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عنوان البحث

إدارة المخاطر التعاقدية ومخاطر سلسلة الإمداد باستخدام الذكاء الاصطناعي وأثرها على الأداء المالي في مشاريع الإنشاءات في المنطقة الشرقية بالمملكة العربية السعودية

Artificial Intelligence Driven Contractual and Supply Chain Risk Management and Its Impact on Financial Performance:

Evidence from Construction Projects in the Eastern Region of the kingdom of Saudi Arabia

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Introduction:

The construction sector is among the most vital industries in the world economy, playing a crucial role in economic expansion, infrastructure progress, and job creation. Construction initiatives are crucial for national growth as they deliver necessary amenities like transportation systems, water supply networks, housing, manufacturing facilities, and public infrastructure. The modern construction industry is characterized by large-scale and intricate projects that engage various stakeholders such as project owners, contractors, subcontractors, consultants, suppliers, and regulatory bodies. Engagement among these entities fosters a dynamic setting where efficient coordination and administration are crucial for achieving successful project outcomes.

This study concentrates on construction projects in the Eastern Region of the kingdom of Saudi Arabia, where large-scale infrastructure development and complex project environments give rise to substantial contractual and supply chain risks.

Despite the importance of the construction sector, projects in this industry often face considerable challenges related to cost overruns, schedule delays, and performance inefficiencies. Many construction projects fail to achieve their planned objectives due to uncertainties that arise throughout the project lifecycle. These uncertainties are generally referred to as project risks, which may originate from technical, contractual, financial, operational, or environmental sources. As construction projects become larger and more complex, the number and variety of risks affecting project outcomes continue to increase.

Among the different categories of risks that affect construction projects, contractual risks and supply chain risks are considered among the most critical. Contractual risks arise from the legal and administrative aspects of project agreements between project stakeholders. These risks may include unclear contract clauses, delays in client payments, disputes between contracting parties, variation orders, scope changes, and contractual misinterpretations. In many cases, inadequate contract management or poorly defined responsibilities between parties can lead to disagreements and claims that may significantly affect project performance. Contractual disputes can result in project delays, increased administrative costs, and in some cases even project suspension or termination.

Risks in the supply chain pose another significant challenge in managing construction projects. Construction projects depend significantly on the prompt provision of materials, equipment, and specialized services from different suppliers and subcontractors. Any interruption in the supply chain can directly influence project timelines and efficiency. Risks in the supply chain can stem from supplier

breakdowns, delays in material shipments, transportation issues, quality concerns, and variations in the costs of construction materials. Moreover, shifts in the global economy, political unrest, and market fluctuations could amplify the susceptibility of construction supply chains. When disruptions in the supply chain happen, project managers might need to modify project timelines, find substitute suppliers, or incur extra expenses, all of which can adversely impact the financial outcomes of the project.

In recent years, the construction industry has experienced significant transformation due to rapid advancements in digital technologies. The integration of digital tools such as Building Information Modeling (BIM), enterprise resource planning systems, data analytics platforms, and artificial intelligence has introduced new opportunities for improving project management practices. Among these technologies, artificial intelligence has attracted increasing attention due to its ability to process large volumes of data and generate predictive insights that support decision making.

Technologies in artificial intelligence allow organizations to examine past project data, uncover concealed patterns, and forecast possible risks prior to their occurrence. AI systems can identify early warning signs concerning supply chain interruptions, contractor performance challenges, and possible contractual conflicts via machine learning algorithms and predictive analytics models. These abilities enable project managers to transition from reactive risk management methods to proactive risk management tactics. Rather than addressing issues after they arise, organizations can foresee risks beforehand and execute mitigation plans to lessen their possible effects.

Using artificial intelligence in risk management is especially significant in construction projects, where substantial quantities of operational, contractual, and financial data are produced during the project's lifecycle. By combining information from procurement systems, project timelines, financial systems, and supplier databases, AI-driven systems can deliver immediate insights into project risks. These insights can help decision-makers pinpoint essential risk zones and implement prompt measures to guarantee project stability and continuity.

A significant benefit of artificial intelligence in project management is its capability to enhance coordination among various project functions. In conventional construction management settings, contract management, procurement management, and financial management are frequently handled as distinct operational domains. Nonetheless, numerous project risks stem from the interplay among these functions. For instance, delays in delivery from suppliers can lead to contractual disputes, whereas payment delays might harm supplier relationships and the stability of the supply chain.

Through the integration of data from these areas, AI-based risk management systems can deliver a broader perspective on project risks and their possible effects on project outcomes.

Financial performance represents one of the most important indicators used to evaluate the success of construction projects. Financial performance reflects the ability of a project to achieve its expected financial outcomes, including profitability, cost control, and stable cash flow. When project risks are not managed effectively, they may lead to cost overruns, reduced profit margins, and financial instability for project stakeholders. For construction companies operating in competitive markets, maintaining strong financial performance is essential for sustaining long-term business success.

Effective risk management practices can play a crucial role in protecting project financial performance. By identifying risks early, assessing their potential impact, and implementing appropriate mitigation strategies, organizations can reduce the likelihood of financial losses. The integration of artificial intelligence with risk management practices has the potential to further enhance these capabilities by enabling organizations to predict risks more accurately and respond to them more efficiently.

While earlier research has explored different facets of risk management, supply chain management, and project performance, there has been little investigation into the combination of contractual risk management, supply chain risk management, and artificial intelligence in construction projects. The majority of research has investigated these aspects in isolation, overlooking the possible advantages of integrating them into a cohesive risk management framework. With the rising complexity and data reliance of construction projects, grasping how cutting-edge technologies can aid in comprehensive risk management grows ever more crucial.

Consequently, this research aims to investigate the impact of artificial intelligence on improving contractual risk management and supply chain risk management in construction projects. The study also seeks to investigate how these enhanced risk management strategies affect the financial outcomes of construction projects. Through examining the connections among contractual risks, supply chain risks, artificial intelligence capabilities, and financial performance of projects, the research seeks to offer important insights for construction managers, contract administrators, and stakeholders involved in projects.

Furthermore, the findings of this research may contribute to the development of more effective risk management strategies in construction organizations. By demonstrating the potential benefits of integrating artificial intelligence into risk management processes, this study may encourage construction companies to adopt advanced technologies that enhance their ability to manage complex

project environments. Ultimately, improving risk management practices may help construction organizations deliver projects more efficiently, reduce financial losses, and achieve sustainable project performance.

Problem Statement:

Many construction projects in KSA suffer from cost overruns and project delays. Numerous studies indicate that a significant percentage of construction projects are not completed within the planned time or budget. This is attributed to several factors, including weak contractual and supply chain risk management.

Companies often rely on traditional methods for identifying and managing risks, making risk management reactive rather than proactive. Furthermore, the lack of integration between contract management and supply chain management can exacerbate the impact of risks on project financial performance.

With the rapid advancement of artificial intelligence (AI) and data analytics, it has become possible to develop predictive models that help companies anticipate risks before they materialize. However, the application of these technologies in managing contractual and supply chain risks within the construction sector remains limited.

Therefore, this study aims to understand the relationship between contractual and supply chain risk management and the financial performance of construction projects, as well as to explore the role that AI technologies can play in improving the management of these risks.

Companies often rely on traditional methods for identifying and managing risks, making risk management reactive rather than proactive. Furthermore, the lack of integration between contract management and supply chain management can exacerbate the impact of risks on project financial performance.

Significance of the study:

The importance of this study lies in several scientific and practical aspects. Scientifically, it contributes to enriching the literature on risk management and supply chain management in construction projects, and it also contributes to integrating artificial intelligence (AI) technologies with risk management practices.

Practically, the results of this study can help contracting companies and project managers improve risk management and reduce its impact on project financial performance. The study can also contribute to developing practical AI-based models for predicting and managing risks more efficiently.

Furthermore, the study supports decision-makers in contracting companies by providing information and analyses that help them make strategic decisions related to contract and supply chain management and improve project financial performance.

Research Objective:

This study aims to examine the role of artificial intelligence in enhancing contractual and supply chain risk management and its effects on the financial outcomes of construction projects in Saudi Arabia.

The main objectives of this study are:

1. to identify major contractual risks in construction projects and assess their potential impact on project performance.
2. To examine the key supply chain risks affecting construction projects, including material delays, supplier disruptions, and logistics challenges.
3. To explore the role of artificial intelligence technologies in predicting, identifying, and managing risks within construction projects.
4. To analyze the relationship between risk management and financial performance.
5. Developing a conceptual framework to elucidate the interrelationship between artificial intelligence-driven risk management, contractual risks, supply chain risks, and financial performance in construction projects in Saudi Arabia.

Research Questions:

1. What are the most significant contractual risks in construction projects?

- 1.1 Contractual risks significantly affect the performance of construction projects?
- 1.2 Unclear contract clauses increase the likelihood of disputes in construction projects?
- 1.3 Payment delays represent a major contractual risk in construction projects ?
- 1.4 Variation orders significantly increase project costs?
- 1.5 Effective contract management reduces project risks?

2. What are the major supply chain risks affecting construction project performance?

- 2.1 Supply chain disruptions significantly affect construction project performance?
- 2.2 Delays in material delivery negatively affect project schedules?
- 2.3 Supplier reliability plays a critical role in project success?
- 2.4 Logistics problems can lead to significant project delays?
- 2.5 Price fluctuations of construction materials increase project risks?

3. How can artificial intelligence help in predicting and managing project risks?

- 3.1 Artificial intelligence can help identify risks in construction projects?
- 3.2 AI technologies improve risk prediction in construction projects?
- 3.3 AI-based systems support better decision-making in project management?
- 3.4 AI tools help detect potential project risks at an early stage?
- 3.5 The use of AI improves the effectiveness of risk management practices?

4. What is the impact of contractual and supply chain risks on financial performance?

4.1 Contractual risks increase the likelihood of Construction project cost overruns?

4.2 Supply chain disruptions negatively affect Construction project profitability?

4.3 Project delays lead to financial losses in construction projects?

4.4 Poor risk management negatively affects financial performance?

4.5 Effective risk management contributes to better financial outcomes?

5. Does the use of artificial intelligence improve financial performance in construction projects?

5.1 AI-driven risk management improves cost control in construction projects?

5.2 The use of AI reduces financial losses caused by Construction project risks?

5.3 AI technologies improve financial forecasting in construction projects?

5.4 AI helps improve Construction project financial performance?

5.5 AI adoption contributes to better Construction project decision-making and financial results?

Research Hypothesis:

H1: Contractual risks have a negative impact on the financial performance of construction projects.

H2: Supply chain risks negatively influence project financial performance.

H3: Artificial intelligence improves the effectiveness of risk identification and management.

H4: AI-driven risk management positively influences financial performance in construction projects.

Previous Studies:

Risk management has become a crucial element in ensuring the success of modern construction projects. With the increasing complexity of projects, organizations are exposed to multiple sources of uncertainty that can impact project costs, schedules, and overall performance. Therefore, many researchers have emphasized the importance of adopting systematic risk management practices to improve project outcomes.

Christopher (2016) highlighted the importance of supply chain management in maintaining business continuity and enhancing organizational resilience. According to Christopher, supply chain disruptions, such as material delivery delays, supplier failures, and transportation problems, can significantly impact project performance and lead to financial losses. Effective supply chain management helps organizations mitigate these disruptions and improve project stability

Similarly, Tang (2018) examined supply chain risk management practices, demonstrating that supply chain disruptions can negatively affect operational and financial performance across various sectors. The study emphasized the need for organizations to proactively identify potential risks in their supply chains and implement mitigation strategies

Ivanov (2021) expanded on this perspective by exploring how digital technologies and artificial intelligence (AI) contribute to improving supply chain resilience. His study demonstrated that advanced technologies, such as predictive analytics and AI, enhance risk identification and support decision-making processes in complex supply chain environments

In the field of construction project management, Kerzner (2017) emphasized that effective risk management is essential for achieving project objectives related to cost, time, and quality. He explained

that project managers must identify risks early and develop appropriate mitigation strategies to minimize their potential negative impact on project performance

Professional organizations have also underscored the importance of structured risk management processes. The Project Management Institute (PMI) defines risk management as a systematic process that includes identifying, analyzing, planning, responding to, and monitoring risks. According to PMI (2021), effective risk management improves project decision-making and increases the likelihood of project success

Similarly, the Institute of Risk Management highlighted the importance of enterprise risk management frameworks in helping organizations manage uncertainties and achieve strategic objectives. According to the Institute of Risk Management (2018), organizations that adopt structured risk management practices are better prepared to handle complex and uncertain environments

In addition to international studies, several Arab researchers have addressed the importance of risk management in project environments. Hammad (2015) emphasized that systematic risk management practices are essential for reducing uncertainty and improving project execution efficiency. The study highlighted that risk identification and analysis are crucial steps to ensuring successful project implementation.

Najm (2017) examined the role of supply chain management in improving organizational performance and reducing operational disruptions. The study concluded that effective coordination among suppliers, contractors, and logistics providers can significantly improve supply chain performance and reduce operational risks.

Similarly, Al-Ali (2018) discussed project management practices and emphasized that risk management plays a pivotal role in achieving project objectives. The study highlighted that project success depends on the ability of organizations to effectively manage risks and respond to unforeseen changes during project implementation.

A study conducted by Al-Maadat (2021) investigated construction projects in Jordan from the perspective of project managers. The primary objective of the study was to examine the effect of project

planning on the success of construction projects and to determine whether the level of project risk moderates the relationship between project planning and project success.

The study adopted a descriptive analytical research approach and utilized a structured questionnaire as the main instrument for data collection. The questionnaire included several items designed to measure the key dimensions of the study, including project planning practices and project success factors. The survey was distributed to project managers working in Jordanian construction companies using a non-probability sampling method. A total of 303 valid responses were collected and used for statistical analysis.

To test the proposed hypotheses, the study employed several statistical techniques, including multiple regression analysis and interaction regression analysis. The results revealed that project planning activities—such as feasibility study development, baseline planning, and risk planning—have a significant positive impact on the success of construction projects.

However, the findings indicated that the level of project risk did not significantly moderate the relationship between project planning and project success. Based on these findings, the study recommended increasing attention to effective project planning practices, conducting comprehensive feasibility studies before project implementation, and strengthening risk management practices to address uncertainties and challenges in construction projects.

Despite the significant contributions of previous studies, most existing literature focuses on risk management, supply chain management, or project management separately. Limited research has addressed the integration of contractual risk management, supply chain risk management, and artificial intelligence (AI) in construction project environments. Furthermore, few studies have examined the impact of these integrated risk management practices on the financial performance of construction projects.

Therefore, this research aims to bridge this gap by investigating how AI-enabled risk management can enhance contractual and supply chain risk management practices and contribute to improved financial performance in construction projects.

Recent reports from the Institute of Risk Management have highlighted that modern organizations are facing increasing risks associated with supply chain disruptions, geopolitical instability, and technological transformation. These risks necessitate sophisticated risk management frameworks and the incorporation of digital technologies like artificial intelligence to boost organizational resilience and decision-making.

The Saudi Arabian government has set up institutional frameworks to improve project governance and financial efficiency in large-scale infrastructure projects. The Expenditure and Projects Efficiency Authority (EXPRO) play a significant role in enhancing project performance by improving procurement practices, project planning, and cost control mechanisms across government projects. The initiatives aim to decrease project delays, control cost overruns, and enhance the efficiency of public spending. Frameworks such as these underscore the significance of structured risk management and supply chain governance in attaining improved financial performance in construction projects.

According to the Guide to Project Management and Contract Management for Infrastructure Development Projects issued by the Ministry of Finance of Sri Lanka, weak project and contract management practices are among the major causes of project delays, cost overruns, and contractual disputes in large infrastructure projects. The guide highlights that effective contract management requires systematic monitoring of project progress, proper management of variations and claims, and ensuring that all contractual obligations are fulfilled throughout the project life cycle. Furthermore, the guide stresses that contract management plays a critical role in safeguarding the interests of project stakeholders and ensuring that projects are completed within the allocated budget, time, and quality standards. These insights demonstrate the importance of structured contractual risk management in construction projects, which aligns with the objectives of the current study that aims to investigate how advanced technologies such as artificial intelligence can support risk prediction and improve financial performance in construction projects.

Theoretical Framework:

This study is underpinned by several theoretical perspectives that aid in explaining the relationships between risk management, supply chain performance, and financial outcomes in construction projects. This research integrates Enterprise Risk Management (ERM) theory, Supply Chain Management (SCM) theory, and Project Management theory, as these frameworks offer a comprehensive understanding of how risks can be identified, managed, and mitigated within complex project environments.

The Theory of Enterprise Risk Management

Enterprise Risk Management (ERM) theory centers on the systematic identification, evaluation, and management of risks that may impact the attainment of organizational objectives. ERM stresses that organizations should adopt a proactive and structured approach to managing risks across all operational levels rather than treating risks as isolated incidents. ERM assists construction organizations in identifying potential risks related to contracts, operations, and finances that may occur throughout a project's lifecycle.

Frameworks for Enterprise Risk Management, such as those proposed by international standards like ISO 31000 and COSO ERM, highlight the significance of identifying risks, analyzing risks, responding to risks, and ongoing monitoring. Implementing ERM principles in construction projects allows stakeholders to decrease uncertainty, lower financial losses, and enhance overall project efficiency. ERM theory supports the analysis of contractual risks and supply chain risks as key factors impacting financial performance within this research.

Theories of Supply Chain Management

Supply Chain Management (SCM) theory stresses the significance of coordination and integration among all entities involved in the supply chain, such as suppliers, contractors, manufacturers, logistics providers, and project owners. Effective supply chain management ensures the efficient flow of materials, information, and financial resources throughout the entire project lifecycle.

Supply chain disruptions can have a significant impact on construction project timelines, cost efficiency, and overall financial performance. Common risks that can negatively influence project outcomes include delays in material delivery, supplier failures, and logistics constraints. Supply chain management theory stresses the importance of collaboration, openness, and information exchange among stakeholders in order to enhance supply chain resilience and operational effectiveness.

This research employs SCM theory to examine the impact of supply chain risks on construction project performance and how enhanced coordination and technology adoption can improve supply chain stability.

Theories of Project Management

Project management theory centers on the planning, execution, monitoring, and control of project activities in order to attain specific objectives within predetermined constraints including time, cost, and quality. Successful project management, as defined by widely recognized project management frameworks such as those proposed by the Project Management Institute (PMI), necessitates effective risk management, resource allocation, and stakeholder coordination.

Complexity in construction projects arises from the involvement of numerous stakeholders, contractual agreements, and operational uncertainties. Project management theory stresses the importance of structured planning, effective communication, and ongoing monitoring of project performance to guarantee that project objectives are met. This study's framework is grounded in project management theory, which explains how contractual arrangements, supply chain coordination, and risk management practices impact project outcomes.

Integration of Artificial Intelligence within the Framework

The integration of Artificial Intelligence (AI) within these theoretical frameworks introduces new capabilities for improving decision-making and risk prediction in construction projects. AI technologies such as machine learning, predictive analytics, and data-driven modeling can assist project managers in identifying potential risks at early stages, analyzing large datasets, and forecasting project performance more accurately.

By combining AI tools with ERM, SCM, and project management frameworks, organizations can enhance their ability to detect risks, optimize supply chain operations, and improve financial performance. AI-driven risk management systems can provide predictive insights that help project managers make more informed decisions and respond effectively to uncertainties.

Therefore, the integration of artificial intelligence within these theoretical frameworks provides a modern approach to managing risks and improving project performance, which forms the conceptual foundation of this study.

Research Methodology:

This study employs a descriptive and analytical research methodology to investigate the relationship between contractual risks, supply chain risks, artificial intelligence applications, and financial performance in construction projects. The descriptive approach is employed to document the current practices of risk management in construction projects, whereas the analytical approach is utilized to examine the relationships between the study variables and validate the research hypotheses.

This study employs a quantitative research approach, which enables to gather measurable data from a large number of participants and examine it using statistical methods. This approach is suitable for investigating relationships between variables and validating the proposed hypotheses.

The research population consists of professionals working in the construction industry, particularly individuals involved in project management, contract administration, procurement, and supply chain management. These professionals are directly engaged in managing risks and making strategic decisions related to project execution and financial performance.

The targeted population includes professionals working in:

Engineering and consulting firms, Project management offices, Supply chain and procurement departments

These professionals possess practical experience and knowledge regarding contractual risks, supply chain disruptions, and project performance, making them suitable participants for this study.

The study will employ a non-probability sampling method, specifically purposive sampling, due to the large size of the construction industry. This sampling technique enables the researcher to choose respondents with relevant expertise and experience in construction project management and risk management.

The respondents the intended survey is targeted at include:

Project Managers

Contract Managers

Procurement Managers

Supply Chain Executives

Specialists in Risk Management

Construction engineers involved in project planning and contract administration.

A sample size of 100 to 150 respondents is considered sufficient for statistical analysis using SPSS and for producing reliable research findings.

The data will be analyzed using the Statistical Package for the Social Sciences (SPSS) software. The data will be analyzed and the research hypotheses tested using several statistical techniques.

Descriptive Statistics & Correlation Analysis

Data Collection Tools:

Data for this study will be gathered from both primary and secondary sources in order to guarantee a thorough comprehension of the research problem and to enhance the reliability of the results.

Primary data will be collected via a structured questionnaire distributed to professionals in the construction industry. The questionnaire will be designed to capture respondents' perceptions and experiences of key factors influencing construction project performance. The survey will comprise multiple sections focusing on the key aspects of the study, encompassing contractual risks, Supply Chain Executives, Specialists in Risk Management, the use of artificial intelligence in risk management, and financial performance metrics in construction projects.

The questionnaire will feature statements scored on a five-point Likert scale, spanning from Strongly Disagree to Strongly Agree, enabling respondents to indicate their degree of agreement with each statement. This measurement scale enables quantitative analysis and facilitates the researcher in examining the relationships between the study variables. A questionnaire will be electronically distributed to reach a diverse group of professionals including project managers, contract managers, procurement managers, and supply chain specialists with relevant construction project management experience.

Secondary data will be collected in conjunction with the primary data to underpin the theoretical framework of the study. Sources will comprise scholarly journal articles, academic books, industry reports, and professional guidelines concerning risk management, construction project management, and artificial intelligence in project settings. The sources will offer valuable insights into existing theories, models, and previous research findings related to the study topic.

Utilizing both primary and secondary data sources will facilitate a comprehensive analysis of the research problem, increase the validity of the results, and establish a robust theoretical and empirical basis for the study.

The combination of primary and secondary data enables the study to gain a more in-depth understanding of risk management practices and assess how emerging technologies like artificial intelligence can enhance financial performance in construction projects.

Study Limitations:

Several limitations of this study should be acknowledged. **First**, the research focuses on **construction projects in Saudi Arabia**, which may limit the applicability of its findings to construction industries in other countries due to variations in regulations, market structures, and project management practices.

Second, the study focuses particularly on contractual risks and supply chain risks within construction projects. This research does not encompass other types of risks, such as financial risks, technical risks, environmental risks, and political risks, are not included within the scope of this research, although they may also influence project performance.

Third, the study relies on data collected through a questionnaire distributed to professionals working in construction companies. As a result, the findings depend on the perceptions and experiences of the respondents, which may introduce a degree of subjectivity in the responses.

The study ultimately investigates the role of artificial intelligence in facilitating risk management practices, based on the current level of technological adoption within the construction industry. Future research may explore additional applications and more advanced analytical models for improving risk management in construction projects as artificial intelligence technologies continue to evolve rapidly.

The study offers valuable insights into the role of artificial intelligence in improving financial performance, enhancing contractual and supply chain risk management in construction projects in Saudi Arabia, despite its limitations.

Geographic range: Contracting firms within the Kingdom of Saudi Arabia (Eastern Region).

Time frame: Information for the years 2020–2025

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