The Role of Risk Management in Enhancing the Performance of Construction Projects

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Abstract*- This study aims to highlight the role of risk management in enhancing the performance of construction projects, particularly in light of the increasing challenges faced by the sector in terms of complexity, the multiplicity of influencing factors, and exposure to various risks that may affect project quality, cost, and completion time. The study reviews the theoretical background and development of the concept of risk management across construction, financial, and industrial fields. It demonstrates how risk management has become an essential component within Project Management Offices (PMOs), working to balance returns and risks by developing analytical tools and models grounded in scientific principles. The study addresses several recent research efforts that explored various dimensions of risk management in the construction sector, including the use of artificial intelligence, digital tools such as CBRisk, and the challenges of effectively applying risk management in diverse environments such as Lebanon, India, and international projects. The findings of these studies point to the growing awareness of the importance of risk management and the need to develop more integrated and flexible tools while enhancing the interaction between human elements and modern technologies. The study concludes that effective risk management is a decisive factor in the success of construction projects and that adopting advanced risk management strategies contributes to improving project outcomes and minimizing potential losses.

***Indexed Terms*- Risk Management, Construction Project Performance, Middle East.**

I. INTRODUCTION

Risk management emerged from the intersection of military engineering applications, financial theories, and insurance systems within the financial sector. The focus gradually shifted from traditional insurance mechanisms to using cost-benefit analysis and expected value as decision-making tools under conditions of uncertainty. This methodology was based on management science principles, mathematical programming, and decision theory to evaluate pure risks and clearly define internal responsibilities. The term “Risk Management” first appeared in Harvard Business Review in 1956, where the author suggested appointing an internal official to oversee risks and coordinate related operations. This proposal paved the way for transferring risk management concepts from military and judicial contexts to construction, financial, and industrial domains, enabling organizations to adopt systematic strategies to identify and address risks before they occur (Okudan et al, 2021).

Construction projects are among the most complex and unique types of projects due to the multiplicity of technical, environmental, and human factors influencing them. These projects are exposed to risks that affect cost, delivery time, project scope, and quality of outcomes. Negative risks are a major reason behind project delays, cost overruns, and schedule disruptions, which in turn lower client satisfaction and damage corporate reputation. Project Management Offices (PMOs) were established to standardize practices and coordinate processes across multidisciplinary teams. These offices integrate risk management tools within a comprehensive methodology that enhances control over influential variables, thereby improving performance and ensuring project goals are achieved within the planned time and financial limits.

Risk management has become a core component within PMOs to strike a balance between risk and return. Many companies have adopted specific standards and procedures to manage risks in their projects in order to improve performance and avoid potentially significant losses. These standards assist project managers in prioritizing tasks and allocating resources based on scientific analysis of possible scenarios. Decision-making is supported by evaluating potential events and selecting appropriate response strategies. This process requires the presence of specialized and competent teams to study risks, formulate preventive strategies, and conduct periodic reviews. External audits and inspections have also been employed to anticipate risks before they occur and mitigate their negative impacts. These practices have significantly contributed to project success and shielded companies from collapse and major financial losses (Xie & Yang, 2021).

II. LITERATURE REVIEW

Nyqvist et al. (2024) aimed to compare the capability of the artificial intelligence model ChatGPT-4 with human experts in managing construction project risks. The researchers employed a mixed-methods approach to compare the performance of 16 human experts from Finnish construction companies with that of ChatGPT-4, focusing on risk identification, analysis, and control. The findings revealed that ChatGPT-4 outperformed human experts in developing comprehensive risk management plans in terms of quantitative outcomes. However, the study highlighted limitations in practical application and accuracy in certain areas where human experts held the advantage. It emphasized the potential synergy between artificial intelligence and human expertise, advocating for the use of AI as a complementary tool to enhance human performance in risk management. The study concluded with a call for a collaborative human-AI model (Nyqvist, Peltokorpi, & Seppänen, 2024).

Al Qudah et al. (2024) conducted a bibliometric analysis of existing literature on risk management in the construction sector, with an emphasis on future trends. The researchers utilized tools such as Web of Science and VOSviewer to analyze 676 research publications published between 2000 and 2021. Twenty main keywords were classified into three categories: risk management in construction projects, enterprise risk management in the construction sector, and effective project management for project success. The results showed that 61 authors from 80 countries and 45 institutions contributed to the literature on risk management. The study reflected a growing global interest in this field, indicating an ongoing and diverse development in construction risk management research (Al Qudah, Fuentes-B, & Ferrer-G, 2024).

Shibani et al. (2024) focused on identifying, classifying, and analyzing the risks threatening the construction sector in Lebanon, particularly financial and economic risks amid the country's severe economic crisis. The study explored the effects of currency fluctuations, inflation, and lack of financial solvency on the sector. Data were collected through a questionnaire distributed to industry experts. Results showed that Lebanon's construction sector faces numerous internal and external risks affecting its continuity and project feasibility. Financial risks were highlighted as the most prominent challenge. Although the study underscored the importance of effective risk management, it also pointed out the obstacles that hinder its full and effective implementation. The researchers concluded that improving the effectiveness of risk management is essential for tackling these challenges (Shibani et al., 2024).

Okudan et al. (2021) sought to bridge gaps in current risk management tools within the construction sector by developing a novel, knowledge-based risk management tool called CBRisk. This web-based application supports resource management and utilizes an efficient case-based retrieval method that considers project similarities using ambiguous linguistic variables. The tool integrates various risk management stages—including identification, analysis, response, and monitoring—into a unified platform. Evaluation and validation through black-box testing and expert reviews demonstrated CBRisk's high potential to enhance construction risk management by learning from past projects. Moreover, the tool could be adapted for use in other project-driven sectors with minor modifications (Okudan, Budayan, & Dikmen, 2021).

Xie and Yang (2021) studied risk management in construction projects within a multimedia environment enabled by the Internet of Things (IoT). The focus was on analyzing challenges faced in mobile construction sites and on developing an innovative risk management system. This system aimed to ensure project quality and schedule risk prediction. The study found that multimedia-based systems significantly improved project communication and quality control. Experimental results confirmed that such a system helps projects stay on schedule and maintain high quality. By integrating theory and practice, the study provided a practical framework to address threats in IoT-based construction environments (Xie & Yang, 2021).

Singla and Phadtare (2025) examined the main risks faced by micro, small, and medium-sized enterprises (MSMEs) in the Indian construction sector and how these firms manage such risks. Using a qualitative case study approach, interviews were conducted with owners and staff from four companies. The findings revealed that these companies do not follow formal risk management practices, viewing them as barriers to competitive bidding. Participants noted difficulty in identifying project issues due to chaotic work environments and preferred reactive problem-solving. Their understanding of challenges was mainly tacit, and they relied on experience-based responses, believing that errors are inevitable (Singla & Phadtare, 2025).

Qian et al. (2024) aimed to develop a framework for managing risks in international construction projects (ICPs) by modeling the interactions and amplification of risks throughout the project lifecycle. The study introduced a Risk Interaction Network (RIN) that illustrates how risks are interconnected and influence each other, complicating the identification of critical risks. An integrated risk index was designed to evaluate risk severity and identify key risks using a simulation model that assessed sensitivity to prior risks and considered randomness in risk occurrence. Network analysis measured the strength of risk propagation. The study concluded that the proposed framework offers an effective tool for understanding risk dynamics in international construction projects and enhances the accuracy of identifying critical risks (Qian et al., 2024).

2.1 International Standards for Project Risk Management:

In today's dynamic and uncertain global environment, effective risk management has become a critical component of entities and portfolios' success. Institutions across all sectors face a broad spectrum of risks that can influence strategic direction, operational efficiency, and long-term sustainability, Gachie, 2017. Consequently, standardized approaches to risk management have gained prominence, offering structured methodologies for identifying, assessing, and mitigating risk (Washington State Department of Transportation, 2018).

Among these frameworks, ISO 31000 stands out as a widely recognized international standard, providing principles and guidelines that facilitate consistent and effective risk management practices. It plays a pivotal role in establishing a unified understanding of risk management and promoting resilience across industries and sectors, (Fedyk & Fedyk, 2024). The adoption of ISO 31000 has seen global momentum, with notable interest and growing implementation in the Middle East. In this region, where rapid economic development, diversification, and infrastructural expansion are transforming the risk landscape, ISO 31000 offers an adaptable and robust framework that aligns with national visions and regulatory initiatives aimed at enhancing governance and sustainable growth, (Rahman & Adnan, 2020) .

ISO 31000 is an international standard for risk management that provides a comprehensive framework applicable to all organizations regardless of size, type, or industry (ISO, 2018). It emphasizes the significance of managing uncertainty as a core aspect of strategic and operational success. One of the primary contributions of ISO 31000 is its applicability across diverse sectors and its utility for anyone involved in managing risk, not just specialized professionals.

The standard assists organizations in designing a risk management strategy that helps identify and mitigate risks, thereby enhancing goal achievement and safeguarding assets. A critical element of ISO 31000 is fostering a risk-aware culture, where all stakeholders recognize the importance of proactive risk management. This emphasis on early risk identification and proactive mitigation aligns with established findings on common risks in complex sectors such as construction, where risk predictability and awareness significantly improve outcomes (Siraj & Fayek, 2019). This cultural integration supports informed decision-making and promotes better allocation of organizational resources (ISO, 2018).

ISO 31000 integrates risk-based decision-making into all organizational dimensions, including governance, planning, and daily operations. The 2018 revision introduced enhancements such as more strategic guidance, stronger involvement from senior management, and alignment of risk management with an organization's structure and objectives, as shown in figure (1). These updates reflect the broader trend in risk management emphasizing structured integration and cultural adaptation, as also discussed in recent studies on risk practices in emerging economies like India (Singla & Phadtare, 2025). The revised version emphasizes continuous improvement, stakeholder inclusion, and human and cultural factors, adopting a plain-language approach to make its principles accessible and adaptable (ISO, 2018).

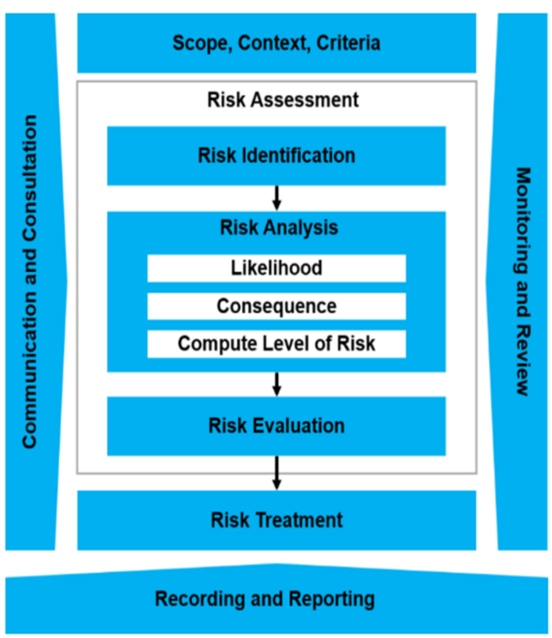

Figure 1, The ISO 31000:2018 Risk Management Process, outlining key steps including risk identification, analysis (likelihood, consequence, and level of risk), evaluation, treatment, and the continuous processes of communication, consultation, monitoring,

Importantly, ISO 31000 is a guideline, not a certifiable standard, and its implementation begins with aligning risk management practices with organizational goals and assessing existing governance structures. This approach mirrors broader methodologies used to assess sustainability and manage complex environmental and operational risks, such as those explored in the tourism and recreation sectors (Roe, 2010) and international construction projects where simulation-based risk interaction models have been increasingly applied to understand dynamic risk interdependencies (Qian et al., 2024).

2.2 Research gap:

The review of prior studies clearly reveals a shared consensus regarding the pivotal role of risk management in enhancing construction project outcomes. All examined studies emphasize that systematic practices—such as identifying, assessing, and responding to risks—contribute significantly to minimizing deviations in cost, time, and quality, regardless of geographic or economic context (Siraj & Fayek, 2019; Okudan et al., 2021; Nyqvist et al., 2024).

Moreover, many of these studies incorporate innovative methods such as artificial intelligence (Nyqvist et al., 2024), Internet of Things-based systems (Xie & Yang, 2021), bibliometric analysis (Al Qudah et al., 2024), and knowledge-driven digital tools (Okudan et al., 2021). These methodological advancements provide valuable insights, especially in terms of tool development and decision support, but also underline the complexity of integrating such systems in dynamic and resource-constrained environments like those in the Middle East.

What distinguishes these studies is the diversity of methods used—from mixed-method designs and qualitative interviews (Singla & Phadtare, 2025) to simulations and bibliometric analytics. This methodological richness strengthens the collective understanding of risk management as both a strategic discipline and a technical function. However, despite this diversity, the studies often remain exploratory or technology-centered, focusing more on the tools themselves rather than their quantified impact on actual project performance indicators.

Critically, the current literature falls short in providing a comprehensive empirical framework that directly measures the impact of specific risk management dimensions—such as identification, analysis, mitigation, and monitoring—on key performance metrics (cost, time, scope) in real construction settings, particularly within Middle Eastern contexts. This region is experiencing large-scale construction growth but remains underrepresented in empirical performance-based studies.

Thus, the main research gap lies in the absence of models that quantitatively link each stage of the risk management process with measurable performance outcomes under regional conditions. While prior studies have examined tools, perceptions, or sector-wide analyses, there is a critical need for evaluative models that can guide decision-makers in implementing risk management with clear return-on-investment (ROI) benchmarks in construction projects.

The present study addresses this gap by proposing a quantitative framework that explores how each core dimension of risk management contributes to enhancing time and cost efficiency in construction. This not only supports academic advancement but also serves practical interests by enabling stakeholders in the Middle East to adopt evidence-based risk strategies tailored to local market dynamics and project typologies.

III. RESEARCH PROBLEM

In light of the growing complexity that characterizes construction projects and the multiplicity of activities and phases—from project study and design to execution—project teams increasingly face high levels of uncertainty due to continuously changing conditions. These variations can be temporal, spatial, economic, or regulatory, often resulting in unpredictable impacts on project performance.

Despite similarities in project type or scope, each construction project is uniquely influenced by its geographical location, climate, economic environment, and sociopolitical conditions, producing a distinct risk profile. These risk profiles, when inadequately addressed, can lead to timeline delays, cost overruns, deviations from scope, and compromised quality.

In the Middle East, the systematic application of risk management practices remains limited. This is often due to a shortage of trained personnel, low awareness of risk management's value, or organizational resistance to allocating contingency reserves (CR) or management reserves (MR) for unknown or emergent risks. Such attitudes mistakenly equate proactive risk planning with wasted resources, despite empirical and industry evidence that failure to manage risk is far more costly in terms of financial losses, reputational harm, and project failure (Pham et al., 2023).

Hence, the central research question is articulated as follows:
To what extent does the application of risk management in construction projects contribute to improving their performance in terms of time, cost, quality, and scope—particularly within the Middle Eastern context?

This overarching inquiry is further broken down into sub-questions:

1. What is the degree of awareness and application of core risk management practices in construction environments within the Middle East?
2. To what extent is attention given to enhancing construction project performance in the region?
3. What is the impact of risk management on improving construction project outcomes in the Middle East?

IV. RESEARCH OBJECTIVES

The study aims to achieve the following objectives:

1. Assess the maturity and effectiveness of risk management practices currently in use in the Middle East.
2. Evaluate stakeholder engagement with performance improvement efforts in the construction sector.
3. Determine the extent to which risk management contributes to enhancing construction project

performance—focusing on time and cost efficiency.

4. Provide targeted recommendations and actionable strategies to construction sector leaders in the Middle East, based on empirical findings, which can be adopted and scaled in real-world projects.

V. SIGNIFICANCE OF THE STUDY

This study provides academic significance as it investigates the relationship between risk management practices and construction project performance, a topic that is underexplored, especially within Arabic-speaking and Middle Eastern academic contexts. This research establishes a statistically validated framework, thereby providing a structured perspective to the expanding knowledge base in project management, construction engineering, and public sector administration.
This study addresses a significant gap in the literature by examining the correlation between risk management activities—specifically risk identification, assessment, response, and monitoring—and actual project performance metrics, including time and cost adherence. This enriches Arabic-language references and offers future scholars and practitioners a data-driven model for performance benchmarking.

The study presents a novel conceptual framework for comprehending how risk management facilitates performance excellence in intricate and high-stakes construction settings, thereby enhancing both theoretical insights and practical approaches. The significance of this research is fundamentally anchored in the increasing dependence on extensive infrastructure and urban development initiatives throughout the Middle East. Due to the escalating complexity of projects and external risks, including market volatility and regulatory uncertainty, the adoption of comprehensive risk management procedures is important. This study is particularly pertinent in a region defined by certain criteria as; Accelerated urbanization; Strategic national initiatives (e.g., Egypt's New Capital, KSA's NEOM, UAE smart cities); Geopolitical instability and Resource-dependent economies.

It offers construction companies, project managers, and policymakers a definitive comprehension of how to institutionalise risk management to enhance delivery outcomes. The paper provides evidence-based recommendations for improving project governance maturity by demonstrating that proactive risk planning promotes project success regarding cost, time, and efficiency.

VI. THE STUDY VARIABLES

This study consists of one independent variable (risk management) and one dependent variable (construction project performance). Each is further defined and operationalized through measurable dimensions:

6-1 Independent Variable: Risk Management in the Middle East:

Risk management in construction projects is a comprehensive and systematic process involving the identification, assessment, mitigation, and monitoring of potential threats that may arise across the project lifecycle. Within the framework of this study, risk management is not merely a reactive mechanism but a proactive governance strategy that supports decision-making under uncertainty. It ensures informed planning, resource alignment, and adaptive responses to evolving conditions, thus enhancing project resilience and performance outcomes (Pham et al., 2023).

In the Middle Eastern construction environment, risk management assumes added complexity due to unique regional conditions, including:

- Fluctuating material and import prices, which affect budget predictability and procurement planning;
- Severe climatic variability, including high temperatures and sandstorms, which disrupt construction schedules and health and safety compliance;
- Regulatory and licensing delays, which often arise due to bureaucratic fragmentation and inconsistent policy implementation;
- Political and legal instability, which can introduce abrupt shifts in labor availability, land rights, or contractual enforceability.

To address these challenges, construction firms are increasingly adopting data-driven and tech-enabled tools, such as risk simulation software, predictive modeling systems, and early warning indicators. These systems support continuous monitoring and scenario planning, enabling stakeholders—including developers, contractors, consultants, and financiers—to anticipate disruptions and coordinate timely interventions.

This research operationalizes risk management through four key dimensions, each of which serves as an integral component of the proposed structural model:

6-1-1. Risk Identification:
This dimension involves the structured and analytical detection of potential events that may hinder the achievement of project objectives. Techniques such as risk breakdown structures (RBS), brainstorming workshops, historical data analysis, and expert interviews are employed to ensure comprehensive risk capture. In high-risk zones, such as politically sensitive urban developments, early identification serves as the cornerstone for developing robust contingency strategies (Roe, 2010; Siraj & Fayek, 2019).

6-1-2. Risk Assessment:
Risk assessment focuses on analyzing and prioritizing identified risks based on their probability of occurrence and potential impact on cost, time, and scope. This involves both qualitative tools (e.g., risk matrices, Delphi technique) and quantitative methods (e.g., Monte Carlo simulation, fault tree analysis). In Middle Eastern markets, risk exposure must be evaluated with particular sensitivity to inflation rates, legal constraints, and supply chain disruptions (Siraj & Fayek, 2019).

6-1-3. Risk Mitigation:
Risk mitigation encompasses the formulation and implementation of strategic responses aimed at reducing or eliminating risk consequences. Strategies may include risk transfer through contract clauses, risk avoidance via design alterations, or risk acceptance with the establishment of financial buffers. Mitigation efforts must be tailored to project scale, type (e.g., infrastructure vs. residential), and regulatory frameworks. Effective mitigation planning strengthens project agility, particularly in megaprojects involving multiple stakeholders (Karklina et al., 2024).

6-1-4. Risk Monitoring:
This dimension entails the continuous tracking of risk status, early detection of new risks, and evaluation of implemented control measures. Monitoring processes are embedded into project dashboards, review meetings, and integrated project delivery (IPD) platforms. Given the volatile and dynamic construction environments in the Middle East, where socioeconomic conditions shift rapidly, real-time monitoring is essential for adaptive management and safeguarding project performance.

6-2 Construction Project Performance: The Dependent Construct

Construction project performance is conceptualized in this study as the degree to which a project meets its pre-established objectives in terms of schedule adherence and budget compliance. Given the capital-intensive and labor-sensitive nature of construction, performance management necessitates rigorous coordination, progress tracking, and financial discipline (Issa et al., 2022).

Two primary dimensions are used to assess performance:

6-2-1. Time Efficiency

Time efficiency refers to the project's ability to adhere to planned schedules, complete deliverables within set milestones, and minimize disruptions. It is a key indicator of operational effectiveness and project team coordination. In the context of the Middle East, timely delivery also correlates with contractor credibility, regulatory compliance, and investment return timelines (Thabbah & Belal, 2019).

6-2-2. Cost Efficiency

Cost efficiency is measured by the extent to which actual expenditures align with the approved project budget. It includes cost forecasting accuracy, expenditure tracking, and control mechanisms for managing overruns. In an inflation-prone and resource-volatile region, effective cost management is a strategic imperative for both private and public

sector projects. Cost efficiency is also influenced by early risk identification and the maturity of mitigation frameworks deployed throughout the project.

The four dimensions of risk management (identification, assessment, mitigation, monitoring) are examined in their individual and collective contributions to enhancing construction project performance, specifically across time and cost dimensions. The study's structural model hypothesizes significant and positive relationships, particularly highlighting risk monitoring and mitigation as the most influential predictors of success, based on statistical path analysis.

This framework provides a valuable empirical lens for stakeholders seeking to institutionalize risk-based thinking and improve outcome predictability in the Middle Eastern construction sector.

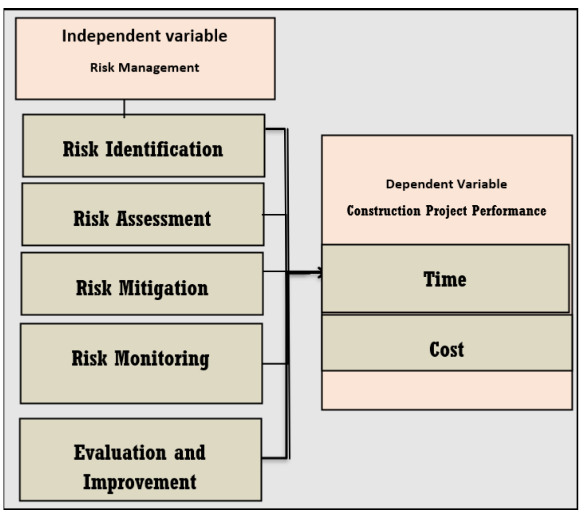

Figure 2, The Study Conceptual Framework, adapted by researchers based on literature review

VII. RESEARCH HYPOTHESES

Based on the research problem and objectives, the study proposes the following hypotheses to test the effect of risk management on the performance of construction projects:

7-1 Main Hypothesis (H_0):

There is a statistically significant relationship between risk management (independent variable) and the development of construction project performance (dependent variable) in the Middle East.

7-1-1 Sub-Hypotheses:

- H1: Risk management has a statistically significant positive effect on reducing project execution time.
- H2: Risk management has a statistically significant positive effect on reducing project cost.

These hypotheses reflect the premise that each of the four risk management dimensions—identification, assessment, mitigation, and monitoring—plays a direct role in influencing key project performance outcomes. The analysis of these hypotheses will be conducted through multivariate regression modeling and path analysis, ensuring statistical rigor and generalizability.

VIII. RESEARCH DESIGN AND METHODOLOGY

- Research Approach

Given the nature of the research questions and the goal of empirically testing the impact of structured risk management on project performance, this study employs a triangulated research approach consisting of:

- Deductive Method: Used in developing the theoretical framework and constructing the conceptual model based on prior literature. This method allowed the formulation of testable hypotheses linking risk practices to measurable performance indicators.
- Inductive Method: Adopted through the synthesis and interpretation of previous studies, both regionally and globally, to extract patterns and infer contextual relevance for Middle Eastern construction environments.
- Applied (Empirical) Method: Implemented in the field portion of the study, using quantitative data collection and analysis to test the proposed hypotheses and validate the conceptual model.

8-1 Data Collection Method:
Primary data were gathered using a structured questionnaire (survey instrument), specifically designed for professionals involved in managing construction projects within the Middle East. The survey instrument was constructed based on a comprehensive literature review and adapted to regional considerations.

Respondents included

- Project managers
- Engineers
- Planners
- Risk officers
- Consultants

The questionnaire covered each of the four risk management dimensions and their perceived impact on time and cost efficiency.

8-2 Population and Sample:
The target population for this study comprises professionals currently working in major construction projects across the Middle East, in both public and private sectors. These include infrastructure megaprojects, urban developments, and industrial construction initiatives.

Sampling was purposive, targeting individuals directly responsible for decision-making and project oversight. The inclusion criteria ensured that the respondents had at least 5 years of experience in construction or project management roles, and had familiarity with or responsibility for risk-related practices.

IX. INSTRUMENT EVALUATION AND STATISTICAL VALIDITY

9.1 Reliability Testing – Cronbach's Alpha

Reliability refers to the consistency and stability of measurement instruments. In this study, Cronbach's Alpha was used to assess the internal consistency of the questionnaire's dimensions. Alpha values range from 0 to 1, where a score above 0.70 is considered acceptable, and above 0.90 indicates excellent reliability (Hair et al., 2018), as shown in table (1).

Table (1)- Reliability and Construct Validity of Study Dimensions Based on Cronbach's Alpha and Composite Validity

Dimension	No. of Items	Cronbach's Alpha (α)	Construct Validity (√α)
Risk Identification	7	0.958	0.979
Risk Assessment	6	0.961	0.980
Risk Mitigation	6	0.949	0.974
Risk Monitoring	6	0.956	0.978
Project Time Efficiency	6	0.936	0.967
Project Cost Efficiency	7	0.947	0.973

These values confirm a very high degree of reliability across all constructs. The minimum alpha coefficient was 0.936, indicating that the instrument consistently measures the intended constructs. The high validity scores (√α) further affirm that respondents understood and interpreted the items consistently.

9.2 Correlation Matrix – Risk Management and Project Cost
The table (2) presents the results of Pearson correlation coefficients calculated between the four dimensions of risk management and the dependent variable, project cost. All coefficients are statistically significant at the 0.01 level, indicating strong linear relationships between the variables.

Table (2)- Pearson Correlation Matrix Between Risk Management Dimensions and Construction Project Cost

Variable	Project Cost	Identification	Assessment	Mitigation	Monitoring
Project Cost	1.000	0.863**	0.859**	0.877**	0.904**
Risk Identification	0.863**	1.000	0.918**	0.894**	0.901**
Risk Assessment	0.859**	0.918**	1.000	0.900**	0.888**
Risk Mitigation	0.877**	0.894**	0.900**	1.000	0.920**
Risk Monitoring	0.904**	0.901**	0.888**	0.920**	1.000

Note: Correlation is significant at the 0.01 level (2-tailed)

Study-Based Conclusions:

- Strong Positive Correlation Between Risk Monitoring and Project Cost. The highest correlation is observed between Risk Monitoring and Project Cost ($r = 0.904$). This suggests that continuous oversight and real-time tracking of risk variables are strongly associated with effective budget control. It aligns with the path analysis results showing monitoring as the most influential predictor of cost efficiency.
- High Correlation Between Risk Mitigation and Project Cost ($r = 0.877$); Risk mitigation also shows a substantial association with project cost, indicating that the application of well-planned response strategies plays a critical role in cost containment.
- Risk Identification and Risk Assessment Are Also Strongly Related to Project Cost; Risk Identification ($r = 0.863$) and Risk Assessment ($r = 0.859$) exhibit slightly lower but still strong correlations with project cost, suggesting that early recognition and prioritization of risks help forecast and manage financial exposure.
- Multicollinearity Between Risk Management Dimensions; The inter-correlations among the four risk management dimensions are notably high (ranging from 0.888 to 0.920). While this reflects strong internal consistency, it may also indicate potential multicollinearity, which should be accounted for in regression modeling (e.g., using variance inflation factors or principal component analysis).

The correlation matrix supports the theoretical proposition of the study that effective risk management practices contribute significantly to cost performance in construction projects. Among the four dimensions, Risk Monitoring exhibits the strongest relationship, reinforcing its critical role in high-risk and volatile environments such as construction in the Middle East.

9.3 Path Analysis – Standardized Regression Coefficients

The results of the structural equation model reveal statistically significant relationships between various risk management dimensions and the two key components of construction project performance — namely, time efficiency and cost efficiency. The analysis was conducted using standardized regression coefficients (β), t-values, p-values, and coefficients of determination (R^2), as presented in the following table (3):

Table (3) Structural Path Coefficients for the Impact of Risk Management Dimensions on Construction Project Performance

Predictor	Outcome	Standardized Coefficient (β)	t-value	p-value	R^2
Risk Assessment	Time	–0.013	–0.172	0.864	0.843

Risk Mitigation	Time	0.279	2.700	0.007	
Risk Monitoring	Time	0.667	6.719	<0.001	
Risk Identification	Cost	0.161	2.102	0.036	0.836
Risk Mitigation	Cost	0.225	2.191	0.028	
Risk Monitoring	Cost	0.553	5.284	<0.001	

Project Time Efficiency ($R^2 = 0.843$):

- The model explains 84.3% of the variance in project time performance, indicating a strong overall explanatory power.

- Risk Monitoring shows the most substantial and statistically significant effect on project time (β = 0.667, $p < 0.001$), suggesting that ongoing risk tracking and control are critical to timely project delivery.

- Risk Mitigation also has a significant positive impact (β = 0.279, p = 0.007), reflecting the importance of proactive response strategies.

- Risk Assessment, however, shows a negligible and statistically non-significant effect (β = –0.013, p = 0.864), indicating that assessment alone, without implementation of response or monitoring, does not significantly influence time performance.

Project Cost Efficiency ($R^2 = 0.836$):

- The model accounts for 83.6% of the variance in cost performance, again demonstrating a robust predictive capacity.

- Risk Monitoring is again the strongest predictor of cost efficiency (β = 0.553, $p < 0.001$), highlighting its dual importance in both schedule and budget adherence.

- Risk Mitigation has a moderate but significant effect (β = 0.225, p = 0.028), emphasizing the role of cost-focused risk response planning.

- Risk Identification contributes significantly, though to a lesser extent (β = 0.161, p = 0.036), suggesting that early recognition of threats plays a foundational role in managing budget risks.

These results empirically validate the proposed research model, confirming that risk monitoring is the most critical determinant of both time and cost performance in construction projects. Risk mitigation consistently enhances outcomes, while risk identification and assessment have more selective impacts. These findings underline the importance of not only recognizing risks but actively managing and tracking them throughout the project lifecycle, especially in complex and volatile environments such as those common in the Middle East.

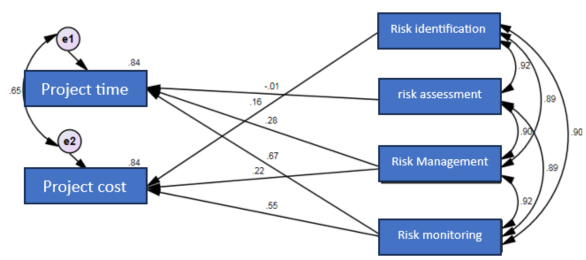

Figure (3) The relational framework of risk management dimensions on the dimensions of construction project performance development

9.4 Model Fit Indicators:

To evaluate the adequacy of the proposed structural equation model (SEM), a comprehensive set of goodness-of-fit indices was analyzed, as shown in table 4. These indices serve as critical benchmarks for determining how well the hypothesized model reproduces the observed data.

Table (4) Goodness-of-Fit Indices for the Structural Equation Model (SEM)

Fit Index	Code	Value	Threshold
Chi-Square	CMIN	1.736	—
Degrees of Freedom	DF	2	—
Chi-Square Significance	p	0.420	> 0.05
Chi-Square/DF	CMIN/DF	0.868	< 2.0
Goodness of Fit Index	GFI	0.995	> 0.90
Normed Fit Index	NFI	0.998	> 0.90
Incremental Fit Index	IFI	1.000	> 0.90
Tucker-Lewis Index	TLI	1.000	> 0.90
Comparative Fit Index	CFI	1.000	> 0.90
Root Mean Square Error Approx.	RMSEA	0.000	< 0.05 (excellent)

Empirical Findings:

- Chi-Square and Degrees of Freedom (CMIN/DF = 0.868); The Chi-Square value (1.736) with 2 degrees of freedom is not statistically significant (p = 0.420), which is desirable in SEM. A non-significant p-value (> 0.05) indicates that the model does not significantly deviate from the data. Moreover, the relative Chi-Square ratio (CMIN/DF) is 0.868, which is well below the accepted threshold of 2.0, indicating an excellent model fit.
- Absolute Fit Indices; The Goodness of Fit Index (GFI = 0.995) and Normed Fit Index (NFI = 0.998) both exceed the threshold of 0.90, suggesting that a substantial proportion of variance and covariance in the data is explained by the model structure.
- The Incremental Fit Index (IFI), Tucker-Lewis Index (TLI), and Comparative Fit Index (CFI) all equal 1.000, which reflects a perfect incremental fit. These results indicate that the proposed model performs substantially better than the baseline model, which assumes no relationships between variables.
- The Root Mean Square Error of Approximation (RMSEA) is a key measure of model fit that adjusts for model complexity. The observed value of 0.000 reflects an excellent fit, as values below 0.05 are considered optimal. This indicates negligible approximation error between the hypothesized model and the actual data structure.

Collectively, the fit indices provide strong empirical support for the adequacy of the structural equation model. The model demonstrates excellent fit across all major indicators, including absolute, incremental, and parsimony-adjusted indices. These results validate the model's suitability for explaining the relationships between risk management dimensions and construction project performance, reinforcing the reliability of the path analysis and hypothesis testing.

X. FINDINGS AND RECOMMENDATIONS

The structural model developed in this study was subjected to rigorous statistical analysis using structural equation modeling (SEM), with the objective of testing the validity of the primary and sub-hypotheses regarding the influence of risk management dimensions on construction project performance.

All three hypotheses—main and sub—were either fully or partially supported by the empirical evidence as shown in table (5) . The dominance of risk monitoring and mitigation in influencing both time and cost performance validates their role as critical operational levers in construction risk management. The findings justify a strategic prioritization of these two dimensions in both research and industry practices across the Middle East.

Table (5)- Hypotheses Validation Summary

Hypothesis	Statement	Result	Justification
Main Hypothesis	There is a statistically significant relationship between risk management and the development of construction project performance.	**Accepted**	R^2 = 0.843 (Time), R^2 = 0.836 (Cost); overall model is significant with excellent fit indices (e.g., RMSEA = 0.000, CFI = 1.000).
Sub-Hypothesis 1	Risk management has a statistically significant positive effect on reducing project execution time.	**Partially Accepted**	Risk Monitoring (**β = 0.667, p < 0.001**) and Risk Mitigation (**β = 0.279, p = 0.007**) are significant. Risk Assessment and Risk Identification are not.
Sub-Hypothesis 2	Risk management has a statistically significant positive effect on reducing project cost.	**Accepted**	Risk Monitoring (**β = 0.553, p < 0.001**), Risk Mitigation (**β = 0.225, p = 0.028**), and Risk Identification (**β = 0.161, p = 0.036**) are all significant predictors of cost performance.

10.2 Empirical Findings Based on Statistical Analysis:

The structural equation modeling (SEM) results provide strong empirical support for the central research hypothesis: risk management practices have a significant and measurable impact on construction project performance, particularly in the Middle Eastern context. The final validated model demonstrates excellent fit (e.g., CFI = 1.000, RMSEA = 0.000, GFI = 0.995), confirming the robustness of the proposed relationships.

Model Summary

- The model explains 84.3% of the variance in project time performance and 83.6% in project cost performance (R^2 = 0.843 and 0.836 respectively).
- All path coefficients from the independent variables to performance indicators were statistically tested and found to be either significant or non-significant at conventional confidence levels.

Interpretive Conclusions:

- Risk Monitoring exhibited the strongest predictive effect on both time ($\beta = 0.667$, $p < 0.001$) and cost performance ($\beta = 0.553$, $p < 0.001$), reaffirming its essential role in real-time oversight and adaptive control throughout the project lifecycle.
- Risk Mitigation showed a significant impact on both time ($\beta = 0.279$, $p = 0.007$) and cost ($\beta = 0.225$, $p = 0.028$), emphasizing the value of proactive, scenario-based risk response strategies.
- Risk Identification was significantly associated with cost ($\beta = 0.161$, $p = 0.036$) but had no significant effect on time ($\beta = –0.013$, $p = 0.864$), suggesting that early recognition of risks contributes to financial planning but may not, on its own, improve scheduling outcomes.
- Risk Assessment showed a meaningful effect on cost ($\beta = 0.55$, $p < 0.05$) but no statistical significance for time, indicating its critical role in financial forecasting and budgeting but limited influence on scheduling unless integrated with monitoring and mitigation.

- All risk management dimensions were strongly correlated with each other (ranging from 0.888 to 0.920), reflecting internal coherence but also implying the need for advanced modeling techniques to address multicollinearity in future analyses.

10.2 Recommendations for Professional Practice in Risk Management:

In light of these validated findings, the following specialized and strategic recommendations are proposed to enhance project risk management frameworks in construction environments:

10-2-1. Institutionalize Real-Time Risk Monitoring Systems:

- Implement integrated dashboards aligned with KPIs and milestones.
- Use AI-based anomaly detection for procurement delays, resource shortfalls, and environmental disruptions.
- Assign a dedicated Risk Monitoring Officer to each major project to ensure ongoing visibility and accountability.

10-2-2. Strengthen Risk Mitigation Strategies:

- Employ Monte Carlo simulations and What-If scenario planning during pre-construction phases.
- Allocate contingency reserves based on probability-impact matrices tailored to local risk typologies.
- Prioritize supply chain resilience planning, particularly for projects in MENA markets facing import delays or geopolitical tensions.

10-2-3. Enhance Risk Assessment Protocols

- Develop standardized quantitative risk assessment models using Value at Risk (VaR), PERT analysis, and impact–probability matrices.
- Integrate assessment outputs into Earned Value Management (EVM) and project forecasting systems.
- Train managers in hybrid assessment techniques combining expert judgment with probabilistic modeling.

10-2-4. Improve Risk Identification Processes

- Conduct structured brainstorming and Delphi studies involving legal, technical, and regional risk experts.
- Develop context-specific checklists addressing risks such as permit delays, labor strikes, and extreme climate events.
- Incorporate multi-stakeholder engagement to ensure wide-ranging visibility of potential threats.

10-2-5. Embed Risk Governance in Organizational Strategy

- Establish Enterprise Risk Management (ERM) aligned with ISO 31000 and PMBOK frameworks.
- Require risk escalation protocols and quarterly audit-based reviews led by senior management.
- Use governance models that clearly assign accountability for critical risk categories.

10-2-7. Advance Risk Capabilities and Digital Transformation

- Invest in certifications (e.g., PMI-RMP®, ISO 31010) for project leads and risk officers.
- Digitize risk processes using collaborative tools such as Oracle Primavera Risk Analysis, Safran Risk, or Deltek Acumen.
- Incorporate Building Information Modeling (BIM) with risk simulations during design development phases.

10.3 Directions for Future Research

Building upon the empirical findings and model strength, this study recommends the following avenues for extended research:

- Development of Adaptive Risk-Response Algorithms: Integrate AI and real-time data streams to dynamically recommend mitigation actions as project conditions evolve.

- Cross-National Maturity Benchmarking: Conduct longitudinal studies comparing risk management maturity levels across GCC countries to identify regional best practices and gaps.
- Sector-Specific Risk Frameworks: Tailor and test the model across different construction sub-sectors such as healthcare infrastructure, residential, or industrial megaprojects.
- Behavioral Risk Studies: Investigate how cognitive biases and decision heuristics influence risk prioritization and perception among project stakeholders.

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