Adoption of Modern Construction Technologies in Enhancing Time Performance of Building Projects in Lagos State

Chinonso D. Agoha[1], Emmanuel M. Rotimi[1], Israel E. Oseyomon[1] and Gideon O. Adeyanju[1]
[1]Department of Building, University of Lagos, 101017, Nigeria
Corresponding Author's Email: agohachinonso@gmail.com

Abstract
Purpose *– Building project delays in Lagos State average over 40% beyond scheduled completion, yet the relationship between modern construction technology (MCT) adoption and time performance remains empirically underexplored in the Nigerian context. This study therefore investigates the extent to which the adoption of modern construction technologies influences the time performance of building projects in Lagos State, Nigeria.*

Findings *– Construction firms exhibited significant adoption of BIM and mobile technologies, but critically low usage of IoT, RFID, AR/VR, and 3D printing. A strong positive correlation was observed between technology adoption and improved time performance ($r = 0.553$, $p < 0.05$), crucially demonstrating that adoption of data-centric MCTs across interconnected phases offers the most significant leverage for improving project delivery time. Execution-phase technologies alone showed no significant correlation with timeliness.*

Research limitations/implications *– The study focused on Lagos State, limiting generalisation to other regions. Future research could explore longitudinal impacts of technology adoption across diverse geographic contexts.*

Practical implications *– The findings emphasise the need for government incentives, skill development programs, and standardise regulations to accelerate technology integration. Stakeholders should prioritise integrated deployment of data-centric technologies (including BIM and mobile tools) to significantly enhance time performance and reduce project delays.*

Originality/value *– This study uniquely links technology adoption to time efficiency in Lagos state' construction sector, addressing a critical gap in developing economies. It provides actionable strategies to enhance project resilience, safety, and economic outcomes in rapidly urbanising regions.*

Keywords: Adoption; Building projects; Lagos State; Modern construction technologies; Time performance.

Introduction

Lagos State, Nigeria's economic powerhouse, faces a critical challenge: rampant delays in building projects, averaging over 40% beyond scheduled completion dates (Akintola, 2015; Titilayo, 2023). These delays inflate project budgets by more than 80% (Crampton, 2017), hinder infrastructure development, and create unsustainable living conditions. While global construction leverages modern technologies like Building Information Modelling (BIM), drones, prefabrication, and data analytics to enhance efficiency and timeliness (Darko et al., 2020; Wang et al., 2020), the Nigerian construction industry, particularly in Lagos, lags in adoption (Olanrewaju et al., 2020; Turkyilmaz, 2021). The industry relies heavily on traditional, labour-intensive methods, leading to fragmented communication, poor coordination, and reduced productivity (Habu & Oni, 2024; Hajirasouli et al., 2022).

The potential of MCTs to revolutionise construction time performance is undeniable. BIM facilitates clash detection and optimised sequencing before construction begins (Gurgun & Kunkcu, 2024; Rui & Yaik-Wah, 2021). Prefabrication reduces on-site construction time significantly (Jin et al., 2020; Mohamed, 2021). Drones enhance site monitoring and progress tracking (Rao et al., 2022). Mobile technologies streamline communication and documentation (Alreshid et al., 2018), and data analytics enables proactive decision-making (Czvetko et al., 2022; Munawar et al., 2022). However, the adoption journey in Lagos is fraught with barriers, including high upfront costs (Borowiecki et al., 2021), lack of technical expertise (Asad et al., 2021), insufficient awareness of benefits (Akintola, 2018), and an underdeveloped regulatory framework fostering innovation (Sepasgozar et al., 2018).

Understanding the current landscape of adoption, and crucially, quantifying the relationship between MCT usage and time performance, is essential for driving change. This study addresses this critical gap. It specifically investigates the relationship between the use of modern construction technologies and the time performance of building projects.

By identifying usage patterns and establishing empirical links to time performance, this research provides actionable insights for stakeholders seeking to harness technology for timely project delivery in Lagos State. The justification for this study is threefold. First, Lagos State accounts for a disproportionate share of Nigeria's construction activity, making it an ideal and high-impact setting for empirical investigation. Second, despite growing global evidence on MCT benefits, no study has quantitatively established the relationship between MCT adoption and time performance specifically within Lagos' construction ecosystem. Third, the findings provide evidence-based guidance for policymakers, construction firms, and professional bodies seeking to reduce the pervasive project delays that inflate costs and hinder infrastructure development across the State.

Literature Review

Modern Construction Technologies (MCTs) and Time Performance

The imperative for efficiency in the construction industry has propelled the development and adoption of MCTs globally. These technologies transcend traditional methods, offering digital, automated, and data-driven solutions to enhance planning, execution, and control, ultimately targeting improved project outcomes, especially timeliness (Sepasgozar et al., 2020; Taofeeq et al., 2020).

a) Building Information Modelling (BIM): BIM creates a dynamic digital representation of a building, integrating geometric and functional data. Its impact on time performance is profound during planning and design. BIM enables multidisciplinary collaboration in a virtual environment, allowing for precise planning, early clash detection, and optimisation of construction sequences (Abobakirov, 2023; Akponeware & Adamu, 2017; Rui & Yaik-Wah, 2021). By identifying and resolving conflicts before breaking ground, BIM significantly reduces the likelihood of costly rework and delays during construction (Gurgun & Kunkcu, 2024). Its utility extends into construction execution, project management, and performance monitoring (Al-Ashmori, 2020; Alaloul et al., 2016; Munawar et al., 2022).

b) Prefabrication and Modular Construction: This approach involves manufacturing building components in controlled factory settings before transporting them to the site for assembly. It drastically reduces on-site construction time by minimising traditional, time-consuming processes like formwork and casting (Mohamed, 2021). Concurrent manufacturing and site preparation enable faster project completion (Mossman & Sarhan, 2021). Prefabrication also enhances quality control and reduces weather-related delays (Jin et al., 2020).

c) Unmanned Aerial Vehicles (Drones/UAVs): Drones provide rapid, high-resolution aerial surveys, site inspections, and progress monitoring (Rao et al., 2022). They offer real-time visibility over large or complex sites, enabling quick identification of potential safety hazards, logistical bottlenecks, or deviations from the schedule. This facilitates proactive management interventions to keep projects on track (Dadhich et al., 2016; Irizarry et al., 2013).

d) Mobile Technologies: Smartphones, tablets, and specialied apps enable real-time communication, access to project documents (drawings, specifications), digital reporting, time tracking, and on-site collaboration (Alreshid et al., 2018). This streamlines workflows, reduces communication delays, improves decision-making speed, and enhances overall site management efficiency, directly contributing to time savings.

e) 3D Printing/Additive Manufacturing: While still emerging in large-scale construction, 3D printing offers potential for rapid prototyping of complex components, creating custom parts on-demand, and even printing entire structures layer-by-layer. This can reduce material waste and potentially shorten construction timelines for specific elements, though its impact on overall project time performance in mainstream construction is still evolving (Jia et al., 2019).

f) Augmented Reality (AR) & Virtual Reality (VR): AR overlays digital information onto the real-world view (e.g., via tablets or glasses), aiding on-site assembly, maintenance guidance, and visualising designs in context. VR creates immersive simulations, valuable for design reviews, client presentations, safety training, and planning complex tasks. Both can reduce errors and rework, contributing to time efficiency (Delgado et al., 2020).

g) Internet of Things (IoT) & Sensors: Networks of interconnected sensors embedded in equipment, materials, or the environment collect real-time data on parameters like location, movement, temperature, humidity, vibration, or structural stress (Zhou et al., 2021). This data feeds into systems for equipment monitoring, environmental control, safety alerts, predictive maintenance, and optimising resource utilisation and logistics, preventing delays caused by failures or inefficiencies.

h) Radio Frequency Identification (RFID): RFID tags attached to materials, equipment, or worker badges enable automatic identification and tracking using readers. This automates inventory management, tracks material movement through the supply chain and on-site, monitors equipment usage, and controls site access (Le, 2017; Teizer, 2015). Accurate, real-time tracking minimises delays caused by material shortages, misplacement, or inefficient logistics (Attaran, 2020; Harris et al., 2021).

The Relationship Between the Use of Modern Construction Technologies and Time Performance of Building Projects

The correlation between the utilisation of contemporary construction technologies and the timeliness of building projects is complex and essential to comprehending the dynamics of construction productivity (Raul & Malik, 2021). There are several interconnected dimensions to this relationship spanning project planning and design, construction execution, material management and logistics, project management and coordination, and data analytics and performance monitoring (Al-Ashmori, 2020). During Project Planning and Design, BIM enables multidisciplinary collaboration, clash detection, and sequence optimisation, thereby reducing delays by identifying conflicts early (Rui & Yaik-Wah, 2021; Deng et al., 2021; Abobakirov, 2023; Gurgun & Kunkcu, 2024). Studies confirm that early integration of BIM significantly reduces rework and improves schedule adherence.

In the Construction Execution phase, prefabrication and modular construction minimise on-site time, while robotics and automation accelerate repetitive tasks. These technologies compress timelines and reduce dependence on labour-intensive traditional methods (Al-Ashmori, 2020; Jin et al., 2020; Mohamed, 2021; Cai et al., 2019).

For Material Management and Logistics, RFID and GPS systems enable real-time tracking of materials, while digital supply chain tools prevent procurement delays. Accurate material tracking has been shown to reduce time losses from shortages and misplacement (Harris et al., 2021; Le, 2017; Attaran, 2020).

Project Management and Coordination benefit substantially from integrated cloud platforms that facilitate real-time scheduling, resource allocation, and proactive decision-making. These tools enhance team coordination and reduce communication-related delays (Alaloul et al., 2016; Parsamehr et al., 2023; Alreshid et al., 2018).

Finally, Data Analytics and Performance Monitoring, drawing on IoT sensor data, drone feeds, and BIM outputs, enable the identification of inefficiencies and optimise resource utilisation in real time. This evidence-based approach directly supports proactive management of project timelines (Munawar et al., 2022; Rao et al., 2022; Czvetkó et al., 2022).

Together, these five dimensions illustrate that the relationship between MCT use and time performance is not linear or phase-specific but is characterised by interdependence and synergy. The empirical investigation that follows seeks to quantify these relationships within the Lagos State construction context.

Research Methods

This study employed a quantitative, cross-sectional survey research design. This approach is suitable for gathering numerical data from a sample of a population to describe attitudes, perceptions, behaviours (usage), and relationships (between usage and time performance) at a specific point in time (Hancock et al., 2021). Structured questionnaires were used as the primary data collection instrument.

The research was conducted in Lagos State, Nigeria. Lagos was selected due to its status as the nation's economic hub, hosting the highest concentration of construction firms, professionals, and ongoing building projects in Nigeria (GlobalData, 2023; Nigerian Bureau of Statistics, 2016). This provided access to a diverse and representative sample for the study.

The population for this study comprises construction firms in Lagos State consisting of registered and unregistered professionals working within these construction firms at different levels. For this study, a simple random sampling technique was used to select a representative sample of construction firms from the population of interest. The population for this research is 232, which is the number of registered construction firms carrying out construction works in Lagos, according to the Lagos State Public Procurement Agency. For an acceptable error of 5% and reliability level of 95% or significance level 0.05, with a population size of 232, the sample size was calculated using Yamane's formula for finite populations:

$$n = \frac{N}{1+N(e)2} \qquad (1)$$

Where n = sample size, N = Population size, e = confidence interval.

$$n = \frac{232}{1+232(0.05)2}$$

$$n = 147$$

Therefore, the sample size for this study is 147.

The structured questionnaire comprised four sections. Section A gathered respondent and firm demographics, including profession, years of experience, firm size, and types of projects handled. Section B assessed awareness and usage levels of eight specified MCTs (BIM, Prefabrication, Drones, Mobile Technologies, 3D Printing, AR/VR, IoT/Sensors, and RFID) using a 5-point Likert scale (1 = Never used to 5 = Always used). Section C measured time performance perceptions across five project phases — Project Planning & Design (F1), Construction Execution (F2), Material Management & Logistics (F3), Project Management & Coordination (F4), and Data Analytics & Performance Monitoring (F5) — also rated on a 5-point scale (1 = Strongly Disagree to 5 = Strongly Agree). Section D contained open-ended questions on perceived barriers to MCT adoption. The same five phases were mirrored in Section B to generate the MCT use variables (F6–F10) corresponding to F1–F5 respectively, enabling phase-level correlation analysis. The questionnaire was pre-tested with five construction professionals to ensure clarity and content validity before full administration.

a) Demographic information of respondents and their firms.
b) Perceptions of time performance factors related to the project phases mentioned above (for correlation analysis).

The questionnaire included both closed-ended (Likert scales) and open-ended questions. Pre-testing ensured clarity and validity. A total of 194 questionnaires were distributed electronically and physically to construction professionals across Lagos State. Of these, 158 completed questionnaires were retrieved, yielding a response rate of 81.4%. This exceeds the minimum required sample of 147 determined by Yamane's formula, providing a sufficient basis for statistical analysis. Data analysis was performed using IBM SPSS Statistics software:

a) Descriptive Statistics: Frequencies, percentages, mean scores, and standard deviations were calculated to summarize demographic data.

b) Inferential Statistics: Pearson's correlation coefficient (r) was used to analyze the relationship between the usage levels of MCTs within specific project phases (independent variables) and the perceived time performance related to those phases (dependent variable). Significance was tested at $p < 0.05$ and $p < 0.01$ levels.

Results and Discussion

Demographic Characteristics of Respondents

The study achieved a high response rate (81.4%, N=158), well above the typical survey average (Wu et al., 2022). Respondents represented key professions: Architects, Builders, Engineers (Civil, Structural, etc.), and Quantity Surveyors. Firms of various sizes (small, medium, large) were represented, reflecting the structure of Lagos's construction sector.

Relationship between MCT Use and Time Performance

This objective investigated the relationship between the use of modern construction technologies and time performance of building projects by construction firms in Lagos State. In order to investigate the relationship between MCT use and time performance, descriptive statistics (means, standard deviations, and frequency distributions) were first computed for all ten variables (F1–F10) to characterise central tendency and variability. F1–F5 represent the five time performance variables (Project Planning & Design; Construction Execution; Material Management & Logistics; Project Management & Coordination; and Data Analytics & Performance Monitoring respectively), while F6–F10 represent the corresponding MCT use variables for the same phases. Pearson's correlation analysis was then applied to examine the inferential relationships between these variables, as presented in the tables below.

TABLE 1. Pearson's correlations showing the relationship between the use of modern construction technologies and time performance of building projects by construction firms in Lagos State

Variables			TIME PERFORMNCE					USE OF TECHNOLOGIES				
			F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**
TIME PERFORMANCE	F1	r	1	0.045	.441**	.363**	.512**	.434**	-0.017	-0.073	.350**	.387**
		p		0.578	0	0	0	0	0.83	0.359	0	0
	F2	r	0.045	1	0.105	0.055	0.042	-0.073	0.139	0.076	0.12	-0.052
		p	0.578		0.191	0.494	0.603	0.361	0.082	0.343	0.134	0.515
	F3	r	.441**	0.105	1	.475**	.598**	.219**	0.049	0.152	.454**	.356**
		p	0	0.191		0	0	0.006	0.543	0.057	0	0
	F4	r	.363**	0.055	.475**	1	.510**	.270**	0.072	0.087	.354**	.352**
		p	0	0.494	0		0	0.001	0.367	0.276	0	0
	F5	r	.512**	0.042	.598**	.510**	1	.282**	0.074	0.001	.333**	.403**
		p	0	0.603	0	0		0	0.358	0.993	0	0
USE OF TECHNOLOGIES	F6	r	.434**	-0.073	.219**	.270**	.282**	1	0.08	0.039	.388**	.289**
		p	0	0.361	0.006	0.001	0		0.32	0.626	0	0
	F7	r	-0.017	0.139	0.049	0.072	0.074	0.08	1	.179*	0.124	-0.051
		p	0.83	0.082	0.543	0.367	0.358	0.32		0.025	0.121	0.527
	F8	r	-0.073	0.076	0.152	0.087	0.001	0.039	.179*	1	.294**	.182*
		p	0.359	0.343	0.057	0.276	0.993	0.626	0.025		0	0.022
	F9	r	.350**	0.12	.454**	.354**	.333**	.388**	0.124	.294**	1	.422**
		p	0	0.134	0	0	0	0	0.121	0		0
	F10	r	.387**	-0.052	.356**	.352**	.403**	.289**	-0.051	.182*	.422**	1
		p	0	0.515	0	0	0	0	0.527	0.022	0	

Note(s): ** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

F1, F6 = PROJECT PLANNING AND DESIGN; F2, F7 = CONSTRUCTION EXECUTION; F3, F8 = MATERIAL MANAGEMENT AND LOGISTICS; F4, F9 = PROJECT MANAGEMENT AND COORDINATION; F5, F10 = DATA ANALYTICS AND PERFORMANCE MONITORING

Table 1 provides insights into the relationships between various factors related to time performance and the use of modern construction technologies by construction firms in Lagos State. Correlations are measured using Pearson's correlation coefficient (r), with significance levels (p-values) indicating the strength and reliability of these relationships.

TABLE 2. Significant Pearson Correlations between MCT Use and Time Performance

Variables Correlated	**Correlation Coefficient (r)**	**Significance (p)**	**Interpretation**
Data Analytics & Perf. Monitoring (F5) & Material Mgmt & Logistics (F3)	0.598	0.000	Strong Positive Correlation: High use of Data Analytics significantly improves Material Management efficiency and timeliness.
Material Mgmt & Logistics (F3) & Project Planning & Design (F1)	0.441	0.000	Moderate Positive Correlation: Effective logistics enhances project planning outcomes and timeliness.
Project Mgmt & Coordination (F4) & Data Analytics & Perf. Monitoring (F5)	0.510	0.000	Moderate Positive Correlation: Efficient data analytics enhances project management coordination and timeliness.
Material Mgmt & Logistics (F3) & Project Mgmt & Coordination (F4)	0.294	0.022	Weak Positive Correlation: Improvements in material management are linked to better project coordination.
Construction Execution (F7) & Project Planning & Design (F1)	-0.017	0.830	No Significant Correlation: Execution activities alone do not directly determine planning effectiveness/timeliness.
Construction Execution (F2) & Material Mgmt & Logistics (F7)	0.08	0.320	No Significant Correlation: Execution does not significantly impact logistics management performance.

Discussion

The analysis reveals crucial insights into how MCT usage impacts time performance drivers:

a) Data Analytics is Key: The strongest correlation (r = 0.598) exists between using Data Analytics & Performance Monitoring and improved efficiency/ timeliness in Material Management & Logistics. This empirically validates that leveraging data (from sensors, drones, BIM, etc.) for real-time insights and proactive decision-making dramatically optimises logistics flows, reduces delays from shortages/ misplacement, and enhances overall material handling speed (Czvetko et al., 2022; Rao et al., 2022). This finding is strongly supported by Adeitan et al. (2021) on information flow in logistics and Okafor et al. (2024) on supply chain challenges.

b) Synergy Between Logistics and Planning: The significant correlation (r = 0.441) between Material Management & Logistics and Project Planning & Design highlights their interdependence. Efficient logistics management provides reliable data and predictability, allowing for more accurate and feasible planning and reducing schedule risks from the outset (Son et al., 2021).

c) Data Enhances Project Management: The correlation (r = 0.510) between Project Management & Coordination and Data Analytics & Performance Monitoring underscores that data-driven insights are crucial for effective coordination, resource allocation, bottleneck identification, and proactive schedule adjustments, directly impacting timely delivery (Kar & Jha, 2020; Patrucco et al., 2020).

d) Execution Alone is Insufficient: The lack of significant correlation between Construction Execution and other phases (Planning F1, Logistics F7) is critical. It indicates that simply focusing on faster on-site work (e.g., using prefab or robotics) without addressing upstream planning accuracy and downstream logistics efficiency is unlikely to yield optimal time performance gains. This reinforces the need for integrated project delivery approaches (Assaad et al., 2020; Ika et al., 2020; Mellado & Lou, 2020).

Conclusion and Recommendations

This study provides a comprehensive assessment of the use of modern construction technologies (MCTs) in Lagos State, focusing on usage levels across project phases and the relationship with time performance. The findings paint a picture of an industry in transition, recognising the importance of foundational digital tools but struggling with the integration of deeper, data-driven technologies essential for optimising timeliness.

The correlation analysis yields powerful insights. The strongest driver is Data Analytics & Performance Monitoring, showing a very strong positive link (r = 0.598) to efficient Material Management & Logistics. This underscores the transformative power of data-driven decision-making for logistics optimisation. Significant positive correlations also exist between Material Management & Logistics and Project Planning & Design (r = 0.441), and between Project Management & Coordination and Data Analytics (r = 0.510), highlighting the interdependence of these phases enabled by technology.

The moderate positive correlations and statistically significant p-values confirm that increased use of MCTs, particularly in data-centric phases, correlates with improved time performance. However, the persistent barriers — such as high costs, skills shortages, lack of supportive policies, and cultural resistance — prevent the widespread adoption needed to fully harness this potential.

Based on the findings, the following recommendations are proposed to enhance MCT adoption and improve time performance in Lagos State's construction industry:

a) Prioritise Investment in Data Analytics: Construction firms and government agencies should prioritise investment in Data Analytics and Performance Monitoring platforms, as this phase demonstrated the strongest empirical correlation with improved time performance in Material Management & Logistics ($r = 0.598$, $p < 0.001$). Practical measures include procurement of real-time data dashboards, training in data interpretation, and integration of analytics tools across project management workflows.

b) Integrate Material Management with Project Planning: Construction firms should strengthen the coordination between Material Management & Logistics and Project Planning & Design functions. The significant positive correlation ($r = 0.441$, $p < 0.001$) found between these phases indicates that firms achieving better logistics performance also experience better planning outcomes and time adherence. Early-stage material planning, procurement scheduling, and supply chain visibility should be embedded into design-phase workflows.

c) Bridge the Gap Between Project Management and Data Analytics: The significant correlation ($r = 0.510$, $p < 0.001$) between Project Management & Coordination and Data Analytics & Performance Monitoring indicates that data-driven insights are essential for effective coordination and proactive schedule management. Firms should invest in integrated project management platforms that draw on real-time performance data to support resource allocation, bottleneck identification, and schedule adjustments.

d) Pursue Integrated Rather than Isolated Technology Adoption: The study found that Construction Execution technologies alone (F7) showed no significant correlation with planning or logistics time performance, underscoring that on-site technology adoption without corresponding integration across planning and data management phases yields limited gains. Lagos construction firms should therefore adopt MCTs as an interconnected system rather than in isolation, ensuring that execution-phase technologies are supported by upstream data-driven planning and logistics management.

Areas for Further Research

Future research should focus on:

a) Longitudinal Studies: Track the long-term impact of specific MCT bundles (e.g., RFID/IoT + Analytics) on actual project duration and cost metrics for building projects in Lagos and beyond.

b) Barrier Mitigation Strategies: Investigate the effectiveness of different policy interventions (tax incentives vs. mandates) and training models (industry-led vs. academic) in overcoming adoption barriers for RFID, IoT, and analytics.

c) Cost-Benefit Analysis: Conduct detailed economic analyses of implementing IoT/RFID and analytics solutions in Lagos's construction context to provide concrete ROI data for firms.

d) Scalability for SMEs: Develop and test low-cost, scalable technology solutions and implementation frameworks tailored to the needs and constraints of Small and Medium-sized Enterprises (SMEs) dominating the sector.

e) Comparative Studies: Compare MCT adoption levels, barriers, and impact on time performance between Lagos and other major Nigerian cities or similar developing economies.

By addressing the identified gaps and implementing the recommended strategies, Lagos State's construction industry can significantly accelerate MCT adoption, harness the power of data, and achieve substantial improvements in the timeliness of building project delivery, supporting its economic growth and development goals.

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