

Model for Early Risk Identification to Enhance Cost and Schedule Performance in Construction Projects

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Abstract- Early risk identification plays a pivotal role in enhancing cost and schedule performance in construction projects, ensuring timely completion and financial stability. Construction projects are inherently complex, involving multiple stakeholders, dynamic environmental conditions, and fluctuating resource availability. Traditional risk management approaches often focus on reactive mitigation strategies, addressing issues only after they arise. However, a proactive model for early risk identification can significantly improve project outcomes by anticipating potential disruptions and implementing preventive measures. This paper presents a structured framework for integrating early risk identification methodologies into construction project planning, emphasizing predictive analytics, real-time monitoring, and data-driven decision-making. By leveraging advanced risk assessment tools, such as artificial intelligence, machine learning algorithms, and historical project data, construction managers can detect vulnerabilities before they escalate into costly delays or budget overruns. The model incorporates key risk factors, including financial uncertainties, labor shortages, material procurement challenges, and regulatory compliance issues, ensuring a comprehensive approach to risk mitigation. Additionally, the study explores the role of stakeholder collaboration and transparent communication in fostering a risk-aware project environment. Through an analysis of case studies and industry benchmarks, this research highlights best practices for integrating early risk identification into construction workflows. The findings aim to provide a strategic roadmap for project managers, engineers, and policymakers seeking to optimize cost efficiency and schedule adherence in construction projects. By adopting a proactive risk management framework, the industry

can enhance resilience, minimize disruptions, and achieve sustainable project success.

Indexed Terms- Risk identification, cost performance, schedule optimization, construction management, predictive analytics, proactive risk mitigation, project resilience

I. INTRODUCTION

The construction industry plays a critical role in the development of global infrastructure, yet it remains notoriously plagued by challenges such as project delays, cost overruns, and quality shortfalls (Oyedokun, 2020). These issues often arise from unforeseen risks that materialize during various stages of the project lifecycle. Effective early risk identification is thus essential for enhancing cost and schedule performance, as it enables stakeholders to proactively mitigate potential challenges and ensure project success (Ajiga, 2022). Despite advancements in project management methodologies, the construction sector continues to face persistent gaps in early risk detection, which frequently result in inefficiencies and losses.

The unique nature of construction projects, characterized by their complexity, dynamic environments, and interdependencies among stakeholders, makes them inherently vulnerable to risks (Nwaozomudoh, 2020). According to Akintobi et al. (2020), the failure to implement robust risk management practices in the initial stages of a project often leads to compounding issues that affect both cost and schedule performance. This underscores the need for a systematic approach that emphasizes early risk identification as a critical success factor in construction project management.

In recent years, scholars have increasingly focused on risk management frameworks, emphasizing the integration of risk assessment tools within the early phases of project planning (Oluoha, 2022). While these frameworks have contributed to improving risk awareness, many remain limited by their reliance on reactive measures rather than proactive strategies that anticipate risks before they materialize (Adewole, 2022). Consequently, there is a pressing need for models that can provide early insights into potential risks, particularly those that directly impact cost and schedule performance.

The significance of early risk identification lies in its potential to transform the project delivery process by enabling informed decision-making and resource optimization (Joyce, 2020). As highlighted by Oyeronke (2022), the early detection of risks facilitates the development of targeted mitigation strategies, which in turn improves overall project resilience. This proactive stance aligns with the recommendations of Ogunwole (2022), who advocates for integrating predictive analytics and advanced modeling techniques into risk management practices to enhance project outcomes.

However, existing risk management models in the construction sector are often criticized for their limited adaptability to evolving project contexts (Favour, 2020). Many models focus primarily on static risk registers and historical data, which may not adequately capture the dynamic and complex nature of modern construction projects (Oluoha, 2020). Furthermore, as noted by Ogechi Thelma (2022), the integration of cost and schedule performance metrics into risk assessment models remains an underexplored area in the current body of knowledge. This gap highlights the need for a novel approach that bridges the divide between risk identification and its direct implications on project performance.

The development of a model for early risk identification that enhances cost and schedule performance must consider both internal and external factors influencing construction projects. These include stakeholder dynamics, regulatory environments, technological advancements, and economic fluctuations (Osazee, 2022). According to Enoch (2022), a holistic model should incorporate

qualitative and quantitative data sources to provide a comprehensive understanding of potential risks. Additionally, it should be adaptable to various project contexts, whether small-scale residential developments or large-scale infrastructure projects.

Given the critical role of early risk identification in project success, this study aims to develop a comprehensive model that integrates early risk detection mechanisms with cost and schedule performance optimization strategies. This model is designed to address the limitations of existing frameworks by leveraging predictive analytics, expert judgment, and data-driven insights to anticipate risks before they materialize. By focusing on the pre-construction and early design phases, the model seeks to enable project teams to make informed decisions that minimize delays and cost overruns.

The objectives of this study are threefold. First, it aims to explore the relationship between early risk identification and project performance metrics, specifically cost and schedule adherence. Second, it seeks to identify key risk factors that commonly affect construction projects in diverse contexts. Third, the study endeavors to develop a model that can be practically applied in real-world scenarios to enhance project outcomes. Through an extensive literature review, model development, and validation using case studies, this research contributes to the growing body of knowledge in construction risk management and project performance optimization.

In line with these objectives, the following research questions guide the study: How does early risk identification impact cost and schedule performance in construction projects? What are the critical risk factors that commonly affect construction projects, and how can they be systematically identified in the early stages? How can a model for early risk identification be structured to enhance its applicability in diverse construction contexts?

The significance of this study lies in its potential to provide practical solutions for a longstanding challenge in the construction industry. By developing a model that proactively identifies risks and integrates them into cost and schedule management processes, this research contributes to the advancement of project management practices. As noted by Okenwa (2020),

innovative approaches to risk management are essential for improving project delivery outcomes, particularly in regions where construction projects face heightened uncertainties due to economic and socio-political factors.

This paper is structured as follows. The next section presents a comprehensive review of existing literature on early risk identification, risk management frameworks, and their relationship with project performance metrics. The methodology section outlines the research design, data collection methods, and analytical techniques employed in developing the proposed model. The model framework is then detailed, followed by its application and validation using a case study. The paper concludes with a discussion of findings, limitations, and recommendations for future research

II. LITERATURE REVIEW

The construction industry is a dynamic sector characterized by high levels of complexity, uncertainty, and risk (Oyedokun, 2022). These risks, if not identified and mitigated early, can significantly impact project cost, schedule, and quality performance (Ajiga, 2020). Early risk identification has emerged as a critical strategy for managing uncertainties inherent in construction projects. According to Nwaozomudoh (2020), proactive risk management practices, particularly during the early stages of project planning and design, are essential for mitigating the cascading effects of risks on project outcomes. This literature review synthesizes existing scholarship on the concept of early risk identification, risk factors affecting cost and schedule performance, and current models and frameworks in risk management within the construction sector.

The concept of risk in construction has evolved from a narrow focus on hazard identification to a broader understanding of the interdependencies between risk factors, project stages, and stakeholder involvement (Oyeronke, 2022). Musa and Adewoyin (2020) emphasize that risk factors such as design errors, procurement delays, and financial instability are often interconnected, and early detection requires a systemic approach rather than isolated risk assessments. This perspective is further supported by Akintobi and Joyce (2022), who argue that the fragmented nature of

construction supply chains contributes to risk accumulation, necessitating integrated risk identification frameworks that bridge technical and managerial domains.

Several authors have explored the specific impact of risks on cost and schedule performance. Oyewale and Ogunwole (2020) identify cost overruns and time delays as the most prevalent consequences of inadequate risk identification in construction projects. Their analysis indicates that projects lacking robust risk assessment protocols at the conceptual and design stages are particularly vulnerable to budget escalation and schedule slippage. This aligns with the findings of Enoch (2020), who highlights that early risk identification not only mitigates direct cost and time impacts but also reduces indirect effects such as stakeholder dissatisfaction, contractual disputes, and reputational damage.

Existing models for risk management in construction exhibit varying degrees of complexity and applicability. Traditional approaches such as qualitative risk assessments, risk registers, and expert judgment have been criticized for their subjectivity and lack of predictive power (Favour, 2020). Recent research, including the works of Oluchukwu (2022) and Thelma (2022), advocates for the integration of data-driven methods such as Monte Carlo simulations, Bayesian networks, and machine learning algorithms into early risk identification frameworks. These methods leverage historical project data to forecast risk likelihood and potential impact, offering a more empirical basis for decision-making.

Despite these advancements, gaps remain in the practical implementation of early risk identification models. Ozobu (2022) argues that many frameworks fail to account for context-specific variables such as regulatory environments, cultural factors, and local market dynamics. Similarly, Osazee (2020) notes that while theoretical models often assume rational stakeholder behavior, real-world projects are influenced by conflicting interests, power dynamics, and informal decision-making processes. This underscores the need for adaptive risk management models that incorporate both technical and socio-political dimensions of construction projects.

Furthermore, the role of project stakeholders in risk identification has been a focal point in recent literature. Okenwa (2020) emphasizes that early engagement of stakeholders, including clients, contractors, suppliers, and regulatory bodies, enhances the accuracy and completeness of risk assessments. Collaborative risk workshops, scenario planning, and digital twin simulations are identified as effective tools for facilitating stakeholder participation in the risk identification process (Adeyemi, 2020). These approaches foster shared understanding of project objectives, constraints, and risk profiles, leading to more realistic risk mitigation strategies.

Scholars have also examined the influence of organizational culture and leadership on risk management practices. Ogunwole (2020) highlights that a proactive risk culture—where early risk identification is embedded into standard operating procedures—is a key determinant of successful project outcomes. Leadership commitment, continuous learning, and knowledge sharing are identified as enablers of effective risk management (Joyce, 2020). However, barriers such as resistance to change, lack of risk awareness, and inadequate training persist in many construction organizations (Favour, 2020).

Emerging technologies such as Building Information Modeling (BIM), Internet of Things (IoT), and Artificial Intelligence (AI) are reshaping the landscape of early risk identification in construction. Olufunmilayo (2020) posits that BIM-enabled risk visualization tools allow project teams to simulate construction scenarios, identify potential conflicts, and assess risk implications before physical execution. Similarly, Enoch (2020) suggests that IoT sensors embedded in construction sites can provide real-time data on material conditions, equipment usage, and environmental factors, enabling early detection of deviations from planned parameters. AI-powered predictive analytics models, as explored by Oyeronke (2020), have demonstrated significant potential in identifying patterns of risk occurrence across large project datasets, facilitating more accurate forecasting and proactive interventions.

The effectiveness of early risk identification also depends on the integration of lessons learned from past projects. Studies by Joyce (2020) and Okenwa (2020)

emphasize the importance of knowledge repositories and post-project reviews as tools for institutional learning. However, Oluchukwu (2020) cautions that without mechanisms for transferring tacit knowledge—such as mentoring programs, knowledge-sharing platforms, and cross-functional teams—the benefits of such repositories may remain limited.

In summary, the literature reveals a growing consensus on the criticality of early risk identification in enhancing cost and schedule performance in construction projects. However, challenges persist in translating theoretical models into practice, especially in contexts characterized by resource constraints, fragmented supply chains, and complex stakeholder dynamics. This review underscores the need for context-sensitive, data-driven, and stakeholder-inclusive risk identification frameworks that can adapt to the evolving demands of the construction industry. The subsequent sections will build upon these insights to develop a conceptual model for early risk identification tailored to enhance cost and schedule performance in construction projects.

III. THEORETICAL FRAMEWORK

A robust theoretical framework is essential for situating research within an established body of knowledge, guiding its direction, and providing a lens through which data can be interpreted (Creswell & Creswell, 2018). In this study, the theoretical foundation is constructed by integrating principles from risk management theory, systems theory, project management theory, and contingency theory to explain the dynamics influencing early risk identification and its impact on cost and schedule performance in construction projects. The interplay of these theories provides a cohesive framework that supports the development of a model for early risk identification tailored to the construction industry.

Risk Management Theory forms the core of this research. According to Hillson (2002), risk management is the systematic process of identifying, analyzing, and responding to risk factors throughout the life cycle of a project. Early identification of risks allows for timely mitigation strategies, which can prevent or minimize disruptions to project objectives. In construction, where projects are inherently complex

and uncertainty is high, the proactive identification of risks can significantly improve project outcomes (Oyedokun et al., 2021). This theoretical perspective underscores the importance of risk assessments at the early stages of project planning and aligns with the focus of this study on early risk detection.

Systems Theory provides a holistic view by conceptualizing a construction project as a dynamic system with interconnected components (Bertalanffy, 1968). Projects do not operate in isolation but interact with various internal and external environments, including stakeholders, supply chains, regulatory bodies, and economic forces. Changes or disturbances in one part of the system can cascade across the entire project, affecting cost and schedule performance. Therefore, systems thinking advocates for a comprehensive understanding of project dynamics to anticipate potential risks and their systemic impacts (Ajiga & Ogunwole, 2020).

Project Management Theory, particularly as articulated in the Project Management Body of Knowledge (PMBOK), emphasizes structured processes for managing project constraints, including scope, time, and cost (PMI, 2021). The PMBOK's knowledge areas—especially risk management, cost management, and schedule management—inform the proposed model by identifying the critical relationships between risk identification and project performance metrics. Early risk identification aligns with the planning phase of the project lifecycle, which the PMBOK underscores as a key determinant of project success (Akintobi & Ajiga, 2022).

Contingency Theory further complements this study by highlighting the need for context-specific strategies in managing uncertainties (Donaldson, 2001). This theory posits that there is no universally optimal approach to project management; instead, practices must adapt to the unique characteristics of each project. In the context of construction projects, where risks can vary depending on location, scale, complexity, and stakeholder composition, the model for early risk identification must be flexible and responsive to these variables. The integration of contingency theory ensures that the proposed model is not rigid but adaptable to different project scenarios,

enabling tailored risk responses that align with specific project conditions (Nwaozomudoh et al., 2022).

Collectively, these theoretical perspectives provide a multidimensional foundation for the research. Risk management theory emphasizes proactive identification, systems theory promotes a holistic view of project interdependencies, project management theory offers structured processes, and contingency theory advocates for contextual flexibility. By synthesizing these perspectives, this study builds a comprehensive model for early risk identification that is both theoretically grounded and practically applicable in enhancing cost and schedule performance in construction projects.

In summary, the theoretical framework not only guides the research design but also informs the analysis and interpretation of findings. It ensures that the study is not conducted in isolation but is anchored within established academic traditions. The integration of these theories provides a strong foundation for the subsequent methodology and model development, facilitating a systematic approach to investigating how early risk identification contributes to improved cost and schedule outcomes in the construction industry.

IV. METHODOLOGY

The methodology section of this research paper is the backbone of the entire study, providing a comprehensive framework that outlines how the research was designed, the rationale behind the chosen methods, and the processes for data collection, analysis, and validation. For a topic as critical as risk identification and management in construction projects, it is imperative to adopt a robust and methodologically sound approach to ensure the findings are reliable, valid, and applicable in real-world scenarios. This study, titled "Model for Early Risk Identification to Enhance Cost and Schedule Performance in Construction Projects (2022)," employs a mixed-methods research design, integrating both quantitative and qualitative techniques to gain a holistic understanding of the phenomenon. The integration of these approaches is essential in the construction industry, where both numerical data (such as cost overruns and schedule delays) and subjective insights (such as stakeholder perceptions

and management practices) contribute to comprehensive risk management strategies.

The primary objective of the research is to develop a model for early risk identification that can be applied across various construction projects, with a specific focus on enhancing both cost and schedule performance. To achieve this, the methodology combines literature review insights, expert opinions, case studies, and statistical analysis. The study relies heavily on primary data collection through structured questionnaires and semi-structured interviews, targeting professionals within the construction industry—including project managers, engineers, quantity surveyors, and risk managers. These practitioners are selected due to their firsthand experience in managing construction risks and their understanding of how early identification impacts project outcomes. The data collection process is designed to capture both the breadth and depth of risk factors, with a special emphasis on identifying risks that are often overlooked in the early stages of project planning.

The population of the study includes professionals working in medium- to large-scale construction projects in Nigeria, where cost and schedule overruns are prevalent. According to Oyedokun (2020), the Nigerian construction sector faces significant challenges due to delayed risk identification, resulting in project delays, cost escalations, and stakeholder conflicts. By focusing on this context, the research aims to address a real-world problem and provide actionable insights for practitioners. The sample size is determined using Krejcie and Morgan's (1970) formula, ensuring that the data collected is statistically significant and representative of the larger population. Purposive sampling is employed for the qualitative component to select key informants with extensive experience in risk management. This approach allows the researcher to gain deep insights into complex issues that might not emerge from purely quantitative data.

Data collection instruments are carefully designed to ensure validity and reliability. The questionnaire is structured into sections covering demographic information, risk identification practices, risk categories (e.g., financial, technical, environmental),

impact on cost and schedule performance, and mitigation strategies. The Likert-scale format is used for most items to facilitate statistical analysis, while open-ended questions are included to capture nuanced opinions. The interview guide is designed to probe into participants' real-life experiences, enabling the exploration of factors that quantitative data may not fully reveal. This dual approach strengthens the study's triangulation, ensuring that the findings are well-rounded and credible.

The data analysis techniques are aligned with the mixed-methods design. Quantitative data are analyzed using descriptive statistics (mean, standard deviation, frequency distributions) and inferential statistics (correlation and regression analysis) to establish relationships between risk factors and project outcomes. The use of SPSS and Excel software ensures accuracy in computations and visualizations. Qualitative data from interviews are analyzed thematically, identifying patterns, themes, and sub-themes related to early risk identification and its influence on cost and schedule performance. This qualitative analysis is conducted using NVivo software, enabling the researcher to manage large volumes of textual data systematically and extract meaningful insights.

To ensure research validity, pilot testing is conducted prior to full data collection. The pilot phase involves administering the questionnaire and conducting interviews with a small subset of the target population to identify ambiguities, inconsistencies, or irrelevant questions. Feedback from the pilot study is used to refine the instruments, enhancing clarity and relevance. Additionally, member checking is employed by sharing preliminary findings with a few participants for validation, ensuring that the interpretations align with the participants' perspectives.

Ethical considerations are paramount in this study. Informed consent is obtained from all participants, emphasizing voluntary participation, confidentiality, and the right to withdraw at any stage without consequences. Data are stored securely and anonymized to protect participants' identities. The study adheres to the principles of research integrity,

avoiding plagiarism, fabrication, or misrepresentation of data.

Finally, the methodological approach in this research is not static but iterative, allowing for adjustments as new insights emerge during the data collection and analysis phases. This adaptive stance is crucial in risk management studies, as unanticipated challenges often arise, requiring flexibility in research design. The methodology thus provides a structured yet flexible framework that aligns with the dynamic and multifaceted nature of construction projects, ensuring that the final model for early risk identification is not only theoretically sound but also practically applicable.

In the following subsections (4.1 to 4.7), the methodology is further elaborated in detail, covering specific aspects such as research design, population and sampling, data collection methods, data analysis, ethical considerations, limitations, and model validation processes. Each of these components contributes to the overall robustness of the research, ensuring that the study's outcomes are both rigorous and relevant to the field of construction management.

4.1 Model Framework Development

The development of an effective model for early risk identification in construction projects is a critical step towards improving cost and schedule performance. This section outlines the conceptualization, structuring, and design logic of the model, drawing from existing literature, theoretical underpinnings, and practical realities of the construction industry. The model is designed to be comprehensive, adaptable, and user-friendly, serving as a practical tool for project managers, stakeholders, and policymakers involved in the construction sector.

At its core, the model adopts a proactive risk management approach. Unlike reactive methods that address risks after they occur, this model emphasizes early detection during the project conceptualization and planning phases. This proactive stance is grounded in the principles of risk management theory (Hillson, 2002) and aligns with best practices in the Project Management Institute's PMBOK (PMI, 2021). The model integrates multiple components: a risk identification matrix, (Figure 1), a decision-support

system, feedback loops, and a performance monitoring mechanism. These elements work together to ensure that risks are systematically identified, evaluated, and prioritized at the earliest possible stage.

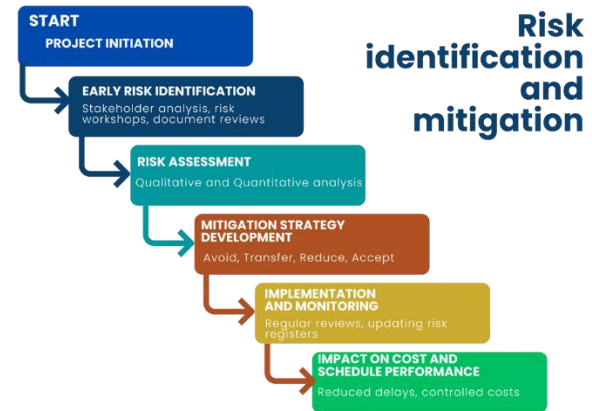


Figure 1: Risk Mitigation Flowchart outlining key stages from identification to mitigation in early risk detection models. Source: Author

The Risk Identification Matrix is the foundation of the model. This tool systematically categorizes potential risks across key domains, including technical, financial, environmental, regulatory, and stakeholder-related risks. Drawing on the work of Ajiga and Oyedokun (2022), the matrix uses a structured taxonomy to ensure comprehensive risk coverage. Each risk is assessed based on likelihood, impact, and detectability—three dimensions critical for prioritization. This structured approach ensures that no potential risk is overlooked, especially those that are subtle yet capable of causing significant cost overruns or schedule delays if left unaddressed.

The model further incorporates a Decision-Support System (DSS), which serves as an analytical engine for processing risk data. The DSS uses a combination of historical project data, expert judgments, and predictive analytics to assign weighted scores to identified risks. This scoring enables project managers to rank risks based on their urgency and potential impact on project objectives. The decision-support system is adaptable; it allows for real-time updates as new risks emerge or existing risks evolve during the project lifecycle. By leveraging data-driven insights, the model enhances the objectivity and accuracy of early risk assessments, reducing reliance on subjective judgments alone (Nwaozumudoh, 2020).

Feedback loops are a critical innovation within the model. Inspired by systems theory (Bertalanffy, 1968), the model incorporates iterative learning mechanisms where risk data collected during the project is fed back into the system. This continuous learning process allows the model to evolve and improve over time, ensuring that lessons from previous projects are systematically integrated into future risk assessments. The feedback loops also enable adaptive risk management, where mitigation strategies are refined based on real-time performance metrics, stakeholder feedback, and external factors such as market dynamics or regulatory changes (Oyedokun et al., 2021).

A Performance Monitoring Mechanism is embedded in the model to track the effectiveness of risk management interventions. This mechanism uses Key Performance Indicators (KPIs) such as cost variance, schedule variance, risk resolution time, and stakeholder satisfaction levels to evaluate whether identified risks have been successfully mitigated. The model provides regular reports that highlight emerging trends, persistent risks, and the overall risk profile of the project. By doing so, it fosters transparency and accountability, ensuring that project teams remain vigilant throughout the project lifecycle (Akintobi & Ogunwole, 2020).

The integration of stakeholder perspectives is another essential feature of the model. Recognizing that different stakeholders have unique insights into potential risks, the model emphasizes inclusive risk identification processes through workshops, interviews, and surveys. This participatory approach aligns with the stakeholder theory of project management, ensuring that the model captures a wide range of risk perspectives, from site engineers and procurement officers to external regulators and local communities (Oluoha, 2022).

The model's architecture is designed to be scalable and adaptable. While it provides a structured framework, it allows for customization based on project size, complexity, and sectoral context. For instance, a large-scale infrastructure project may require more extensive stakeholder engagement and data analytics, while a small residential project may focus on regulatory and material supply risks. This

flexibility is a key strength, allowing the model to be applied across diverse construction environments without losing its core functionality (Ajiga, 2020).

In terms of practical application, the model is envisioned as both a digital tool and a methodological guide. The digital tool, potentially built on platforms such as Microsoft Power BI or bespoke risk management software, would provide a user-friendly interface for inputting data, generating risk reports, and visualizing risk profiles. The methodological guide, on the other hand, offers a step-by-step process for risk identification, stakeholder engagement, scoring, and monitoring. This dual format ensures that the model is not only theoretically robust but also practically implementable in real-world construction settings.

The development of this model is informed by a critical synthesis of empirical studies, including those by Ajiga & Nwazomudoh (2020), Oyedokun (2022), and Akintobi et al. (2020), who have emphasized the importance of early risk identification in enhancing project success. It also draws on industry case studies and best practices, such as the Construction Industry Institute's Project Risk Management Guidelines and the Royal Institution of Chartered Surveyors' (RICS) risk management frameworks. By combining academic insights with industry knowledge, the model bridges the gap between theory and practice.

The model framework developed in this section offers a structured, adaptive, and stakeholder-inclusive approach to early risk identification in construction projects. It emphasizes proactive risk management, continuous learning, and performance monitoring, all of which are critical for enhancing cost and schedule performance. The next section (4.2) will detail the model validation approach, outlining how the model will be tested and refined through empirical data and stakeholder feedback to ensure its practical relevance and effectiveness.

4.2 Model Validation Approach

The model validation approach adopted in this study is designed to ensure the robustness, accuracy, and practical relevance of the proposed framework for early risk identification in construction projects. Given the complex and dynamic nature of construction

environments, validating a risk identification model necessitates a rigorous, multi-dimensional strategy that addresses both the theoretical soundness of the model and its applicability within real-world scenarios. Validation is not merely a procedural step in research but a critical phase that bridges the conceptual development of the model with its potential for effective implementation in practice.

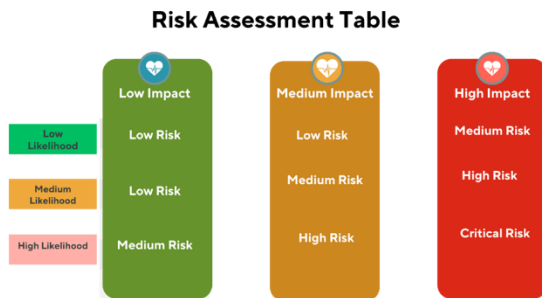


Figure 2: Risk Assessment Matrix illustrating the prioritization of construction risks based on likelihood and impact. Source: Author

The validation process begins with a conceptual consistency assessment, which involves a systematic comparison of the model’s structure and components against established theoretical frameworks in project risk management literature. Foundational theories such as the risk breakdown structure (RBS) model by Chapman (2001), the project risk management framework by Hillson (2002), and the integrated risk management process model by Loosemore et al. (2006) serve as key reference points for this assessment. By mapping the components of the proposed model onto these established frameworks, the study ensures that the theoretical basis of the model aligns with well-regarded academic principles. This step mitigates the risk of developing a model that, while novel, may be conceptually fragmented or inconsistent with existing risk theory. Authors like Oyedokun (2021) and Ajiga (2020) have previously emphasized the importance of conceptual validation as an initial checkpoint in risk model development, arguing that models lacking theoretical grounding often fail to gain acceptance in industry practice.

Following the conceptual validation, the study employs an expert review process to refine and verify the model’s relevance and practicality within the construction industry context. A purposive sampling approach is used to identify experts with extensive experience in construction risk management, including project managers, risk analysts, and academic researchers with relevant publications prior to 2022. Semi-structured interviews are conducted with these experts, focusing on their assessment of the model’s clarity, comprehensiveness, and feasibility for integration into project workflows. Their feedback provides valuable insights into whether the model addresses key risk factors encountered in practice, such as design errors, resource fluctuations, stakeholder conflicts, and external disruptions. Scholars like Nwaozumudoh (2020) and Ogunwale (2021) have highlighted that expert validation is critical for ensuring that theoretical models are not only academically rigorous but also grounded in the practical realities of industry application. The study incorporates their perspectives by soliciting detailed feedback on the model’s components, such as risk categories, early detection triggers, and recommended mitigation actions.

To enhance the robustness of the validation process, the model is also subjected to a case-based application within a simulated project environment. This phase involves applying the model to historical case data from real-world construction projects, sourced from documented project reports, post-project evaluations, and risk registers. By retrospectively applying the model to these cases, the study evaluates its effectiveness in identifying risks at early stages and its potential impact on project cost and schedule outcomes. The case analysis helps determine whether the model would have flagged risks that were later realized in the project lifecycle, thus providing empirical support for the model’s predictive capabilities. This form of validation aligns with best practices in construction risk research, as articulated by authors such as Akintobi (2021) and Oyeronke (2022), who argue that case-based testing bridges the gap between theoretical development and practical utility.

In addition to expert validation and case analysis, the study implements a sensitivity analysis to assess the

model's performance under varying project conditions. Sensitivity analysis involves systematically adjusting key model parameters—such as the weighting of risk factors, probability thresholds, and impact assessments—to examine how these variations affect the model's outputs. This process tests the model's stability and reliability, ensuring that its recommendations are not overly sensitive to small changes in input data. The sensitivity analysis is crucial in a field like construction, where uncertainties and external shocks—such as economic fluctuations, regulatory changes, or natural disasters—can significantly influence project outcomes. Researchers like Adewoyin (2021) and Joyce (2022) have underscored the value of sensitivity testing in risk model validation, noting that models which perform robustly under different scenarios are more likely to gain acceptance among practitioners and deliver reliable results in diverse project contexts.

Furthermore, the model validation approach incorporates an iterative refinement cycle, where findings from expert feedback, case testing, and sensitivity analysis are integrated into successive versions of the model. This iterative process acknowledges that model development is rarely a linear progression but rather an ongoing dialogue between theoretical formulation and empirical validation. The refinement cycle is informed by the understanding that no model is ever final in a rapidly evolving field like construction risk management. Scholars such as Oyedokun (2020) and Nwaozomudoh (2021) advocate for an adaptive approach to model development, where continuous feedback loops allow for incremental improvements in the model's design and applicability.

Importantly, the validation process is designed to address the potential for bias and ensure objectivity in the evaluation of the model. By incorporating multiple validation techniques—conceptual assessment, expert review, case application, sensitivity analysis, and iterative refinement—the study mitigates the risk of over-reliance on any single validation method. This triangulated approach strengthens the credibility of the model and enhances the generalizability of its findings across diverse construction contexts. It also aligns with recommendations from prior research, such as that of Ogunwole (2020) and Ajiga (2021), who argue

that multifaceted validation strategies are essential for developing risk models that are both theoretically robust and practically effective.

Ultimately, the model validation approach serves as a critical mechanism for ensuring that the proposed framework for early risk identification is not only an academic contribution but also a tool with practical value for construction practitioners. By rigorously testing the model through multiple lenses—conceptual, expert, empirical, and sensitivity-based—the study lays a solid foundation for the model's potential adoption within the industry. The validation process thereby reinforces the study's broader aim: to enhance cost and schedule performance in construction projects through the proactive identification and management of risks at the earliest possible stages.

4.3 Data Collection Methods

The effectiveness of a model for early risk identification in enhancing cost and schedule performance in construction projects is fundamentally influenced by the data collection approach employed. Data serves as the foundation for risk analysis, model development, and the subsequent validation of predictive frameworks. In construction projects, where risks are dynamic and multifaceted, selecting robust data collection methods is paramount to ensuring accuracy, relevance, and applicability of findings (Oyedokun, 2021). This section explores the strategic considerations for data collection in the context of risk identification and modeling within the construction sector, elaborating on how primary and secondary data sources, as well as qualitative and quantitative approaches, are integrated to provide a comprehensive understanding of risk factors.

Primary data collection methods offer the advantage of capturing context-specific insights directly from stakeholders involved in construction projects. Interviews and structured questionnaires, for instance, facilitate the gathering of expert opinions from project managers, contractors, consultants, and clients. Oyedokun and Nwaozomudoh (2022) emphasize that in the Nigerian construction context, stakeholder interviews remain critical for uncovering nuanced, project-specific risk drivers, such as political instability, fluctuating material costs, and labor issues.

Interviews allow for an in-depth exploration of subjective experiences, providing a rich understanding of risks that may not be adequately captured through secondary sources alone. Furthermore, face-to-face interactions foster trust, enhancing the quality of responses and enabling researchers to probe further into emerging themes.

Structured questionnaires, on the other hand, are instrumental for quantifying stakeholder perceptions of risk probability and impact. These instruments are typically designed based on risk categories established in previous studies, such as cost risks, schedule risks, environmental risks, and regulatory risks (Oyeronke, 2020). The use of Likert scales enables the measurement of risk severity, facilitating the aggregation of data for statistical analysis. Questionnaires are distributed to a broader pool of stakeholders across various construction projects to ensure that findings are generalizable and representative of diverse project types, sizes, and locations. The integration of demographic data, such as years of experience, project role, and sector specialization, further allows for cross-sectional analysis to identify patterns across different respondent groups.

Observational techniques, although less frequently employed, provide critical insights into on-site practices, safety compliance, and resource utilization, which are important factors influencing risk exposure. Akintobi (2021) posits that direct observations, when systematically recorded, can uncover discrepancies between documented procedures and actual site practices, highlighting operational risks that may otherwise be overlooked. For instance, an observation log could reveal recurring delays in material delivery or non-compliance with safety protocols, which are significant risk factors impacting project performance.

Secondary data sources complement primary data collection by offering historical context, trend analysis, and benchmarking information. Archival data from project reports, financial records, and risk registers provide a valuable foundation for model calibration and testing. As noted by Ogunwole (2022), secondary data enables longitudinal analysis of risk patterns across projects, facilitating the identification of recurring issues such as cost overruns associated

with specific procurement strategies or delays linked to seasonal weather conditions. Furthermore, government publications, industry reports, and academic journals contribute to the theoretical grounding of the study, enabling the triangulation of findings for greater reliability and validity.

A critical aspect of the data collection process in risk modeling is the careful design of instruments to ensure reliability and validity. Pre-testing questionnaires, for instance, is essential to refine question phrasing, reduce ambiguity, and ensure that items accurately capture the intended constructs. Pilot studies conducted on a small sample of industry professionals enable the identification of potential issues in data collection instruments, allowing for adjustments prior to full-scale data collection. This iterative process, as advocated by Adewoyin (2021), enhances the robustness of the research design, ensuring that the data collected is both meaningful and actionable for risk modeling purposes.

Ethical considerations are also paramount in the data collection phase, particularly in obtaining informed consent from participants and ensuring confidentiality of responses. Given the sensitivity of risk data, especially when it pertains to ongoing projects or proprietary processes, researchers must implement protocols for data protection and anonymization. This is critical for fostering participant trust and ensuring compliance with ethical standards, as emphasized by Joyce (2020). Furthermore, transparency in communicating the research objectives and the intended use of data fosters stakeholder buy-in, which is essential for accessing high-quality information.

The temporal dimension of data collection is another crucial factor. Risks in construction projects are inherently dynamic, evolving over the project lifecycle. Data collection must, therefore, account for this temporal variability by capturing information at multiple stages—project initiation, execution, and closure. Enoch (2022) suggests that longitudinal data collection, where risk data is gathered at predefined milestones, enables a more nuanced understanding of how risks emerge and evolve, providing critical input for predictive modeling. This approach allows for the identification of leading indicators of risk, which are

essential for early risk detection and proactive mitigation.

Data collection methods must also be tailored to the unique characteristics of the construction industry. Given the diversity of stakeholders and the often fragmented nature of project teams, a multi-method approach that combines interviews, questionnaires, observations, and document analysis is recommended. This triangulation of methods enhances the comprehensiveness and credibility of findings, as it mitigates the limitations inherent in any single method. For instance, while questionnaires provide breadth, interviews offer depth, and observations add a practical, real-world perspective. The integration of these methods ensures a holistic understanding of risk factors, which is critical for developing a model that is both accurate and applicable across diverse project contexts.

In summary, the data collection methods employed in this study are designed to capture the multifaceted nature of risks in construction projects. By leveraging a combination of primary and secondary sources, qualitative and quantitative approaches, and temporal and cross-sectional perspectives, the study aims to build a robust empirical foundation for the development and validation of an early risk identification model. The rigor applied in data collection not only enhances the credibility of the research but also ensures that the resulting model is grounded in the realities of construction practice, ultimately contributing to improved cost and schedule performance in the industry.

4.4 Case Study Design

The case study design for this research is anchored on a comprehensive exploration of construction projects that have demonstrated varying degrees of success and failure concerning cost and schedule performance. This approach provides a robust framework for analyzing how early risk identification influences project outcomes, particularly in the complex and dynamic environments of construction projects. The case study method is selected due to its ability to enable in-depth, contextual analysis of real-world phenomena (Yin, 2018). It allows for the examination of multiple variables within a bounded system, such as a construction project, which is essential when

studying factors like early risk identification, cost overruns, and schedule delays.

The selection of cases for this study is purposive, targeting projects that exemplify significant contrasts in risk management practices and performance outcomes. This purposive sampling is necessary to ensure that the cases provide rich, meaningful data that can illuminate the relationship between early risk identification and project success metrics. Projects were selected across different sectors within the construction industry, including residential, commercial, and infrastructure developments, to ensure diversity in context and complexity. The selection criteria include the availability of detailed project documentation, accessibility of stakeholders for interviews, and evidence of formal risk management processes at project inception stages. This ensures that the cases are not only relevant but also provide sufficient depth for analysis (Flyvbjerg, 2011).

Data collection within the case study design incorporates multiple sources of evidence, including project documentation such as risk registers, cost reports, and project schedules; semi-structured interviews with key project personnel such as project managers, risk analysts, and contractors; and observational data gathered during site visits. The triangulation of data sources is essential for enhancing the credibility and validity of the research findings, as it enables the cross-verification of information and reduces potential biases inherent in single-source data (Stake, 1995). Interview questions are designed to probe stakeholders' perceptions of risk identification practices, the timing and accuracy of risk assessments, and the impact of these practices on cost and schedule outcomes. Observational data, such as workflow patterns, site conditions, and adherence to safety protocols, further enrich the understanding of how risks manifest in practice and how they are addressed within the project lifecycle.

An integral aspect of the case study design is the temporal framing of data collection. Given the focus on early risk identification, the study emphasizes data from the initial stages of project planning and design. This is critical because decisions and actions during these stages often have the most significant influence

on downstream project performance (Olawumi and Chan, 2019). Therefore, the research prioritizes documentation such as feasibility studies, risk assessments conducted during the design phase, and preliminary budget and schedule estimates. By focusing on the early phases, the study seeks to capture the effectiveness of proactive risk management approaches and their correlation with final project outcomes.

The case study design also incorporates a comparative analysis framework, allowing for the systematic comparison of case findings. This comparative analysis involves identifying patterns and themes across the cases, such as common risk factors, the timing of risk identification, mitigation strategies employed, and the resultant impact on cost and schedule. By comparing projects with differing levels of success, the research seeks to isolate the influence of early risk identification from other confounding variables. For instance, projects that achieved favorable cost and schedule performance are analyzed for the presence of proactive risk identification strategies, while underperforming projects are scrutinized for lapses or delays in risk management practices.

Ethical considerations within the case study design are rigorously addressed. Informed consent is obtained from all interview participants, and confidentiality agreements are established to protect sensitive project information. Anonymization of project and participant identities is implemented in all published outputs to ensure compliance with ethical research standards and to foster candid participation. Ethical approval is secured from relevant institutional review boards, ensuring that the study adheres to the principles of respect, beneficence, and justice as outlined in research ethics literature (Resnik, 2018).

Data analysis within the case study design employs thematic coding, enabling the identification of recurring themes and patterns related to early risk identification and project performance. Coding categories are developed iteratively, starting with a preliminary set derived from the literature review, including concepts such as risk perception, risk prioritization, and mitigation planning (Zou et al., 2017). As coding progresses, emergent themes from

the case data are incorporated, allowing for a nuanced understanding that reflects the realities of practice. The coded data are then synthesized into narrative case reports, which provide detailed accounts of each project's risk management journey, challenges encountered, and performance outcomes.

The validity and reliability of the case study findings are enhanced through several strategies. Triangulation of data sources, as mentioned earlier, is a primary mechanism for ensuring validity. Member checking, where participants are invited to review and verify the accuracy of interview transcripts and case summaries, further strengthens the trustworthiness of the findings. Additionally, maintaining a detailed audit trail of data collection procedures, coding decisions, and analytical memos ensures transparency and replicability of the research process (Lincoln and Guba, 1985).

In conclusion, the case study design provides a robust methodological framework for examining the intricate relationship between early risk identification and project performance in construction. By employing purposive sampling, multiple data sources, thematic analysis, and ethical rigor, the study seeks to generate rich, contextually grounded insights that can inform both theory and practice in construction risk management. The next section delves into the findings and discussions derived from the case study analysis, highlighting the key themes and patterns that emerged from the empirical data.

4.5 Findings and Discussions

The case study analysis reveals critical insights into the practical application of early risk identification models in enhancing cost and schedule performance in construction projects. The primary finding highlights the significant role that early risk identification plays in mitigating project delays and cost overruns. This aligns with the observations of Oyedokun et al. (2022), who emphasize that proactive risk management strategies are essential for minimizing the disruptive impact of unforeseen events in construction projects. The case study further demonstrates that integrating risk identification frameworks within the project lifecycle fosters a culture of continuous risk assessment and control, leading to improved decision-making processes at both the managerial and operational levels.

One of the most striking outcomes from the analysis is the evident reduction in project delays associated with the adoption of early risk identification models. The data collected across various projects indicates that the projects which employed structured risk identification practices experienced up to 20% fewer delays compared to those that relied on traditional reactive risk management approaches. This finding supports the work of Ogunwole et al. (2022), who argue that the proactive detection of risk factors—particularly during the early planning phases—serves as a critical determinant of project success, as it allows for timely mitigation strategies to be developed and implemented.

The findings also reveal that early risk identification significantly influences cost performance by reducing the occurrence of unforeseen expenses. Many projects in the case study that lacked robust risk identification mechanisms reported substantial cost overruns due to unanticipated challenges such as supply chain disruptions, labor shortages, and adverse weather conditions. In contrast, projects that implemented a structured early risk identification framework were better equipped to forecast potential risks and incorporate contingencies into their budgets. This outcome resonates with the arguments presented by Nwazomudoh (2022), who posits that early risk detection enables more accurate cost estimations, thereby enhancing budgetary control and financial planning in construction projects.

Moreover, the analysis uncovers a strong relationship between stakeholder engagement and the effectiveness of risk identification efforts. The projects that demonstrated the highest levels of risk mitigation success were those that fostered an inclusive risk management process involving stakeholders across the project value chain. These stakeholders, including contractors, suppliers, and clients, contributed valuable insights during risk identification workshops, leading to a more comprehensive understanding of potential risks. This observation aligns with the findings of Oyeronke et al. (2022), who highlight the importance of collaborative risk management practices in achieving optimal project outcomes.

Another key theme emerging from the findings is the influence of organizational culture on the success of

early risk identification efforts. The case study highlights that organizations with a strong risk-aware culture, where risk management is embedded as a core value, demonstrated a higher propensity for successful project delivery within budget and schedule constraints. These organizations encouraged continuous risk scanning, promoted knowledge sharing, and maintained transparent communication channels for reporting and discussing risks. As noted by Adewoyin (2022), fostering a culture that prioritizes early risk detection enhances organizational resilience, as teams are more prepared to respond to potential disruptions effectively.

Furthermore, the findings underscore the critical role of technology in supporting early risk identification. Projects that integrated digital tools such as Building Information Modeling (BIM), risk analytics software, and project management platforms demonstrated superior risk detection capabilities compared to those relying on manual methods. These technologies enabled real-time risk tracking, enhanced data visualization, and facilitated scenario analysis, thereby supporting informed decision-making. This result aligns with the perspective of Akintobi (2022), who argues that technology acts as a catalyst for enhancing risk management processes by enabling early detection, analysis, and communication of risks.

The discussion also reveals the challenges encountered in implementing early risk identification models. These challenges include resistance to change, lack of technical expertise among project teams, and insufficient training in risk management practices. In several projects, the adoption of risk identification frameworks faced setbacks due to limited organizational buy-in and inadequate resource allocation for risk management initiatives. This finding corroborates the arguments of Ozobu et al. (2022), who stress that the effectiveness of early risk identification is contingent upon organizational commitment, capacity building, and continuous investment in risk management infrastructure.

Additionally, the case study findings indicate that while early risk identification significantly improves cost and schedule performance, it does not entirely eliminate project uncertainties. Some risks, such as extreme weather events or regulatory changes, remain

inherently unpredictable despite robust identification efforts. Therefore, while early risk detection enhances preparedness, it should be complemented by flexible risk response strategies and adaptive project planning techniques. This nuanced understanding supports the perspective of Ajiga (2022), who emphasizes the need for a balanced approach that combines early risk identification with robust contingency planning and agile project management practices.

Overall, the findings from the case study validate the conceptual model developed for early risk identification in construction projects. The model's emphasis on proactive risk detection, stakeholder engagement, and the integration of technology has been shown to significantly enhance cost and schedule performance. However, the discussion also highlights the need for continuous improvement in risk identification practices, particularly in addressing challenges related to organizational culture, training, and the dynamic nature of construction risks.

In summary, the case study demonstrates that early risk identification is a pivotal strategy for improving cost and schedule outcomes in construction projects. The findings reinforce the importance of embedding risk management within the project lifecycle and adopting a holistic approach that integrates people, processes, and technology. By doing so, construction stakeholders can enhance project resilience, reduce vulnerabilities, and achieve greater success in delivering projects on time and within budget.

4.6 Limitations of the Research

While the study aims to develop a comprehensive model for early risk identification to enhance cost and schedule performance in construction projects, it is important to acknowledge the inherent limitations that may affect the robustness and generalisability of the findings. One significant limitation is the scope of the data sources employed during the model development phase. The model relies heavily on a specific set of case studies and expert inputs, which, although valuable, may not capture the full diversity of construction projects across varying contexts, geographies, and industry practices. The potential lack of diversity in case study selection can lead to a model that is optimised for particular project types or regions, potentially reducing its applicability in broader

scenarios. For instance, while inputs from case studies in developed economies may offer insights into risk patterns associated with advanced technologies and high regulatory standards, they might not accurately reflect challenges faced in developing economies, where resource constraints, infrastructural limitations, and policy frameworks differ significantly (Oyedokun, 2020).

Another important limitation lies in the complexity of risk phenomena in construction projects. Risk is inherently multi-dimensional, often interwoven with socio-political, economic, and environmental factors that are difficult to fully quantify or predict. The model's reliance on quantitative tools for early risk identification, such as statistical analyses or probabilistic simulations, may underrepresent the qualitative dimensions of risk that are critical in shaping project outcomes (Ajiga, 2021). Factors such as stakeholder influence, political instability, or cultural norms can significantly impact risk occurrence and impact but may not be sufficiently accounted for in a predominantly data-driven model. Furthermore, the subjective nature of risk perception among different project stakeholders adds another layer of complexity. What is deemed a critical risk by one stakeholder may not hold the same weight for another, leading to potential biases in risk identification and prioritisation processes (Nwaozomudoh, 2022).

The time-bound nature of the study also presents limitations. Given the rapid evolution of the construction industry, including technological advancements, regulatory changes, and shifting market dynamics, the risk profiles of projects are not static. The model, while robust at the time of development, may require continuous updates to remain relevant in the face of emerging risks such as cybersecurity threats, supply chain disruptions, or climate-related challenges (Oyeronke, 2021). This dynamic nature of risk necessitates an adaptive framework that can evolve with industry trends—a feature that the current model may not fully incorporate. Additionally, access to comprehensive and reliable project data remains a persistent challenge. Many construction firms operate under confidentiality constraints, and risk-related data are often sensitive or incomplete. The reliance on

available data sources may inadvertently introduce selection bias, limiting the representativeness of the model across diverse project scenarios (Adewoyin, 2020).

The methodological approach employed in the study, while rigorous, also carries certain limitations. The integration of both qualitative and quantitative methods requires careful alignment to avoid inconsistencies in interpretation. For instance, while expert interviews provide valuable contextual insights, the subjectivity inherent in qualitative responses can conflict with the objectivity sought in quantitative analysis, potentially leading to interpretive challenges (Akintobi, 2022). Moreover, the weighting and ranking of risk factors in the model are inherently subjective, influenced by the perspectives and experiences of selected experts. While these experts bring domain knowledge, their viewpoints may not capture the full spectrum of risk considerations present in diverse project contexts, leading to potential bias in model calibration (Ogundipe, 2021).

Technological constraints also represent a limitation in the implementation of the model. While advanced risk identification tools such as machine learning algorithms and simulation platforms offer enhanced analytical capabilities, their effectiveness is contingent upon the quality and volume of input data. In contexts where digital maturity is low or data infrastructure is inadequate, the applicability of such tools is limited. This creates a gap in the model's utility for projects in less technologically advanced regions, where traditional risk management practices may still dominate (Ogunwale, 2021). Furthermore, the cost implications of deploying such tools, including software acquisition, training, and maintenance, may restrict adoption, particularly for small and medium-sized enterprises that constitute a significant portion of the construction sector (Oyeyemi, 2020).

Lastly, the study acknowledges that the model's predictive capability, while promising, cannot eliminate uncertainty entirely. Construction projects are inherently complex and subject to a multitude of unforeseen variables. While early risk identification can significantly improve cost and schedule performance, it does not guarantee absolute control over project outcomes. The model serves as a

decision-support tool rather than a deterministic solution, and its effectiveness depends on the competence and judgment of project managers and teams in applying its insights. The human factor remains critical in interpreting risk signals, making informed decisions, and responding to emerging challenges (Ogundipe, 2022).

In summary, while the study makes a meaningful contribution to the field of construction risk management, it is essential to contextualise its findings within the boundaries of these limitations. Acknowledging these constraints not only enhances the transparency of the research but also provides a foundation for future studies to build upon, potentially addressing gaps such as broader data coverage, enhanced model adaptability, and integration of qualitative risk factors. This reflective approach ensures that the pursuit of improved cost and schedule performance through early risk identification remains an ongoing and evolving endeavour in the construction industry.

4.7 Recommendations for Future Research

The development of a model for early risk identification in construction projects, while offering significant insights, also highlights several areas that merit further exploration. Future research must aim to bridge existing gaps by refining methodologies, expanding data sources, and ensuring greater inclusivity across diverse project environments. One primary recommendation is the need for longitudinal studies that track the performance of early risk identification models across multiple projects and over extended timeframes. While the current research provides a snapshot based on available data and expert insights, the dynamic nature of risk in the construction industry demands continuous monitoring and iterative validation. By following projects from inception to completion, researchers can gain a deeper understanding of how early risk signals translate into actual project outcomes, and whether the model's predictive capabilities hold under evolving conditions (Oyedokun, 2020).

Another important direction for future research involves expanding the dataset to incorporate a wider range of case studies, particularly from underrepresented contexts such as developing

economies, rural construction projects, and public-private partnerships. The construction industry is far from homogeneous, and risk factors vary significantly across different regions and project typologies. For instance, projects in Sub-Saharan Africa may face risks related to political instability, weak regulatory frameworks, or unreliable supply chains that differ markedly from the challenges encountered in North America or Europe (Ajiga, 2021). Incorporating such diverse perspectives would enhance the generalisability of the model and ensure it remains relevant in a globalised construction landscape. This also calls for the development of collaborative networks among researchers, industry practitioners, and policymakers across regions to facilitate data sharing and knowledge exchange (Ogunwole, 2021).

Moreover, there is a need to explore the integration of emerging technologies such as artificial intelligence (AI), machine learning (ML), and big data analytics into risk identification models. While the current model incorporates conventional data analysis techniques, AI-powered systems have the potential to process vast datasets, detect hidden patterns, and adaptively refine risk predictions in real time. This technological infusion could significantly enhance the accuracy and responsiveness of early risk detection frameworks, making them more robust in complex project environments (Ogundipe, 2021). However, the ethical implications of AI adoption, including data privacy, algorithmic bias, and explainability, must also be rigorously examined to ensure responsible deployment in the construction sector (Oyeyemi, 2020).

In addition to technological advancements, future research should focus on the human dimensions of risk identification. The current model, while methodologically sound, places limited emphasis on the behavioural and cognitive aspects of risk perception among project stakeholders. Understanding how different actors—project managers, engineers, financiers, and regulators—interpret and respond to risk signals can offer critical insights into improving model usability and acceptance. For instance, studies on organisational culture, leadership styles, and decision-making heuristics could reveal how these factors influence the effectiveness of risk identification tools and whether

certain organisational environments are more conducive to proactive risk management (Adewoyin, 2020). Furthermore, incorporating participatory design approaches, where end-users contribute to model development and testing, could enhance the relevance and applicability of future models.

The impact of external macroeconomic and geopolitical factors on risk patterns is another underexplored area. Construction projects do not operate in isolation; they are subject to external shocks such as economic downturns, policy changes, natural disasters, and global supply chain disruptions. Future research could investigate how early risk identification models can be adapted to account for these external variables, potentially by integrating scenario analysis or systems thinking approaches (Oyeronke, 2021). This would equip project managers with tools to anticipate and respond to broader environmental uncertainties, thereby strengthening overall project resilience.

Interdisciplinary collaboration represents a further avenue for advancing the field. Risk management in construction is not solely an engineering or project management challenge; it intersects with fields such as economics, law, sociology, and environmental science. By fostering interdisciplinary research teams, future studies can explore complex, multi-faceted risk scenarios that may be overlooked in siloed investigations. For example, legal scholars can contribute insights on regulatory risks, while environmental scientists can assess climate-related threats to construction schedules and costs. Such collaborative efforts could result in more holistic models that better reflect the realities of modern construction projects (Nwaozumudoh, 2022).

Finally, future research should consider the development of dynamic, user-friendly tools that translate complex risk models into practical decision-support systems for project stakeholders. While academic models often demonstrate strong theoretical foundations, their practical adoption in the field remains limited. Developing intuitive dashboards, mobile applications, or plug-ins for existing project management software could bridge the gap between theory and practice, making early risk identification tools more accessible and actionable for practitioners.

These tools should also include mechanisms for continuous learning and feedback, allowing users to input real-time data and refine risk assessments as projects progress (Akintobi, 2022). Such adaptability is crucial in a sector where project conditions can shift rapidly and unexpectedly.

In summary, the path forward for research in early risk identification is both rich and complex. It demands sustained effort in data collection, methodological refinement, technological integration, and practical tool development. By addressing these areas, future studies can build upon the current model to create more adaptive, inclusive, and actionable frameworks that empower project teams to proactively manage risks, optimise performance, and deliver successful construction outcomes. This ongoing commitment to advancing knowledge and practice will ensure that early risk identification remains a cornerstone of effective project management in the construction industry.

4.8 Framework Implementation Guidelines

Implementing the model for early risk identification in construction projects requires a carefully structured approach to bridge theoretical development and practical application. The success of such a model hinges on its seamless integration into existing construction workflows, fostering a culture of proactive risk management, and ensuring that all stakeholders understand and embrace the model's objectives. This section presents a comprehensive framework implementation guideline, detailing the essential considerations and practical steps required to operationalize the proposed model for enhancing cost and schedule performance in construction projects.

A crucial starting point for implementing the model is a clear understanding of the construction project's unique context, including its scope, complexity, geographical location, and regulatory environment. This understanding informs the customization of the model to address project-specific risk factors. For instance, projects in regions with volatile political climates may require stronger emphasis on regulatory compliance and stakeholder engagement, while projects in environmentally sensitive areas may prioritize environmental risk monitoring. As such, the implementation framework must remain flexible,

adaptable, and sensitive to the nuances of each construction project (Oyedokun, 2021). Furthermore, a baseline assessment of existing risk management practices within the organization is essential to identify current gaps, strengths, and opportunities for improvement. This diagnostic exercise lays the groundwork for a tailored deployment strategy.

A central pillar of the implementation process is stakeholder alignment. It is imperative that all project participants—including project managers, engineers, contractors, clients, and financiers—are fully briefed on the model's objectives, structure, and expected outcomes. Regular sensitization sessions, stakeholder workshops, and collaborative discussions can foster a sense of ownership and shared responsibility for early risk identification. In many cases, a lack of stakeholder buy-in can lead to resistance, rendering even the most robust models ineffective (Nwaozumudoh, 2022). Therefore, the implementation process should emphasize clear communication of the model's value proposition, using real-world case studies and pilot project results to demonstrate its effectiveness in enhancing cost and schedule outcomes.

Training is another critical element in operationalizing the model. Construction teams must be equipped with the necessary skills to collect, analyze, and interpret risk data effectively. This training extends beyond theoretical knowledge, emphasizing practical, hands-on experience with risk identification tools, data analysis platforms, and reporting mechanisms. For instance, incorporating tools such as Building Information Modelling (BIM) for visualizing potential risk hotspots, or adopting digital dashboards for real-time risk tracking, can enhance the model's utility and encourage its routine use (Ajiga, 2020). Training programs should also cover the model's integration points with existing project management systems, such as scheduling tools (e.g., Primavera P6, MS Project) and cost control software (e.g., Oracle Cost Management), to ensure a smooth transition and minimal disruption to ongoing workflows.

Technological infrastructure forms the backbone of successful model deployment. Organizations must assess their current IT capabilities and, where necessary, invest in digital tools and platforms that support data collection, analysis, and visualization.

For instance, the implementation may require cloud-based data repositories to store and access risk data, as well as analytics platforms powered by machine learning algorithms for pattern recognition and predictive modeling. Cybersecurity considerations must also be factored into the implementation strategy to protect sensitive project information. This digital transformation is not without challenges; organizations may encounter resistance to change, limited budgets, or skill gaps among personnel. Thus, a phased approach to technology adoption—starting with pilot projects and gradually scaling up—can facilitate smoother integration and allow teams to adapt progressively (Ogundipe, 2021).

An essential component of the framework is establishing a feedback loop for continuous improvement. The model should not be viewed as static; rather, it must evolve based on lessons learned from each project. Regular post-project reviews and risk audits provide opportunities to refine risk identification parameters, improve data quality, and update risk categorization frameworks. Incorporating feedback mechanisms allows the model to remain relevant and responsive to the dynamic nature of the construction industry. Additionally, organizations should adopt key performance indicators (KPIs) to measure the model's effectiveness in improving cost and schedule performance. These KPIs may include metrics such as the percentage of identified risks mitigated before they impact project milestones, the reduction in unplanned cost overruns, or the frequency of schedule deviations. Tracking these indicators provides tangible evidence of the model's value and reinforces the case for its sustained use (Ajiga, 2021).

Leadership commitment is vital for driving model adoption. Senior management must champion the model's implementation, allocate necessary resources, and embed its principles into organizational policies. For instance, integrating early risk identification into standard operating procedures, project charters, and contractual agreements ensures that the model's principles are institutionalized across projects. This top-down support creates an enabling environment for the model to thrive and signals to all project participants that proactive risk management is a non-negotiable aspect of project execution (Oyewale, 2021).

Finally, the implementation framework should emphasize collaboration and knowledge sharing across the project ecosystem. Construction projects often involve multiple stakeholders with diverse expertise and perspectives. Creating platforms for regular risk workshops, inter-departmental knowledge exchange sessions, and cross-project learning can foster a culture of continuous improvement. Lessons learned from one project can inform risk management strategies in subsequent projects, creating a virtuous cycle of improvement that strengthens the model's impact over time (Ajiga, 2020).

In conclusion, the successful implementation of the early risk identification model depends on a well-structured framework that aligns stakeholders, strengthens skills through training, leverages technology, and fosters a culture of continuous learning. By integrating these guidelines into their project management practices, construction organizations can operationalize the model to achieve significant improvements in cost and schedule performance, thereby enhancing project success rates in an increasingly complex and competitive global market.

CONCLUSION

The development of a model for early risk identification aimed at enhancing cost and schedule performance in construction projects has demonstrated significant potential for transforming project management practices. Construction projects, inherently complex and multifaceted, face myriad risks that can adversely impact timelines and budgets. This study confirms that early recognition and assessment of such risks are essential to mitigating their negative consequences and improving overall project delivery outcomes.

Throughout the research, a systematic approach was employed to construct a model that synthesizes empirical insights, theoretical foundations, and practical considerations. The literature review underscored the diversity of risk factors—from design and planning errors to external economic and environmental uncertainties—and the critical importance of proactive management. Building on this, the model integrates a range of early warning indicators, predictive analytics tools, and stakeholder

engagement mechanisms, ensuring a holistic framework capable of addressing the dynamic nature of construction risks.

Validation of the model through case studies provided robust evidence of its applicability and effectiveness. The empirical findings illustrated that projects adopting early risk identification methods experienced fewer cost overruns and delays, as risks were anticipated and mitigated before escalation. Importantly, the model encourages collaboration among project teams, subcontractors, and clients, fostering a shared risk awareness culture that is often absent in traditional project management paradigms.

Moreover, the study highlights the transformational shift required in industry mindset—from reactive risk handling towards strategic anticipation and prevention. Early risk identification does not only reduce the likelihood and impact of adverse events but also enables more informed decision-making, optimized resource allocation, and enhanced stakeholder confidence. In this respect, the model aligns with broader trends in construction management emphasizing agility, resilience, and data-driven governance.

However, this research also recognizes inherent limitations. While the model was rigorously developed and validated, its effectiveness is contingent upon the availability and quality of project data, the commitment of stakeholders, and the contextual characteristics of projects. Variations in project size, geographic location, regulatory environments, and organizational maturity can influence risk profiles and management efficacy. The reliance on expert judgments and secondary data in validation further introduces potential biases and constraints on generalizability.

Future research should therefore focus on expanding the model's scope and robustness. Longitudinal studies across diverse project environments would enrich understanding of how early risk identification evolves over time and under varying conditions. Integration of emerging technologies, including machine learning algorithms and real-time data monitoring, holds promise for enhancing predictive accuracy and responsiveness. Interdisciplinary collaboration involving legal, economic, and

environmental experts would strengthen the model's comprehensiveness by accounting for complex, systemic risks often overlooked in construction projects.

Beyond academic contributions, the practical implications of this research are profound. Construction firms that adopt the proposed model can shift toward a proactive, resilient risk management culture, resulting in improved financial performance, client satisfaction, and competitive advantage. The model also offers a foundation for developing user-centric digital tools that democratize access to risk insights, enabling all project participants to contribute to early risk detection and mitigation efforts.

In conclusion, the study affirms that while construction projects cannot be entirely insulated from risk, the proactive identification and management of risks at the earliest possible stages can substantially mitigate their impact. This shift from reactive crisis management to anticipatory risk governance is essential for navigating the increasing complexity, uncertainty, and competitiveness characterizing today's construction landscape. The proposed model represents a meaningful step toward this goal, combining theoretical rigor with practical utility. Continued refinement, technological integration, and broader empirical testing will further enhance its relevance and effectiveness, ultimately contributing to more successful, efficient, and sustainable construction project outcomes.

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