to prioritize and evaluate elements according to their contribution to economic outcomes, helping stakeholders make informed decisions by considering the financial implications of each factor."

Economic Impact of any delay factor should be calculated as,

$$Economic\ Impact\ due\ to\ delay\ factor = \frac{Cost\ incurred\ by\ the\ delay\ factor}{Duration\ of\ the\ delay\ factor}$$

The value of economic impact is obtained in amount of money incurred per unit time. Relative ranking of Economic importance are then assigned to each with higher value as a most critical and important factor.

Cost of delay factor can be calculated by traditional methods of delay analysis or comparing planned schedule and actual schedule.

IV. APPLICATIONS OF EII

- To identify critical delay factors
- Prioritizing delay factors
- Monetary quantification of delay
- Decision making in construction project planning
- To assess time and cost overruns

V. LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

The Economic Importance Index (EII) can be an effective in evaluating the financial impact of delays in construction projects. However, to enhance its precision, future research should delve into considering not only the impact and duration of delay factors but also their frequency. It remains unclear whether the financial impact of specific delay factors remains consistent throughout the various stages of a project or if it evolves or how the position of delay in project timeline, affects its corresponding nature of impact. Understanding the relationship between the frequency of delay factors and their position in the project timeline is crucial for refining EII rankings. Researchers are encouraged to conduct case studies to assess the applicability of EII in diverse scenarios, thereby contributing to its continued improvement.

VI. CONCLUSION

In conclusion, the Economic Importance Index (EII) emerges as a valuable tool theoretically for assessing the financial impact of delays. Most critical delay factors can be identified and quantified through this tool and can aid in decision making for mitigating cost and time overruns in construction projects. By incorporating considerations for the frequency of delay factors, EII can offer a more nuanced understanding of their economic significance. The need for further case studies and exploration of how delay impacts evolve throughout project stages represents promising avenues for future research, enhancing the applicability and refinement of EII in construction management.

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