Journal of Intelligent Computing, Digital Technologies and New Media Systems

journal homepage: https://ojs.universityedu.org/index.php/jicdtnms

Integration of Building Information Modeling (BIM) with Artificial Intelligence for Real-time Cost Estimation in Megaprojects

Chukwunonye Raphael Okpala
Department of Quantity Surveying, Federal University of Technology Owerri.

KEYWORDS

Building Information Modelling (BIM), Artificial Intelligence (AI), Real-Time Cost Estimation, Megaprojects.

ABSTRACT

The increasing complexity of megaprojects has intensified the need for more efficient and accurate cost estimation systems within the construction industry. Conventional quantity surveying methods are often characterized by manual calculations, fragmented information management, and delayed cost reporting, which contribute to budget overruns and poor financial decision-making. Building Information Modelling (BIM) has improved digital coordination in construction projects by enabling integrated project visualization and automated quantity extraction. More recently, Artificial Intelligence (AI) technologies have been introduced into BIM environments to support intelligent data processing, automated classification, and predictive cost analysis. This study investigates the integration of AI with BIM for real-time cost estimation in megaprojects. A mixed-methods research design was adopted, involving comparative analysis of documented project case studies and semi-structured interviews with industry professionals. The findings reveal that AI-assisted BIM systems improve estimation efficiency, reduce manual errors, and enhance coordination between design and commercial teams. However, challenges relating to data standardization, interoperability, implementation costs, and workforce competence continue to affect adoption. The study concludes that AI-enabled BIM systems have significant potential to improve quantity surveying and commercial management practices when supported by appropriate digital standards and organizational readiness.

1. Introduction

Megaprojects are among the most complex forms of project delivery within the global construction industry because they involve extensive financial commitments, multiple stakeholders, sophisticated engineering systems, and long implementation periods. Such projects commonly include transportation infrastructure, industrial facilities, urban development projects, and large commercial developments. Despite improvements in project management practices and digital technologies, many megaprojects continue to experience significant cost overruns and schedule delays. According to Flyvbjerg (2014), inaccurate forecasting, ineffective project coordination, and inadequate risk management are among the major factors contributing to poor cost performance in large-scale infrastructure projects.

Cost estimation plays a critical role in project planning and commercial management because it provides the basis for budgeting, procurement planning, resource allocation, and financial decision-making. Traditional quantity surveying methods largely depend on manually prepared Bills of Quantities (BOQs), spreadsheet calculations, and the interpretation of two-dimensional drawings. Although digital systems have improved documentation processes over time, many estimation activities continue to rely on repetitive manual procedures. Frequent design modifications further increase the complexity of estimation activities because quantity surveyors are often required to repeatedly update project quantities and associated costs throughout project development stages.

* Corresponding author's E-mail address: chukwunonyeokpala@gmail.com
Received April 28, 2026; Received in revised form May 26, 2026; Accepted: June 8, 2026.

Building Information Modelling (BIM) has emerged as one of the most influential technological developments in the architecture, engineering, and construction industry. BIM facilitates the creation of integrated digital models that contain both geometric and non-geometric project information. These digital environments support collaboration, improve visualization, and strengthen information management across project lifecycles. Within quantity surveying practice, BIM has contributed to improvements in automated quantity extraction and enhanced coordination among project stakeholders. Previous studies have highlighted the potential benefits of BIM in construction cost management. Azhar (2011) noted that BIM improves project communication and coordination while reducing inconsistencies associated with traditional project documentation systems. Similarly, Smith (2014) emphasized that the integration of cost information into BIM environments through 5D BIM enables improved cost planning and quantity management processes. These developments have significantly reduced dependence on traditional estimation approaches and improved the efficiency of project information exchange.

Recent technological advancements have also accelerated the application of Artificial Intelligence (AI) within construction management practices. Artificial Intelligence refers to computational systems capable of performing tasks associated with learning, reasoning, pattern recognition, and predictive analysis. Within the construction sector, AI technologies have been applied in project scheduling, risk management, safety monitoring, and predictive cost analysis. Machine learning techniques can process large datasets, identify relationships among variables, and generate intelligent predictions capable of supporting project decision-making processes.

The integration of Artificial Intelligence with BIM has received increasing research attention because of its potential to improve estimation efficiency and support automated decision-making systems. Studies have suggested that AI-assisted BIM platforms can automate quantity extraction processes, classify model components, identify cost patterns, and generate estimation outputs more efficiently than traditional workflows. Lee et al. (2023) argued that AI-driven quantity take-off systems improve estimation consistency and reduce repetitive manual tasks through automated object recognition and classification procedures. Despite these potential advantages, several challenges continue to affect the implementation of AI-assisted BIM systems within construction organizations. The effectiveness of AI-generated outputs depends largely on the quality and structure of available project data. Inconsistent object naming systems, poor BIM model quality, and limited interoperability between software platforms can negatively affect automation performance. Furthermore, workforce competence, implementation costs, and resistance to technological change remain significant barriers affecting digital transformation efforts within the construction industry.

Although existing studies have examined BIM applications and AI technologies independently, limited research has focused on the practical integration of both technologies for real-time cost estimation in megaproject environments. Much of the available research emphasizes technological capabilities while giving less attention to operational implementation challenges and their implications for quantity surveying practices. This study therefore investigates the integration of Artificial Intelligence with Building Information Modelling for real-time cost estimation in megaprojects, with particular emphasis on workflow efficiency, estimation reliability, and implementation challenges.

1.1 Statement of the Problem

Accurate cost estimation remains a major challenge in megaproject delivery due to the complexity of construction information and the dynamic nature of project design development. Traditional quantity take-off processes often require estimators to manually interpret large volumes of architectural, structural, and engineering information. In complex projects, this process increases the likelihood of omissions, duplication of quantities, and clerical errors, which may negatively affect project budgets and procurement decisions. Another major challenge involves the continuous revision of project designs during planning and pre-

construction stages. Under conventional workflows, quantity surveyors are often required to repeatedly update Bills of Quantities following design modifications. These revisions consume significant time and may delay financial reporting, thereby reducing the ability of stakeholders to make timely commercial decisions.

Although BIM technologies have improved project visualization and digital coordination, many organizations still face difficulties establishing fully integrated and automated cost management systems. The absence of standardized BIM protocols, inconsistent data structures, and limited integration between estimating software and digital models continue to affect workflow efficiency. Consequently, there is a need to investigate how AI-assisted BIM systems can improve the speed, reliability, and responsiveness of cost estimation processes within megaproject environments.

1.2 Purpose of the Study

The purpose of this study is to examine the integration of Artificial Intelligence with Building Information Modelling for improving real-time cost estimation in megaprojects. Specifically, the study seeks to:

1. examine the effectiveness of AI-assisted BIM systems in automating quantity take-off and cost estimation processes;
2. evaluate the extent to which AI-driven BIM workflows reduce manual estimation errors in megaproject delivery;
3. identify the major operational and organizational challenges affecting the adoption of AI-BIM systems in the construction industry.

1.3 Research Questions

The study seeks to answer the following research questions:

1. How effective are AI-assisted BIM systems in improving quantity take-off and cost estimation processes in megaprojects?
2. To what extent do AI-driven BIM workflows reduce manual estimation errors during project cost estimation?
3. What operational and organizational challenges affect the implementation of AI-BIM integration in the construction industry?

2. Methodology

This study adopted a mixed-methods research design involving both quantitative and qualitative approaches. The mixed methods approach was selected because it enabled the study to evaluate technical workflow performance alongside professional experiences relating to AI-BIM implementation.

Research Design: A comparative case-study strategy was adopted to examine selected megaprojects that implemented BIM-supported digital estimation systems between 2022 and 2025. The study combined analysis of documented project performance data with qualitative insights obtained from industry professionals.

Data Collection: Quantitative data were obtained from published industry reports, conference proceedings, and documented international project case studies involving large-scale infrastructure developments. The collected data included:

- Quantity take-off duration;
- Design revision frequency;
- Workflow efficiency indicators;
- Estimation discrepancy records.

Semi-structured interviews were conducted with:

- Quantity surveyors;
- BIM coordinators;
- Commercial managers;

- Construction consultants.

The interviews focused on implementation experiences, operational challenges, organizational readiness, and perceptions regarding the effectiveness of AI-assisted BIM systems.

Data Analysis: Quantitative data were analyzed using comparative workflow assessment techniques to evaluate differences between conventional estimation systems and AI-assisted BIM workflows. Qualitative interview data were analyzed through thematic coding to identify recurring operational and organizational issues affecting implementation.

3. Findings

*Improvement in Estimation Efficiency***:** The study found that AI-assisted BIM systems improved the efficiency of quantity take-off and cost estimation activities within megaproject environments. Automated extraction of quantities from BIM models reduced the time required for preparing and updating Bills of Quantities, especially during periods of frequent design revision. Participants indicated that integrated digital workflows improved coordination between design teams and commercial departments by enabling faster access to updated project information.

Table 1: Comparison of Workflow Characteristics

Activity	Conventional Workflow	AI-BIM Workflow
Quantity Take-off	Manual calculations from drawings	Automated extraction from BIM models
Cost Updates	Periodic revisions	Continuous updates
Design Revision Processing	Time-consuming	Faster response
Information Coordination	Fragmented documents	Centralized digital environment

Reduction in Manual Errors: The findings further revealed that AI-assisted classification systems improved consistency in quantity estimation by reducing omissions, duplicate entries, and clerical calculation errors. Automated validation tools enabled project teams to identify incomplete or improperly classified BIM objects more efficiently than under traditional workflows. Interview participants also noted that reduced dependence on spreadsheet-based calculations improved the overall reliability of cost estimation outputs.

Table 2: Common Errors Across Workflows

Error Type	Conventional Workflow	AI-BIM Workflow
Quantity Omissions	Common	Reduced
Duplicate Entries	Frequent during revisions	Less frequent
Clerical Errors	High probability	Lower probability
Classification Inconsistency	Often observed	Improved through automation

3.1 Challenges Affecting Implementation

Despite the identified operational benefits, several barriers affecting AI-BIM adoption were observed. Poor BIM standardization was identified as a major challenge because inconsistent naming conventions and incomplete digital models reduced the effectiveness of automated classification systems.

Participants also highlighted:

- High software acquisition costs;
- Inadequate technical expertise;
- Interoperability limitations between software platforms;
- Resistance to organizational change.

Cybersecurity concerns and data management challenges associated with cloud-based collaboration systems were also identified as emerging implementation issues.

Table 3: Major Barriers to AI-BIM Adoption

Barrier	Impact on Implementation
Poor BIM Standardization	Reduced automation accuracy
High Technology Costs	Limited adoption
Inadequate Technical Skills	Reduced workflow efficiency
Interoperability Problems	Data transfer limitations
Resistance to Change	Slower organizational transition

4 Discussion

The findings demonstrate that the integration of Artificial Intelligence with Building Information Modelling has the potential to improve quantity surveying and commercial management practices within megaproject delivery. Automated quantity extraction and intelligent data processing contribute to faster decision-making and more responsive cost management systems. The findings support existing research suggesting that digital technologies can improve estimation consistency and reduce repetitive manual calculations in construction workflows. Through the integration of cost information directly within BIM environments, project stakeholders can evaluate the financial implications of design modifications more efficiently than under conventional estimation systems.

However, the study also revealed that technological capability alone does not guarantee successful implementation. The effectiveness of AI-assisted BIM systems depends heavily on the quality and structure of project data. Poorly organized BIM models and inconsistent classification standards may reduce the reliability of automated outputs. Furthermore, organizational readiness remains a major factor influencing adoption. Many firms continue to experience challenges relating to digital competence, software integration, and institutional resistance to technological change. These findings suggest that successful AI-BIM implementation requires both technological investment and organizational adaptation.

The study also emphasizes that AI-assisted BIM systems should be viewed primarily as decision-support tools rather than complete replacements for professional expertise. Quantity surveyors and commercial managers remain essential for validating outputs, interpreting project-specific conditions, and managing procurement-related risks.

5 Conclusion

The integration of Artificial Intelligence with Building Information Modelling presents important opportunities for improving cost estimation processes within megaproject environments. AI-assisted BIM systems improve workflow efficiency by automating quantity extraction, supporting continuous cost updates, and reducing repetitive manual estimation activities. The study found that these technologies improve coordination between design and commercial teams while enhancing the consistency and responsiveness of financial reporting systems. However, successful implementation depends on standardized BIM practices, digital infrastructure readiness, workforce competence, and effective organizational management. The study concludes that AI-enabled BIM systems can contribute significantly to modern quantity surveying and commercial management practices when supported by structured implementation frameworks and collaborative digital strategies.

6 Recommendations

1. Construction organizations should establish standardized BIM object libraries and unified classification systems before implementing AI-assisted estimation platforms.

2. Academic institutions and professional bodies should strengthen training in digital construction technologies, data analytics, and AI-supported quantity surveying practices.
3. Construction firms should invest in interoperable software systems capable of supporting integrated project coordination and real-time cost management.
4. Further research should investigate the long-term operational and financial impacts of AI-BIM integration across different project delivery systems and regional construction markets.

References

Azhar, S. (2011). Building Information Modelling (BIM): Trends, benefits, risks, and challenges for the AEC industry. *Leadership and Management in Engineering*, 11(3), 241–252.

Flyvbjerg, B. (2014). What you should know about megaprojects and why: An overview. Project Management Journal, 45(2), 6–19.

Lee, S., Kim, K., & Yu, J. (2023). Artificial intelligence-driven automated quantity take-off framework for infrastructure projects. Automation in Construction, 149, 104118.

Smith, P. (2014). BIM implementation and project cost management practices. Procedia - Social and Behavioural Sciences, 119, 475–484.

Zhang, Y., & Lu, W. (2025). Real-time cost estimation using AI-integrated BIM systems for infrastructure delivery. Journal of Construction Engineering and Management, 151(4), 04025012.