CHAPTER 63

Evaluating Risk Management in Construction through Knowledge-Based Practices: A Spearman's Rank Correlation Analysis

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ABSTRACT

Risk management is a critical aspect of construction projects due to their inherent complexity and uncertainty. This study explores the effectiveness of knowledge-based risk management (KBRM) practices in mitigating risks within the construction industry. Traditional risk management strategies often rely on reactive measures, which may not sufficiently address the dynamic nature of construction risks. This research investigates the role of knowledge-sharing, historical data utilization, and expert judgment in enhancing risk mitigation efforts. A structured survey was conducted among construction professionals, including project managers, engineers, and risk analysts, to assess their perception of KBRM practices. The study employs Spearman's Rank Correlation Analysis to establish the statistical relationship between the adoption of knowledge-based practices and risk reduction effectiveness. Findings indicate a positive correlation, highlighting the significance of structured knowledge management systems in identifying and mitigating project risks. The results suggest that integrating KBRM into existing risk frameworks improves decision-making, enhances risk prediction accuracy, and fosters a proactive risk management culture. The study provides valuable insights for construction firms and policymakers, advocating for the incorporation of knowledge-based strategies to enhance project resilience and sustainability.

Keywords: Risk management; Construction industry; Knowledge-based practices; Relative importance index; Spearman's rank correlation.

1.0 Introduction

The construction industry is characterized by high levels of uncertainty due to its complex nature, making risk management a critical aspect of ensuring project success. Effective risk management strategies help minimize financial losses, improve decision-making, and enhance overall project efficiency. more structured approach to mitigating risks by leveraging historical data, expert judgment, and collaborative strategies.

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Traditional risk management techniques primarily focus on reactive measures, often failing to address risks proactively. The incorporation of knowledge-based practices offers a This study employs Spearman's Rank Correlation Analysis to statistically analyze the relationship between the adoption of KBRM and its effectiveness in mitigating risks. The research investigates the extent to which structured knowledge-sharing, learning-based approaches, and data-driven decision-making contribute to improved risk management outcomes. The findings aim to provide construction firms with actionable insights for integrating knowledge-based strategies into their existing risk management frameworks. This research contributes to the existing body of knowledge by providing data-driven insights into the effectiveness of knowledge-based risk management in construction projects. By establishing a clear correlation between KBRM and improved risk mitigation outcomes, the study seeks to encourage broader adoption of structured knowledge-sharing practices within the industry. Ultimately, the research aims to enhance project resilience and sustainability by advocating for more systematic and proactive risk management approaches.

1.2 Research objectives

The primary objective of this research is to examine the impact of Knowledge-Based Risk Management (KBRM) on risk mitigation in construction projects. The study aims to:

- Identify the key risk factors affecting construction projects and assess their impact on project performance.
- Evaluate the role of knowledge-based practices in construction risk management.
- Analyze the relationship between knowledge-based risk management and risk mitigation effectiveness using Spearman's Rank Correlation Analysis.

1.3 Research questions

To address the research objectives, the study focuses on the following key research questions:

- What are the primary risk factors influencing construction projects, and how do they impact project outcomes?
- How do knowledge-based practices contribute to improved risk management in construction?

2.0 Literature Review

Risk management in the construction industry has evolved from traditional reactive approaches to more proactive, knowledge-based strategies. The complexity of construction projects necessitates a structured risk management framework that incorporates historical data, expert judgment, and analytical tools to improve decision-making. This chapter provides an

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overview of risk management methodologies, highlights key risk factors, and explores the role of knowledge-based practices in enhancing risk mitigation.

2.1 Risk management in construction

Risk management in construction involves the identification, assessment, and mitigation of risks that may impact project success. Traditional risk management techniques primarily rely on qualitative assessments and reactive strategies, which often result in inefficiencies and project delays. Modern approaches emphasize the integration of quantitative analysis, technology-driven risk assessment, and knowledge-sharing frameworks to improve risk prediction and mitigation.

Key risk factors in construction

Construction projects are exposed to multiple risks, including:

- *Financial risks:* Cost overruns, budget constraints, and fluctuating material prices.
- *Operational risks:* Delays due to labor shortages, poor project planning, and supply chain disruptions.
- *Technical risks:* Design errors, quality control issues, and material defects.
- *Regulatory risks:* Compliance with safety regulations, environmental laws, and contractual obligations.
- *Environmental risks:* Natural disasters, extreme weather conditions, and climate change impacts.

Understanding these risk factors is essential for developing effective mitigation strategies that enhance project efficiency and reduce uncertainties.

2.2 Methodology: PRISMA approach

The systematic review follows PRISMA methodology, which involves four phases:

- Identification: Searching databases for relevant studies.
- Screening: Applying inclusion and exclusion criteria.
- Eligibility: Evaluating the relevance and quality of studies.
- Inclusion: Finalizing the selection of studies for analysis.

2.3 Systematic literature review flowchart

The Initial search generates 4952 results in many languages from various subject areas. Engineering, Engineering Sciences, CS, Social are vague words, and had attracted many articles from fields like medicine, IT infrastructure, business, etc. Therefore, the irrelevant results/ articles were screened out based on criteria mentioned:

2.4 Knowledge-based risk management (KBRM)

Knowledge-based risk management leverages past project data, expert insights, and collaborative decision-making to improve risk mitigation. Unlike traditional methods, KBRM focuses on:

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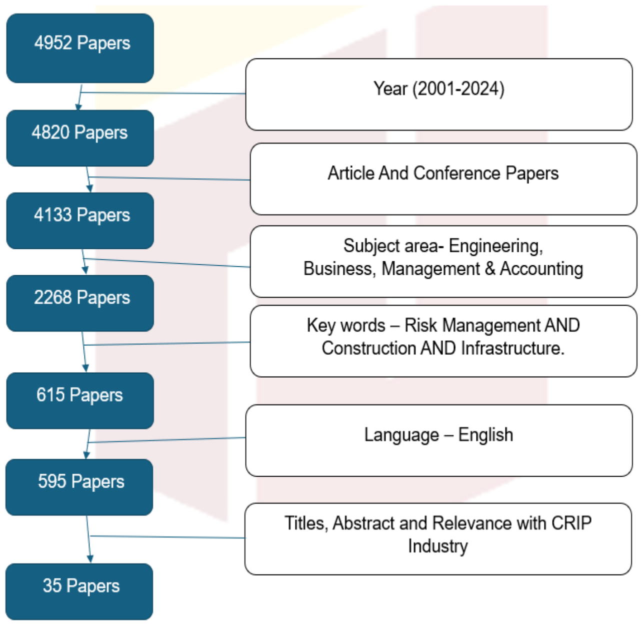
Figure 1: Systematic Literature Review Flowchart



- *Data-driven decision-making:* Using predictive analytics and AI for risk assessment.
- *Expert knowledge integration:* Incorporating lessons learned from previous projects.
- *Collaborative risk management:* Encouraging stakeholder participation in risk identification and resolution.

2.5 Emerging technologies in risk management

Recent advancements in technology have significantly improved risk assessment and mitigation in construction. Key innovations include:

1. *Artificial Intelligence (AI):* AI-powered tools analyze project data to predict potential risks and suggest preventive measures.
2. *Building Information Modeling (BIM):* BIM enhances risk visualization and improves coordination among project stakeholders.
3. *Digital Twins:* Virtual replicas of construction sites enable real-time monitoring and proactive risk management.

2.6 Research gaps and future directions

Limited empirical studies validating the impact of knowledge-based risk management.

- The need for standardized frameworks integrating KBRM into construction practices.
- The role of AI and machine learning in predictive risk analysis remains underexplored.

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3.0 Reseach Methodology

This study adopts a quantitative research methodology to analyze the impact of Knowledge-Based Risk Management (KBRM) on construction risk mitigation. The methodology includes a questionnaire survey**,** Likert scale analysis**,** Relative Importance Index (RII), and Spearman's Rank Correlation Analysis to assess and interpret industry insights.

3.1 Questionnaire survey

A structured questionnaire was designed to collect data from construction industry professionals, including project managers, engineers, risk analysts, and consultants. The survey aimed to capture their perceptions of KBRM effectiveness and how it influences risk mitigation. The questionnaire contained Likert-scale questions to measure respondents' opinions on various risk management factors, such as the role of knowledge-sharing, the impact of past project data, and the efficiency of knowledge-based risk mitigation strategies. The survey was distributed digitally and targeted at professionals with at least five years of industry experience to ensure informed responses.

3.2 Likert scale

A 5-point Likert scale was used to evaluate responses, ranging from Strongly Disagree (5) to Strongly Agree (1). The Likert scale facilitated the quantification of subjective perceptions. The collected responses provided a structured dataset for statistical analysis and ranking of risk management factors.

The Relative Importance Index (RII) is calculated using the following formula:

$$RII = \frac{\sum(W_i \times X_i)}{(k \times n)}$$

Where:

- RII is the Relative Importance Index for an item.
- W_i is the weight assigned to the i^{th} level of the Likert scale.
- X_i is the frequency of respondents who chose the i^{th} level of the Likert scale.
- k is the highest level on the Likert scale.
- n is the total number of respondents.

In the formula, $\sum(W_i \times X_i)$ represents the sum of the product of the weights and frequencies for each level of the Likert scale.

Relative Importance Index (RII) is a widely used statistical tool to determine the relative importance of different factors in research studies, especially in construction management, social sciences, and engineering. It helps in ranking factors based on their level of significance according to survey respondents' ratings.

Spearman's Rank Correlation Analysis was applied to measure the strength and direction of the relationship between KBRM practices and risk mitigation effectiveness. The Spearman coefficient (ρ) was calculated using:

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$$r_s = 1 - \frac{6\sum D^2}{n(n^2-1)}$$

where; rs = Spearman's rank correlation coefficient

D = Difference between the two ranks of each observation

n = number of observations

The coefficient rs ranges from -1 to +1:

- +1+1 indicates a perfect positive correlation, where an increase in one variable is matched by a proportional increase in the other.
- −1-1 signifies a perfect negative correlation, meaning an increase in one variable corresponds to a proportional decrease in the other.
- 00 suggests no correlation, indicating no consistent pattern in the ranking relationship.

4.0 Data Analysis and Result

The data analyzed, is derived from a structured questionnaire distributed among professionals in the construction industry. The responses were collected using a Likert scale, enabling a quantitative assessment of various risk factors and their management through knowledge-based practices. The collected data has been systematically processed and is presented in tabular format for clarity and ease of interpretation.

Table 1: Relative Importance Index (RII)

Questionnaire	Que.	Overall Rank	Client	Consultant	Contractor
	n = 14	R0	R1	R2	R3
1. Is knowledge management crucial for risk management?	C1	1	3	2	1
2. Do lessons learned reduce future risks?	C2	2	1	4	2
3. Are knowledge-based tools used for risk identification?	C3	8	3	4	13
4. Are risk databases consulted in planning?	C4	12	10	12	7
5. Does expert judgment prevent common risks?	C5	4	8	4	4
6. Is past project data essential for risk strategies?	C6	11	8	12	7
7. Is training provided for knowledge-based risk management?	C7	13	14	11	11
8. Does knowledge sharing minimize execution risks?	C8	2	1	4	2
9. Does technology enhance risk management?	C9	8	5	8	7
10. Is historical data used for risk mitigation?	C10	14	11	12	14
11. Does a knowledge-based approach improve project success?	C11	6	5	8	5
12. Are KM systems updated to address new risks?	C12	4	5	1	11
13. Does access to KM systems aid in unforeseen risks?	C13	10	11	8	7
14. Does KM-based risk management prevent pitfalls?	C14	6	11	2	6

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4.1 Relative Importance Index (RII)

Ranking in Table 1 highlights the key factors influencing knowledge-based risk management in construction projects. The highest-ranked factor, "Is knowledge management crucial for risk management?" (C1), indicates that industry professionals strongly recognize its significance. Similarly, "Do lessons learned reduce future risks?" (C2) is ranked second, reinforcing the importance of past experiences in mitigating risks. Factors such as the use of knowledge-based tools (C3) and historical data (C10) also show high relevance. Conversely, aspects like training for knowledge-based risk management (C7) and database consultation in planning (C4) received lower rankings, suggesting areas for improvement in industry practices. This analysis provides valuable insights for enhancing risk management strategies through structured knowledge-sharing and learning-based approaches.

4.2 Spearman's rank correlation analysis

Values in the Table 2 indicate the strength of agreement between different stakeholder groups (Client, Consultant, and Contractor) regarding the ranking of risk management factors. The highest correlation (R12 = 0.5824) between Clients and Consultants suggests a moderate to strong agreement in their perspectives.

Meanwhile, the correlation between Clients and Contractors (R13 = 0.4923) and between Consultants and Contractors (R23 = 0.4044) shows a moderate level of alignment, though slightly weaker. The average correlation (r-avg = 0.4930) reflects an overall moderate agreement among stakeholders. This suggests that while there is consensus on key risk management factors, some variations in prioritization exist, possibly due to differences in roles, experiences, and risk perception in construction projects.

Table 2: Spearman's Rank Correlation Analysis

Rs 1-2	0.5824
Rs 1-3	0.4923
Rs 2-3	0.4044
R-Avg	0.4930

4.3 Organization type distribution chart

The organizational graph illustrates the structured flow of knowledge-based risk management within a construction firm. It highlights key roles and their interactions, emphasizing how knowledge is shared, processed, and applied to mitigate risks. The hierarchy ensures that risk-related information flows from project teams to decision-makers, facilitating informed choices and effective risk mitigation strategies.

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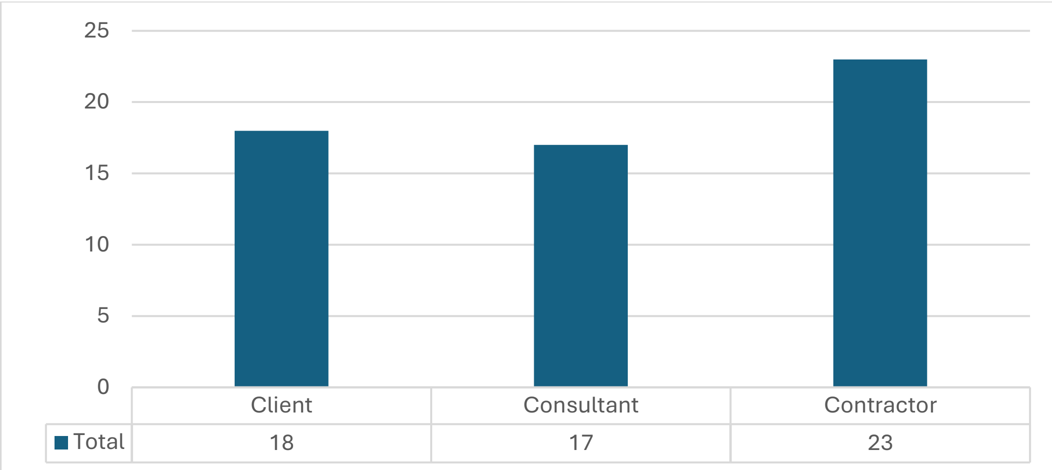
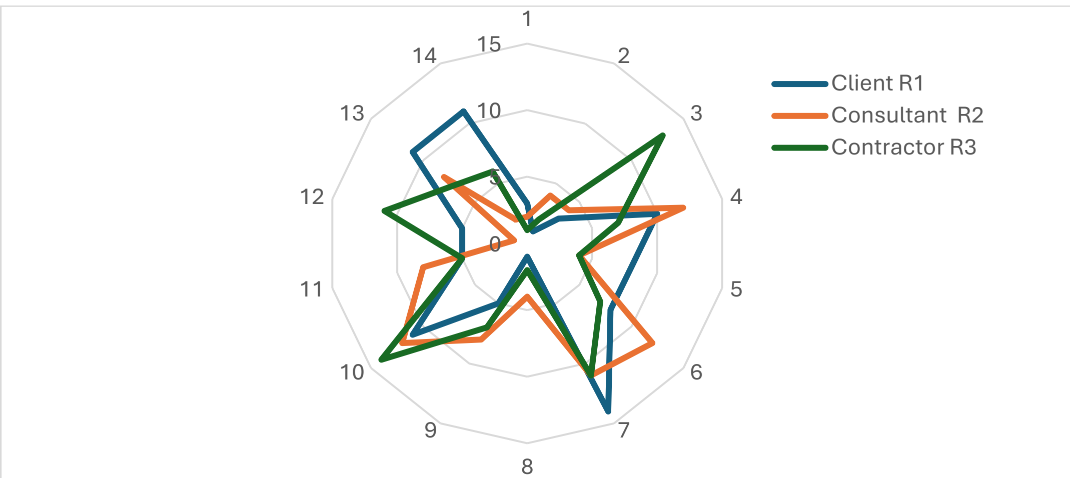
Figure 2: Count of Organization Type



4.4 Radar Chart

Figure 3: Rank Radar



The radar graph visually represents the significance of various risk factors across different stakeholders, such as clients, consultants, and contractors. Peaks in the graph indicate areas of strong agreement, while dips suggest differences in perception. The balanced distribution of values showcases which risk factors are considered more critical and where inconsistencies exist among stakeholders in prioritizing risk management aspects.

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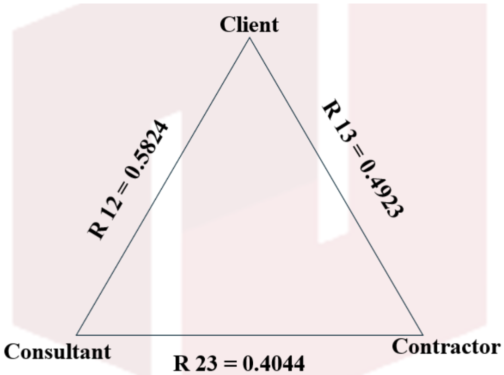
4.5 Spearman's rank correlation triangle (Figure 4)

The Spearman's correlation triangle represents the degree of agreement between different stakeholder groups regarding risk rankings. Higher correlation values indicate strong alignment in risk perception, while lower values suggest differing priorities. This visualization helps assess how well stakeholders align in their risk management strategies and where coordination can be improved for better project outcomes.

Figure 4: Spearman's Rank Correlation Triangle



5.0 Conclusion

This research highlights the significance of Knowledge-Based Risk Management (KBRM) in construction projects by examining its role in mitigating risks through structured learning and data-driven decision-making. The findings confirm that knowledge-sharing mechanisms, historical data utilization, and expert judgment play a critical role in improving risk management effectiveness. The RII analysis revealed that stakeholders prioritize risk management elements differently, while the Spearman's Rank Correlation demonstrated a moderate agreement among clients, consultants, and contractors regarding risk prioritization. Additionally, the integration of technology-driven solutions such as AI, BIM, and Digital Twins further enhances risk management efficiency. However, gaps in training, database utilization, and knowledge system updates indicate areas for improvement. Overall, this study validates that systematic knowledge management enhances risk mitigation and project success in the construction sector.

6.0 Recommendations

- *Implement structured knowledge management systems:* Construction firms should establish centralized knowledge repositories to document lessons learned, risk factors, and mitigation strategies for future projects.

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- *Enhance stakeholder collaboration:* Stronger communication channels between clients, consultants, and contractors can help improve alignment in risk perception and management strategies.
- *Improve training and awareness:* Conduct regular training sessions to equip professionals with knowledge-based risk management skills, ensuring better adoption of structured methodologies.
- *Leverage advanced technologies:* Utilize Artificial Intelligence (AI), Building Information Modeling (BIM), and Digital Twins to improve predictive risk analysis and real-time monitoring.
- *Optimize risk identification and response strategies:* Firms should refine their risk evaluation processes using data-driven decision-making to enhance mitigation measures.
- *Regularly update knowledge-based systems:* Keep knowledge management systems updated with new industry trends, risk factors, and mitigation strategies to ensure relevance and accuracy.
- *Encourage a learning-oriented culture:* Promote a continuous learning environment where professionals can share insights and best practices to enhance overall risk management effectiveness.

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