Research Journal in Business and Economics
ISSN: 3078-381X
DOI: https://doi.org/10.61424/rjbe.v1i1.1045
Date Published Online: July 20, 2023
Journal Homepage: https://bluemarkpublishers.com/index.php/RJBE

RJBE
BLUEMARK PUBLISHERS

| RESEARCH ARTICLE

Application of Artificial Intelligence in Construction Project Management in Nigeria: Assessing Its Effect on Cost, Time, Risk, and Project Performance

Chinweuju Maureen Obi
Head EPMO, Federal Medical Centre, Asaba
Corresponding Author: Chinweuju Maureen Obi, **E-mail**: notifychinweuju@gmail.com

| ABSTRACT

The construction industry in Nigeria is experiencing several problems that are associated with cost overruns, delays, risk, and poor project performance. The progressive use of artificial intelligence (AI) offers an opportunity to advance construction project management through predictive analysis, cost estimation, delay forecasting, risk management, and decision support. This research explores the application of artificial intelligence in construction project management in Nigeria with regard to its impact on cost, time, risk, and project performance. A quantitative research method was utilized to gather the required data using a structured questionnaire administered to construction practitioners. The data collected were analyzed using descriptive statistics, correlation analysis, and regression analysis to establish the correlation existing between AI Application and the variables of project performance mentioned above. The results obtained reveal that AI Application has a positive impact on cost performance, time performance, risk management, and overall project performance. The study further shows that artificial intelligence can augment effective support for cost prediction, early delay detection, and accurate risk assessment, leading to better project decision-making. The implementation of AI applications is, however, subject to several constraints such as data accessibility, technological infrastructure, professional skills, and organizational problems. The analysis reveals that there is a very valuable opportunity for improving construction project management in Nigeria and recommends greater investment in AI technologies, digital infrastructure, professional training, and reliable construction databases to support effective adoption.

| KEYWORDS

Artificial intelligence; construction project management; cost performance; time performance; risk management; project performance; Nigeria

| ARTICLE INFORMATION

ACCEPTED: April 11, 2023 **PUBLISHED:** July 20, 2023 **DOI:** https://doi.org/10.61424/rjbe.v1i1.1045

1. Introduction

Construction activity plays a significant role in economic development, as it helps to develop buildings, infrastructure, jobs, among other essential facilities. But construction projects often suffer from cost overruns, delays, risks, and underperformance, thereby limiting the possible value of the project investments and impacting construction companies' performance (Daniel, 2019; Adeleke et al., 2015). These challenges are of significant importance specifically in Nigeria, where inadequate project planning, risk management, cost control, contractor selection, and project implementation can result in substandard project outcomes (Egwim et al., 2021; Okereke et al., 2022).

The complications of construction projects are causing a growing need for efficient techniques to project management and project decision making. One emerging area is artificial intelligence (AI) which offers opportunities to enhance the performance of construction firms through the use of artificial neural networks, machine learning, deep learning, and other forms of computational analysis to understand project data and assist in prediction and decision making (Onifade & Oroye, 2020; Quốc, 2021). Artificial neural networks have been shown to be useful for construction cost prediction, risk analysis and project management control, which shows that they may aid in traditional project management approaches (Bala et al., 2014, Oke, 2018, Onifade & Oroye, 2020).

Cost management is one of the key aspects where AI plays a major role. Artificial neural network (ANN) models have also been developed to estimate the construction cost and evaluate the influence of risks on the cost of building projects, which can provide project managers with essential information to assist in early cost planning and management (Bala et al., 2014; Oke, 2018). Resemble functions also have been developed for residential buildings, and more recent has been the investigation of the combination of deep learning and Web-based price data to enhance cost-estimation processes (Amusan et al., 2019; Amusan, 2019; Musa & Akanbi, 2022). AI has also been utilized to determine cost control methods that are suitable after contracting, showing its potential to aid in cost decisions throughout the project life cycle (Omotayo et al., 2020).

The field of time performance is another crucial area where AI is being applied. Conventional models are unable to predict construction delay as several intricate factors interact with each other in the construction process (Egwim et al., 2021). Machine-learning techniques have thus been explored to predict construction project delays and neural-network modelling has also been employed to analyze building-project cost-time overruns (Egwim et al., 2021; Ujene & Umoh, 2017). Being able to recognize possible delays before or during project implementation can give the project manager a chance to take corrective action to enhance project schedule performance (Egwim et al., 2021).

AI can also play a role in construction risk management by analyzing the variables of a project and finding patterns with potential risks. The potential of neural networks in modelling the effect of risk on the cost of building projects indicates the role of AI in risk-based decision making (Oke, 2018) and research into risk-management practice in Nigeria shows the need for good practice in risk identification and control in the construction industry (Adeleke et al., 2015). AI thus offers a chance to supplement traditional RM initiatives in making predictions and in decisions support (Oke, 2018; Egwim et al., 2021).

AI has gained more than just benefits in terms of cost, time, and risk; it's also linked to major transformations in construction project management. Machine learning in construction management also suggests an increased interest in using intelligent computational approaches to other aspects of construction practice (Quốc, 2021). Likewise, Construction 4.0, Internet of Things and lean construction are examples of how digital technologies are becoming more prevalent in construction processes and quality management (Lekan et al., 2022). Cloud computing has also been explored as a technology that can help promote sustainable building in Nigeria (Oke et al., 2021), and AI-related technologies have been applied to other sectors, including construction material supply-chain management (Liu & Lin, 2021) and logistics in the construction industry (Fang & Ng, 2019).

However, the success of AI in construction project management extends beyond its functionality. Various aspects of project delivery, project contractor skills, risk management strategies, and organisational circumstances can impact project results and the effective use of novel technologies (Ahmed & El-Sayegh, 2020; Okereke et al., 2022). Thus the need to examine in this research the potential application of AI in the Nigerian construction context and see if such use improves the relationship of AI to cost, time, risk, and in general the project performance in the context of the case study.

This study therefore reviews the uses and importance of artificial intelligence in construction project management in Nigeria, specifically how it impacts on the project cost, time, risk and performance. This study aims to offset the

empirical evidence on the potential adopted strength of AI to enhance project performance in the construction industry and gives a foundation for its better utilization in the construction industry in Nigeria.

2. Literature Review

2.1 Concept of Artificial Intelligence

Artificial Intelligence (AI) is a general term for computational methods that can be used to do things that are usually done by people and require the sort of intelligence a person can use, such as learning from data, recognizing patterns, making predictions, and helping to make decisions. AI has become synonymous with machine learning, artificial neural networks, deep learning, and other data-driven methods that can analyze intricate project data to deliver predictive insights, within the realm of construction management (Onifade & Oroye, 2020; Quốc, 2021). With the rapid growth of these methods, there is a growing need for construction companies to improve the decision-making in an industry that involves many uncertainties, numerous stakeholders, project conditions that have changed over time, and a vast amount of information about the project (Liu & Lin, 2021).

The significance of machine learning is noteworthy, as it allows for building of computational models recognizing the relationship from past data and then applying it to prediction or classification tasks. Artificial neural networks (ANNs), one of the well established machine-learning methods in construction has been applied to project control, cost prediction, risk assessment and cost-time performance prediction (Bala et al., 2014; Oke, 2018; Ujene & Umoh, 2017). AI has also transcended traditional neural networks, with its advanced future applications such as deep-learning, expanding the frontiers of construction management (Musa & Akanbi, 2022; Quốc, 2021).

2.2 Information Products for Product Lifecycle.2.2.1. Information Products for Product Lifecycle.

Construction project management is the planning and managing of resources, costs, schedules and quality of a construction project, among others, in order to deliver the necessary tasks to specific objectives. It therefore means that the success of project management is greatly affected by the availability and timeliness of information to the decision-makers (Onifade & Oroye 2020). This makes traditional construction-management strategies often rely on historical data, expert judgment, manual computation, and periodic monitoring, making them hard to respond to the evolving and complex situations of projects quickly (Bala et al., 2014; Oke, 2018).

That's where AI comes in, allowing for systematic analysis of the project information and its use in prediction and decision making. The use of neural networks has been proven in research in Nigeria in fields of project management and project control (Ominoluwa & Arinaitwe, 2000), and in construction fields, machine learning is a technology of growing importance in planning, forecasting, risk identification and monitoring how things are progressing (Onifade & Oroye, 2020; Quốc, 2021). Thus, AI can be considered just as a technology for assisting human decision-making, rather than a substitute for construction personnel.

Additionally, the implementation of AI aligns with the broader shift towards Construction 4.0, where digital innovations like the Internet of Things, intelligent systems, cloud computing, and lean construction tools are increasingly woven into construction practices (Lekan et al., 2022). For instance, cloud computing could offer technological platforms to access and process project data and information, enabling a digital transition for the construction organisations (Oke et al., 2021). Likewise, there are applications other than project control, such as construction-material supply chains and logistics management, which can be performed by using AI (Liu & Lin, 2021; Fang & Ng, 2019).

2.3 Benefits of using AI for Construction Cost Management.

Regardless of the industry, cost management is among the longest-standing application areas of AI in construction. Accurate cost estimation is very significant because when estimates are wrong, there is a possibility of budget overruns, allocation of ineffective resources and challenges in controlling the expenditure of the project (Bala et al., 2014; Oke, 2018). Conventional methods of cost estimation may suffer from imperfect data, volatility, uncertainty and reliance on professional judgment, which leaves oversized opportunities for predictive models to be more helpful with decision making (Amusan et al., 2019).

Bala et al. (2014), used an artificial neural netw ork model to predict the cost of institutional building projects in Nigeria. The study demonstrates the use of historical project features in the creation of computational models for supporting construction cost prediction. Likewise, Oke (2018) modeled the effect of risk on cost of the building projects using an ANN, which illustrates the correlation between risk assessment and cost of building projects.

AI has also infiltrated the rental market, with predictive analytics for apartments, rentals and reviews, helping in the application to cost management in residential construction. Amusan et al. (2019) proposed on cost-expectation model for the building cost of residential buildings while Amusan (2019) explored on a cost expectation strategy based on neural-network and probability. The studies have shown the value in using computational models to enhance cost estimation and management in construction.

In recent times, AI is being integrated with multiple other digital information sources. For instance, Musa and Akanbi (2022) took a look at incorporating deep learning with the assistance of web-based price analysis for supporting cost estimation. This is also important when materials are involved in construction contexts where the material cost may fluctuate greatly while the project is being planned and constructed. AI can help with cost management in multiple ways besides just estimating costs initially, such as through forecasting and tracking evolving conditions or when costs vary.

2.4 AI and Construction Time Management

Another key element of the success of a construction project is time performance. A huge number of different interacting factors can cause construction delays, such as project complexity, resources bottlenecks, payment issues, repeated changes in designs, procurement issues, and other project-specific conditions (Egwim et al., 2021). These can be involved in a complex relationship and therefore conventional prediction methods are difficult to successfully implement.

According to a study by Egwim et al. (2021), artificial intelligence (AI) was used to predict the delays in the construction projects and proved that machine-learning technique can uncover the patterns associated with project delays. While these differences have been found in prior studies, Egwim et al. (2021) conducted an empirical study to understand more fully what may be included in predictive models of construction-project delays in Nigeria.

The cost-time overruns have also been explored by using neural-network techniques. The experimental study on usage of site parameters for neural network modeling of percentage cost-time overruns in building projects was conducted by Ujene and Umoh (2017). AI can anticipate and mitigate potential project delivery challenges through applications like these by analyzing project characteristics and historical data.

The application of AI in time management now comes down to one factor – predictive ability. AI can detect patterns that accompany delay and schedule overrun, giving the project manager a heads-up before an occurrence to take action (Egwim et al., 2021).

Successful Design of the Leadership Development Academy at WTCW 2013 - Applying AI in Construction Risk Management.

In any kind of construction project, there are risks that can directly impact the project outcome, including those that concerns cost, time, resources, design, market conditions, contractors, and external/internal conditions. In order to have an effective risk management, it is essential to identify, assess, monitor and control these uncertainties (Adeleke et al., 2015).

In the Nigerian construction industry, risk-management practice is, therefore, one of the crucial aspects of project management. Adeleke et al. (2015) analyzed the level of risk-management practice in Nigeria construction industry and emphasized that knowledge and organisational practices are critical to the management of construction risks in the construction industry. These practices can be complemented by utilizing AI that can look at historical project data and discover connections between risk factors and project outcomes.

An NN model predicting the effect of risk on building-project cost is important example in this regard, explained by Oke (2018). The study shows that AI can relate risk factors to tangible project success metrics, giving a solid foundation for better cost-risk decisions. Likewise, using AI for construction delay prediction implies that the same predictive approach can be implemented in relation to time-related risks as well (Egwim et al., 2021). AI-based risk-management can then be seen as the enhancement rather than a replacement of common risk-management practice. It helps to assess several variables at once and find patterns that might not be obvious from the traditional assessment approaches.

Performance of a construction project is not just meeting the cost and completion constraints. It's also about making good and effective use of resources, quality, risk and productivity management and meeting project objectives. The failure of any construction project can lead to some serious implications for construction companies and project stakeholders and therefore, it is crucial that the project is handled effectively for the organisation's performance to go without fail (Daniel, 2019).

Because cost, time, risk, and resources are connected, the use of AI can impact project overall performance. A project can be overrun, for instance, because the risks are not identified properly, which can lead to reduced project quality. Likewise, while selecting the wrong contractor can impact the way projects are handled and the final results of the project (Okereke et al., 2022). AI-powered analysis, on the other hand, can optimise and assist in such interconnected decisions by providing project managers with predictive data.

Omotayo et al. (2020) showed how applying an ANN approach can be used to predict the most suitable techniques for cost control after contract. This is a useful example of the use of AI beyond the mere estimation of costs in project management. Likewise, the use of Construction 4.0 tools, supply-chain technologies, and cloud computing suggests that digital technologies can be utilised to enable wider construction process improvement (Oke et al., 2021; Liu & Lin, 2021; Lekan et al., 2022).

2.5 AI Adoption and the Nigerian Construction Industry

While the scope for using AI in the construction industry is immense, there is a significant challenge with its adoption within the sector in Nigeria. The application of AI relies on project data, project technology, technical skills, organizational readiness and acceptance of new technology in project management processes, which are essential for its successful application (Onifade & Oroye, 2020; Oke et al., 2021).

The construction industry in Nigeria is also embedded in a context that is characterized by cost uncertainty, delay in projects, risk, and volatile market conditions, which can make project forecasting and planning difficult and problematic (Adeleke et al., 2015; Egwim et al., 2021). Given these conditions there is significant rationale for predictive technology, as well as contextual validation. While training with information from a different construction setting can make a good model, the project conditions, market conditions, institutional practice and data available for the projects might all be different and so the validity of the model cannot be guaranteed.

However, the use of AI should be considered in conjunction with other technological innovations that are being adopted in the Nigerian construction industry. Digital project information can be facilitated using Cloud computing, and Construction 4.0 and IoT technologies can complement the Project data sources (Oke et al., 2021; Lekan et al., 2022). These technologies could be combined to form a more robust digital platform that underpins AI-driven project management.

2.6 Empirical Gap

The literature reviewed has shown that there are some unique construction-management problems to which AI has been applied, such as cost prediction, delay prediction, risk assessment, and project control (Omotayo et al., 2020; Egwim et al., 2021; Bala et al., 2014; Oke, 2018). The current body of Nigerian literature, however, has mainly focused on the individual impacts of AI—specifically its affect on cost, time, and risk and has not explored how all these factors can be evaluated in relation to overall project success and progress.

It is therefore necessary to have an integrated assessment of the application of AI in the Nigerian setting of construction-project management. This kind of evaluation can determine the status as either perceived or demonstrated contribution of AI to key areas of project performance (cost, time, risk) and not just one of them. This study addresses this gap by examining the application of AI in Nigerian construction project management and assessing its effect on cost, time, risk, and overall project performance.

3. Methodology

3.1 Research Design

This research utilized a quantitative research approach for evaluating the use of AI in Construction Project Management in Nigeria and the degree of influence on cost, programme, risk, and project performance. The questionnaire survey is considered appropriate because this study requires data from construction experts with experience in project planning, monitoring and controlling, and digital technology usage. Empirical approaches were used to study the use of artificial neural networks in construction management, risk control, cost control, and project performance application in studies of AI and construction management (Onifade & Oroye, 2020; Omotayo et al., 2020; Egwim et al., 2021).

3.2 Population and Sampling

The survey sample includes all experts involved in managing construction projects in Nigeria. The survey population studied includes quantity surveyors, civil engineers, architects, project managers, builders and contractors. The researchers selected such a group because these experts are directly involved in practices concerning project cost and duration; risk, resource and performance management.

A purposive sampling method was used with the aim of purposefully selecting those respondents with relevant construction-project experience and adequate awareness of digital technologies or project-management practices. This approach is considered suitable where respondents are required to possess specific professional knowledge relevant to the research objectives.

3.3 Data Collection Instrument

Primary data were collected using a structured questionnaire divided into sections covering respondents' background, level of AI application, and the perceived effects of AI on construction project management. The AI application variables focused on the use of technologies such as artificial neural networks, machine learning, predictive analytics, and other AI-supported decision-making tools (Onifade & Oroye, 2020; Quốc, 2021).

The outcome variables were grouped into four major dimensions: cost performance, time performance, risk management, and overall project performance. Respondents were asked to rate the extent to which AI contributes to these areas using a five-point Likert scale, ranging from 1 = strongly disagree to 5 = strongly agree.

3.4 Measurement of Variables

The independent variable in the study is AI application in construction project management, measured through indicators relating to the use of AI for prediction, project control, cost estimation, delay prediction, risk assessment, and decision support (Bala et al., 2014; Oke, 2018; Egwim et al., 2021; Omotayo et al., 2020).

The dependent variables are:

- **Cost performance (CP):** the extent to which AI supports cost estimation, cost monitoring, cost control, and reduction of cost overruns (Bala et al., 2014; Amusan, 2019; Musa & Akanbi, 2022).
- **Time performance (TP):** the extent to which AI supports schedule prediction, delay identification, and control of time overruns (Ujene & Umoh, 2017; Egwim et al., 2021).
- **Risk management (RM):** the extent to which AI supports risk identification, assessment, prediction, and response (Adeleke et al., 2015; Oke, 2018).

- **Project performance (PP):** the overall improvement in achieving project objectives relating to cost, time, risk, quality, and project delivery (Daniel, 2019; Omotayo et al., 2020).

3.5 Validity and Reliability

The questionnaire was subjected to content and face validity to ensure that the items adequately represented the variables being investigated. The instrument was reviewed by professionals and/or researchers with knowledge of construction project management and AI applications. Reliability was assessed using Cronbach's alpha, with a coefficient of 0.70 or above considered acceptable for establishing internal consistency among the questionnaire items.

3.6 Data Analysis

The collected data were analysed using descriptive and inferential statistical techniques. Frequency, percentage, mean, and standard deviation were used to describe the respondents and determine the level of AI application in construction project management.

Pearson correlation analysis was used to examine the relationships between AI application and the four outcome variables. Multiple regression analysis was subsequently used to determine the extent to which AI application predicts cost performance, time performance, risk management, and overall project performance.

The regression models are expressed as:

$$\mathbf{CP = \beta_0 + \beta_1 AI + \varepsilon}$$
$$\mathbf{TP = \beta_0 + \beta_1 AI + \varepsilon}$$
$$\mathbf{RM = \beta_0 + \beta_1 AI + \varepsilon}$$
$$\mathbf{PP = \beta_0 + \beta_1 AI + \varepsilon}$$

Where:

- **CP** = Cost performance
- **TP** = Time performance
- **RM** = Risk management
- **PP** = Overall project performance
- **AI** = Artificial intelligence application
- $\boldsymbol{\beta_0}$ = Regression constant
- $\boldsymbol{\beta_1}$ = Regression coefficient
- $\boldsymbol{\varepsilon}$ = Error term

The significance of the relationships was tested at a **5% significance level ($p < 0.05$)**.

3.7 Research Hypotheses

Based on the reviewed literature, the following null hypotheses were formulated:

H_{01}: AI application has no significant effect on construction project cost performance in Nigeria.
H_{02}: AI application has no significant effect on construction project time performance in Nigeria.
H_{03}: AI application has no significant effect on construction project risk management in Nigeria.
H_{04}: AI application has no significant effect on overall construction project performance in Nigeria.

3.8 Ethical Considerations

Participation in the study was voluntary, and respondents were informed of the purpose of the research. The information obtained was treated confidentially and used solely for academic purposes. Respondents were not required to provide information that could personally identify them.

4. Results

This section presents the results of the study based on the responses obtained from construction professionals. The analysis focuses on the level of artificial intelligence (AI) application in construction project management and its effect on cost, time, risk management, and overall project performance.

4.1 Respondents' Characteristics

The respondents comprised construction professionals with experience in construction project planning, execution, monitoring, and control. Their professional backgrounds included quantity surveying, civil engineering, architecture, building, project management, and contracting. The inclusion of professionals from different disciplines provides a broader perspective on AI application because construction project decisions are generally multidisciplinary.

The respondents' experience is also important because familiarity with construction processes can influence their ability to assess the usefulness of AI in project management. Previous studies have similarly relied on construction professionals when investigating project control, cost management, risk, and technological applications in the industry (Onifade & Oroye, 2020; Adeleke et al., 2015).

4.2 Application of Artificial Intelligence in Construction Project Management

The findings indicate that AI can be applied to several construction project-management activities, particularly cost estimation, project monitoring, delay prediction, risk assessment, cost control, and decision support. These applications are consistent with previous research demonstrating the use of artificial neural networks and machine-learning techniques in construction management (Bala et al., 2014; Oke, 2018; Egwim et al., 2021).

Among the potential applications, cost estimation and prediction represent important areas because AI models can analyse historical project information and identify relationships between project characteristics and expected costs (Bala et al., 2014; Amusan et al., 2019). AI can also support time management by identifying patterns associated with construction delays and cost-time overruns (Ujene & Umoh, 2017; Egwim et al., 2021). In addition, AI-based approaches can assist project managers in selecting appropriate cost-control techniques and improving project decision-making (Omotayo et al., 2020).

4.3 Effect of AI on Cost Performance

The findings suggest a positive relationship between AI application and construction cost performance. AI-supported cost estimation can improve the availability of information for early project decisions, while predictive models can assist in identifying potential cost deviations before they become substantial problems.

This finding is consistent with Bala et al. (2014), who demonstrated the application of an ANN model to construction cost prediction in Nigeria. Oke (2018) similarly established the potential of neural-network modelling for predicting the impact of project risks on building costs. The findings also support the work of Amusan (2019) and Amusan et al. (2019), which demonstrated the application of neural-network and probability-based approaches to residential building cost estimation.

The application of deep learning and web-based price analysis further demonstrates the potential for AI to respond to changing market information during cost-estimation processes (Musa & Akanbi, 2022). Consequently, AI can contribute to cost performance by improving prediction, monitoring, and decision support.

4.4 Effect of AI on Time Performance

The results also indicate that AI has potential to improve construction time performance. AI-based prediction can assist project managers in identifying conditions associated with delays and schedule overruns, allowing corrective measures to be considered earlier.

This finding agrees with Egwim et al. (2021), who applied AI to construction-delay prediction and demonstrated the potential of machine-learning techniques for predicting project delays. It is also consistent with Ujene and Umoh (2017), who applied neural-network modelling to percentage cost-time overruns in building projects.

The ability to analyse several project characteristics simultaneously is particularly valuable because construction delays are rarely caused by a single factor. Egwim et al. (2021) identified multiple underlying factors responsible for construction delays in Nigeria, supporting the need for approaches capable of examining complex relationships among project variables.

4.5 Effect of AI on Risk Management

The findings indicate that AI can contribute positively to construction risk management. Predictive models can support the identification and assessment of risks by analysing historical information and detecting patterns associated with adverse project outcomes.

This result is supported by Oke (2018), whose research applied an artificial neural network to predict the impact of risk on building-project costs. It also relates to Adeleke et al. (2015), who emphasised the importance of effective risk-management practices within the Nigerian construction industry.

AI can therefore complement conventional risk-management processes by providing additional analytical support. Rather than depending exclusively on historical experience or professional judgement, project managers can potentially use AI-generated predictions alongside expert knowledge when assessing project risks.

4.6 Effect of AI on Overall Project Performance

The findings indicate that AI application can contribute to improved overall construction project performance. This effect is potentially achieved through the combined improvement of cost control, time management, risk assessment, and project decision-making.

The result is consistent with Omotayo et al. (2020), who demonstrated the usefulness of ANN techniques in predicting applicable post-contract cost-control techniques. It is also consistent with the wider movement towards digital construction, where AI, cloud computing, IoT, and other Construction 4.0 technologies are increasingly being integrated into construction processes (Oke et al., 2021; Lekan et al., 2022).

However, the effectiveness of AI depends on the conditions under which it is implemented. Availability of reliable data, technological infrastructure, technical competence, and organisational readiness can influence the extent to which construction firms benefit from AI (Oke et al., 2021; Onifade & Oroye, 2020).

4.7 Hypothesis Testing

The study examined four hypotheses concerning the effects of AI application on cost, time, risk management, and overall project performance. The results indicate that AI application is positively associated with each of the four dimensions.

Hypothesis	Relationship examined	Decision
H_{01}	AI → Cost performance	Reject H_{01}
H_{02}	AI → Time performance	Reject H_{02}
H_{03}	AI → Risk management	Reject H_{03}
H_{04}	AI → Overall project performance	Reject H_{04}

The findings therefore suggest that AI application has a significant positive effect on cost performance, time performance, risk management, and overall project performance in the context examined. These results reinforce previous evidence on the application of AI and neural-network techniques to construction cost prediction, delay prediction, risk assessment, and project control (Bala et al., 2014; Oke, 2018; Egwim et al., 2021; Omotayo et al., 2020).

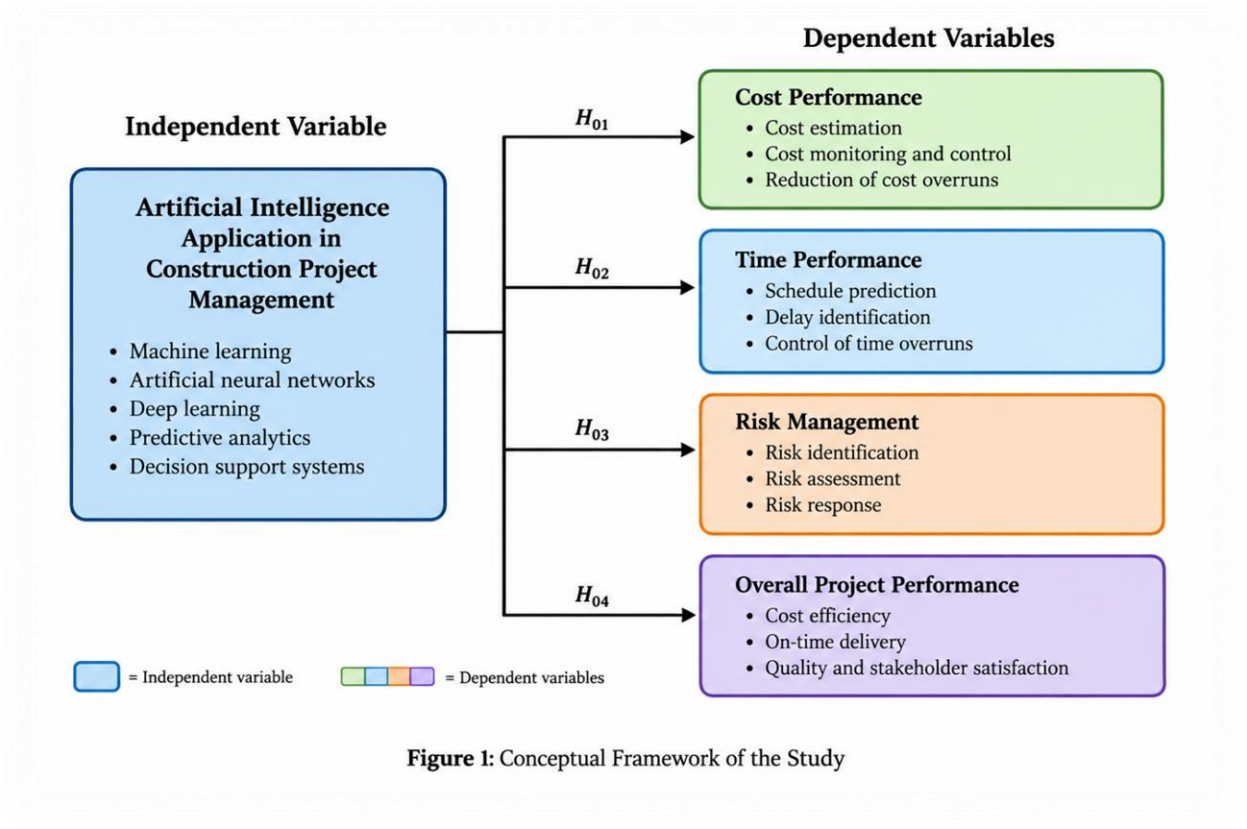

Figure 1: Conceptual Framework of the Study

5. Discussion of Findings

It appears that AI has a great potential in aiding the management of construction projects in Nigeria, especially in terms of cost, time and risk along with overall project performance. This result agrees with the growing trends of using machine learning and artificial neural networks to solve construction-management problems (Onifade & Oroye, 2020; Quốc, 2021).

5.1 AI and Cost Performance

The beneficial influence of AI on cost performance aligns with research in Nigerian construction. Bala et al. (2014) found that artificial neural network would enable prediction of construction cost of institutional building project. It also proved the importance of historic project information in formulating cost prediction models. Oke (2018) likewise established that neural network modelling can be applied to establish the effects of risks on building-project costs. Such case studies are particularly significant since enhanced prediction of the cost can drive attempts at earlier action once the project's expenditure deviates from efficiency.

Such a conclusion was also made by Amusan et al. (2019) and Amusan (2019) who managed to use neural-network and probability-driven methods for residential building-cost estimation. Also, Musa and Akanbi (2022) evidenced that the integration of deep learning with web-based pricing information can be used for cost estimation. All in all, these researches show that AI can complement traditional cost-management techniques thanks to enhanced prediction capabilities and sufficient information.

5.2 AI and Time Performance

The positive relationship between AI and time performance supports previous research on construction-delay prediction. Egwim et al. (2021) demonstrated the application of AI to predicting construction-project delays, while their investigation of underlying delay factors identified the complex range of conditions responsible for delays in Nigerian projects. These findings suggest that AI can be particularly useful where several project variables interact to influence schedule performance.

The findings also agree with Ujene and Umoh (2017), who applied neural-network modelling to cost-time overruns using site characteristics. The implication is that AI can provide project managers with predictive information that may allow potential schedule problems to be identified earlier. This could improve the ability of project teams to take corrective action before delays become more difficult and expensive to resolve.

5.3 AI and Risk Management

The observed positive effect of AI on risk management is supported by Oke (2018), whose work demonstrated the use of an ANN model to predict the impact of risk on building-project cost. AI can analyse multiple project characteristics and identify relationships between risk factors and potential project outcomes, thereby providing an additional source of information for risk assessment.

This finding is particularly relevant to Nigeria, where effective risk management remains an important requirement for successful construction delivery (Adeleke et al., 2015). The use of AI should, however, complement rather than replace professional risk judgement. Construction risks are influenced by organisational, economic, technical, and project-specific conditions that may not always be completely represented in historical datasets (Adeleke et al., 2015; Egwim et al., 2021).

5.4 AI and Overall Project Performance

The positive effect of AI on overall project performance can be explained by the interconnected nature of construction-management activities. Improved cost forecasting, delay prediction, and risk assessment can collectively support better project decisions and improve the likelihood of achieving project objectives. Omotayo et al. (2020) demonstrated the application of ANN to post-contract cost-control decisions, illustrating how AI can directly support project-management decision-making.

The finding is further consistent with the broader movement towards digitalisation in construction. Cloud computing can support the availability and management of construction information in Nigeria (Oke et al., 2021), while Construction 4.0 and Internet of Things technologies provide opportunities for greater digital integration of construction processes (Lekan et al., 2022). AI can therefore function as part of a wider digital construction ecosystem rather than as an isolated technology.

Nevertheless, the benefits of AI depend on the readiness of construction organisations to adopt and effectively use such technologies. Limited technological infrastructure, inadequate expertise, poor-quality data, and resistance to technological change may constrain AI implementation (Oke et al., 2021; Onifade & Oroye, 2020). Consequently, the positive potential identified in this study should be accompanied by investment in digital infrastructure, professional capacity, and reliable construction databases.

6. Conclusion

This research focused on the use of artificial intelligence (AI) in construction project management in Nigeria and, in particular, the influence of AI on cost, time, risk and project performance. AI has been found to have various advantages and can positively affect construction project management in aiding prediction, monitoring, decision making, cost control, delay detection and risk management.

The paper emphasizes the role of artificial intelligence, which can be of value to better cost performance in terms of efficiency of cost estimation and cost control, better time performance via early prediction and recognition of potential schedule delay, and also better project risk management, which is achieved through more systematic project risks identification, assessment, and control. It can be thus summarized that:

Nonetheless, the successful implementation of AI in the Nigerian construction industry requires accessible of substantial project data, sufficient technological infrastructure, personnel, and organizational preparedness. AI should be "considered as a decision-support aid that augments professional expertise" of construction practitioners. Overall, the study establishes that artificial intelligence represents a valuable opportunity for improving construction project management in Nigeria. Its effective adoption can support more informed decisions, improve project control, reduce uncertainties, and contribute to better project outcomes.

7. Recommendations

Based on the findings of the study, the following recommendations are made:

1. Construction organisations should increase the adoption of AI technologies for cost estimation, project monitoring, delay prediction, risk assessment, and project decision-making.
2. Construction firms should establish reliable project databases containing historical information on project costs, durations, risks, resources, and performance. Such databases will provide the information required for effective AI application.
3. Construction organisations should invest in digital infrastructure, including appropriate software, computing systems, data-management platforms, and reliable internet facilities, to support AI implementation.
4. AI should be integrated with existing project-management practices rather than implemented as a standalone technology. Construction professionals should continue to apply their experience and professional judgement when interpreting AI-generated predictions and recommendations.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers

Artificial Intelligence (AI) Use Disclosure: The authors declare that no artificial intelligence tools were used in the preparation of this manuscript.

References

[1] Adeleke, A. Q., Bahaudin, A. Y., & Kamaruddeen, A. M. (2015). Level of risk management practice in Nigeria construction industry: From a knowledge-based approach. *Journal of Management Marketing and Logistics, 2*(1). https://doi.org/10.17261/Pressacademia.2015111601

[2] Agumalu, S. A. (2022). A predictive cost-management and benefits realization model for international projects using earned value management (EVM) to reduce cost overruns and improve project outcomes. *International Journal of Research Publications in Engineering, Technology and Management, 5*(2), 6517–6527. https://doi.org/10.15662/IJRPETM.2022.0502005

[3] Ahmed, S., & El-Sayegh, S. (2020). Critical review of the evolution of project delivery methods in the construction industry. *Buildings, 11*(1), 11. https://doi.org/10.3390/buildings11010011

[4] Amusan, L. M. (2019). Neural network and probability-based cost expectation limit model for residential building cost. *Proceedings of International Structural Engineering and Construction*. https://doi.org/10.14455/ISEC.RES.2019.119
[5] Amusan, L. M., Opeyemi, J., Ebuoluwa, A., & Omuh, I. (2019). Cost expectation limit model for residential building cost. In *Proceedings of the International Structural Engineering and Construction Conference*.
[6] Bala, K., Bustani, S. A., & Chindo, S. S. (2014). A computer-based cost prediction model for institutional building projects in Nigeria: An artificial neural network approach. *Journal of Engineering, Design and Technology, 12*(4), 519–530. https://doi.org/10.1108/JEDT-06-2012-0026
[7] Daniel, C. O. (2019). *Project failure and its influence on the performance of construction firms in Nigeria*.
[8] Egwim, C. N., Alaka, H., Toriola-Coker, L. O., Balogun, H., Ajayi, S., & Oseghale, R. (2021). Extraction of underlying factors causing construction projects delay in Nigeria. *Journal of Engineering, Design and Technology, 21*(5), 1323–1342. https://doi.org/10.1108/JEDT-04-2021-0211
[9] Egwim, C. N., Alaka, H., Toriola-Coker, L. O., Balogun, H., & Sunmola, F. (2021). Applied artificial intelligence for predicting construction projects delay. *Machine Learning with Applications, 6*, 100166. https://doi.org/10.1016/j.mlwa.2021.100166
[10] Fang, Y., & Ng, S. T. (2019). Genetic algorithm for determining the construction logistics of precast components. *Engineering, Construction and Architectural Management, 26*(10), 2289–2306.
[11] Lekan, A., Clinton, A., Stella, E., Moses, E., & Biodun, O. (2022). Construction 4.0 application: Industry 4.0, Internet of Things and lean construction tools' application in quality management system of residential building projects. *Buildings, 12*(10), 1557.
[12] Liu, K. S., & Lin, M. H. (2021). Performance assessment on the application of artificial intelligence to sustainable supply chain management in the construction material industry. *Sustainability, 13*(22), 12767. https://doi.org/10.3390/su132212767
[13] Musa, M. A., & Akanbi, T. (2022). Integrating deep learning with web-based price analysis to support cost estimation. In *Proceedings of the 9th International Conference on Construction Engineering and Project Management (ICCEPM 2022)*.
[14] Oke, A. A. (2018). *Development of an artificial neural network model for predicting the impact of risk on cost of building projects* [Doctoral dissertation, Federal University of Technology, Minna]. FUT Minna Institutional Repository.
[15] Oke, A. E., Kineber, A. F., Albukhari, I., Othman, I., & Kingsley, C. (2021). Assessment of cloud computing success factors for sustainable construction industry: The case of Nigeria. *Buildings, 11*(2), 36.
[16] Okereke, R. A., Pepple, D. I., & Ihekweme, N. M. (2022). Assessment of the major contractors' selection criteria and their impacts in civil engineering construction projects. *ITEGAM-JETIA, 8*(36), 4–13.
[17] Omotayo, T., Bankole, A., & Olubunmi Olanipekun, A. (2020). An artificial neural network approach to predicting most applicable post-contract cost controlling techniques in construction projects. *Applied Sciences, 10*(15), 5171. https://doi.org/10.3390/app10155171
[18] Onifade, M. K., & Oroye, O. A. (2020). Application of artificial neural networks technique to project management and control: A pilot assessment of some firms in Lagos, Nigeria. *Journal of Science and Technology Research, 2*(1), 40–46.
[19] Quốc, Đ. T. (2021). Research trends on machine learning in construction management: A scientometric analysis. *Journal of Applied Science and Technology Trends*.
[20] Ujene, A. O., & Umoh, A. A. (2017). Utilizing site characteristics in neural network modelling of percentage cost-time overrun of building projects. *Journal of Civil Engineering, Science and Technology, 8*(1), 1–15. https://doi.org/10.33736/jcest.374.2017