Exploring the Perspective of Lean Construction Techniques on the Performance of Construction Projects in Nigeria

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The continuous poor performance of construction projects in Nigeria has given the Nigerian construction industry a source of concern, and the inability of the industry to promptly apply innovative strategies that will mitigate these concerns. Improving construction project performance, the concept of lean construction has emerged as a promising approach to addressing the industry's numerous challenges while also significantly increasing project efficiency. Lean construction, founded on the principle of maximising value while minimising waste, is closely aligned with today's global emphasis on sustainability and efficient resource utilisation. Hence, the purpose of this study is to investigate the perspective of lean construction techniques on project performance in some selected states in Nigeria. A quantitative approach was used to collect data from 294 participants. To analyse the collected data, the study used a descriptive-analytical method, specifically the Mean Item Score (MIS). The study also adopted the Kruskal-Walli's test to determine the variation in the opinions of the respondents according to their location. The findings of this study revealed that root cause analysis ranked first with an MIS of 3.92. The study also revealed a shared perception among the respondents regarding the severity of the influence of lean construction techniques on the performance of construction projects in Nigeria. The findings of this study presented the perspectives of industry practitioners on the efficacy of lean construction techniques in improving project performance and also contributed to filling a significant gap in the current understanding of the lean approach.

Keywords: Cost, Construction, Lean, Performance, Project, Techniques

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INTRODUCTION

The construction industry plays an important role in the global economy, driving GDP growth and creating job opportunities (Cherian, 2020; Ofori, 2015). According to recent World Bank statistics, the construction industry contributes significantly to the GDP of every nation, both developed and developing. Furthermore, it accounts for roughly 10% of global GDP, with variations observed across regions and economic contexts (Oyewobi *et al.,* 2023). Nonetheless, despite its importance as a driver of economic growth, the construction industry faces numerous challenges that limit its capacity for impact and effectiveness (Okanlawon *et al.,* 2023). These hurdles result from inefficiencies, cost overruns, delays, and quality problems (El-Wafa & Mosly, 2024). Furthermore, they present serious difficulties for project stakeholders and compromise the performance of the sector as a whole (El-Wafa & Mosly, 2024; Patanakul, 2014).

Bolland (2018) stated that one of the most significant challenges confronting the construction industry is inefficiency, which stems from outdated methodologies, fragmented workflows (Pidgeon & Dawood, 2023), and insufficient collaboration among project stakeholders (Bajpai & Misra, 2022). The conventional construction model frequently relies on sequential procedures and isolated decision-making, resulting in inefficient resource allocation and productivity constraints (Antunes & Gonzalez, 2015). As a result, projects experience frequent delays and budgetary escalations, eroding stakeholder trust and jeopardising project outcomes (Taye, 2016). Furthermore, cost overruns are a common issue in construction, with projects routinely exceeding budgetary limits due to inaccurate estimates, unforeseen expenses, and scope changes (Shane *et al.,* 2009).

Cost overruns are common in construction projects around the world (Le-Hoai *et al.,* 2008), with studies indicating that more than 90% of projects exceed their original budgets (Anigbogu *et al.,* 2019). These overruns not only strain project finances, but also erode stakeholder trust and tarnish the industry's reputation for dependability and accountability (Le-Hoai *et al.,* 2008). As a result, various strategies and methodologies have emerged in recent years to address these issues and transform the construction industry (Koc *et al.,* 2020). These approaches include lean construction and Integrated Project Delivery (IPD). However, lean construction stands out as a particularly promising strategy (Forbes & Ahmed, 2010).

In recent years, the concept of lean construction has emerged as a promising approach to overcoming these challenges of poor project performance and mitigating them (Pan & Pan, 2023). It is based on the principles of lean manufacturing, which were first developed by Toyota's Production System (Čiarnienė &

Vienažindienė, 2012). It aims to streamline the construction process by reducing waste, increasing value, and encouraging continuous improvement throughout the project's lifecycle (Barth & Formoso, 2021). Furthermore, lean construction emphasises collaboration, efficiency, and the elimination of non-value-added activities to increase productivity, reduce costs, and improve project outcomes (Demirkesen *et al.,* 2022). Hence, countries such as the United Kingdom, the United States of America, and Germany have successfully used the lean construction approach (the process of using lean construction techniques, tools, and methods in the construction processes) to address underperformance issues, reduce cost overruns in construction projects, and accelerate project delivery beyond initial projections. However, research has been carried out on lean construction in the Nigerian construction industry. For instance, Fadeke *et al*. (2016) assessed lean construction practices (which are practices designed to eliminate waste and improve process efficiency and productivity; tools, and techniques) within the construction landscape, and it was concluded that most construction professionals are aware of lean construction and its approaches. Furthermore, Babalola *et al.* (2019a) also researched lean construction from a sustainability perspective. Also, Adamu and Abdulhamid (2016) reported a 16.67% reduction in the project schedule with an average productivity increase of 17.24% in the Nigeria housing project in Yobe State. The project was completed in ten months instead of twelve; other projects executed using the conventional approach had time overruns.

Despite the abundance of research on lean techniques (the different features or practices adopted in applying a lean construction tool such as the last planner system, visual management, and just-in-time, among others) and their obvious benefits such as streamlined processes and waste reduction, Amade *et al.* (2019) opined that the application of lean techniques is still in its infancy stage in Nigeria. It is also the result of the inadequacy of the focus on understanding how lean practices affect the overall performance of construction projects in Nigeria, particularly in Abuja, Lagos, and Kaduna states (Paul *et al.,* 2019; Umar *et al.,* 2022). The Nigerian construction industry has also been criticised for its sluggishness in adopting innovative means and techniques for eliminating waste, such as lean techniques (Amade *et al.,* 2019). As a result, this attention gap is notable, given the significant potential for lean construction techniques to improve construction project performance. Therefore, the purpose of this study is to assess the perspective of lean construction techniques on project performance in some selected states (Abuja FCT, Lagos and Kaduna States) in Nigeria in terms of cost, time, quality, health and safety, and stakeholders' satisfaction.

LITERATURE REVIEW

Concept of Lean Construction

Lean Construction is a philosophy based on the concepts of lean manufacturing adopted from the Japanese Toyota Manufacturing system (Gao & Low, 2014). Lean thinking also became a generic term to describe universal applications beyond manufacturing (Haque & James-Moore, 2004; Moyano-Fuentes & Sacristán-Díaz, 2012). The term "lean" was coined by the research team working on international auto production to reflect both the waste and reduction nature of the Toyota production system and contrast it with craft and mass forms of production. However, the International Group for Lean Construction (IGLC) introduced the term "lean construction" at its first meeting in 1993 (Bertelsen, 2004). This designation was intended to represent the integration of lean principles into the construction industry (Mellado & Lou, 2020). Since then, the organisation has been dedicated to promoting lean thinking and developing methodologies for its global implementation through a variety of channels, including seminars, workshops, book and journal publications, and online resources. Its main goal is to improve the building process by reducing waste, increasing value, and encouraging continuous improvement at all stages of a project's lifecycle. Nikakhtar *et al.* (2015) stated that the concepts and principles of lean construction revolve around streamlining the construction process by eliminating waste, which is defined as any activity that adds no value to the finished product or service. Furthermore, the goal is to maintain a constant flow of work, minimising interruptions, and delays while increasing efficiency and value creation at each stage of the project (Mellado & Lou, 2020).

According to Abdelhamid *et al.* (2008), lean construction is guided by five fundamental principles that are critical for achieving market acceptance and operational excellence. The identified five principles of leans are; precisely specifying a value from the customer perspective; understanding (mapping) the value stream; achieving flow within the work process; achieving customer pull at the right time; and striving for perfection and continuous improvement (Cullen *et al*., 2005; Hook & Stehn, 2008; Suresh *et al*., 2012; Fewings, 2013). Hence, these principles are drivers for continuous improvement. The benefits of lean construction can only be achieved through their holistic implementation (Dulaimi & Tanamas, 2005).

Construction Project Performance

According to Koelmans (2004) and Beleiu *et al*. (2015), project success is defined as meeting the objectives outlined in the project plan. Thus, project success is determined by meeting technical requirements, sticking to a schedule, and staying within budget (Beleiu *et al*., 2015; Merrow, 2011). As a result, cost, quality, safety,

stakeholders' satisfaction and timeliness are all critical components of project success that must meet client expectations (Alzahrani & Emsley, 2013). However, it is widely acknowledged that project delays frequently result in increased costs, a phenomenon observed worldwide (Kaliba *et al*., 2009).

Several researchers have proposed alternative frameworks for assessing project success. For example, Simon-Eigbe *et al.* (2022) proposed evaluating process implementation, project perceived value, and customer satisfaction. Furthermore, a comprehensive framework for assessing project performance was also proposed, advocating for evaluation against both short-term and long-term goals. This framework includes efficiency (completing projects on time and within budget), customer satisfaction with the finished product, business success, and future plans (including market opportunities).

Cost performance

Cost is a critical factor that influences project outcomes and has a significant impact on the entire project management process (Belassi & Tukel, 1996; Tam *et al.,* 2020). It is regarded as an important factor in determining the success of a project (Tam *et al.,* 2020). Cost performance analysis is a tool used to determine whether a project is adhering to its budget or aligning with its actual expenditures (Pienkowski *et al.,* 2021). This analysis is based on four key cost-related metrics: total budget cost (TBC), cumulative budget cost (CBC), cumulative actual cost (CAC), and cumulative earned value (CEV) (Osamudiamen *et al*., 2022).

Simon-Eigbe *et al.* (2022) stated that cost overruns occur when the ultimate expenditures of a project exceed the initially projected costs. Furthermore, academics have stressed that cost overruns are a major obstacle in the construction industry (Nuako *et al.,* 2024). As a result, they have emphasised that errors in the initial cost estimation process are the primary causes of these budget overruns (Amini *et al.,* 2023). Furthermore, inflation within projects leads to rising costs, with differences observed in material, equipment, and labour costs in various geographical areas (Musarat *et al.,* 2021). Hence, contracts with subcontractors may include provisions to reduce the impact of inflation risks, which are mutually agreed upon with clients. Furthermore, the presence of deficiencies in project planning and a lack of managerial expertise have been identified as contributing factors to errors in the use of technical data (El Khatib *et al.,* 2020). Hence, cost concerns are further intensified by market-related factors, such as the high expenses associated with machinery.

Mansfield *et al.* (1994) opined that it has a significant impact on both the financial and time aspects of construction projects. The factors include price variations, incorrect initial assessments, delays caused by working extra hours, extra tasks, fraudulent actions, illegal payments, and the use of faster construction methods. The presence of insufficient contract management practices, in addition to difficulties associated with subcontractors and designated suppliers, is highlighted by Kaliba *et al.* (2009). Furthermore, complexities within the financial procedures of client organisations can result in payment delays, creating financial difficulties for contractors and disrupting project timelines (Ithana, 2020).

Time performance

Time performance is another pivotal factor in evaluating the triumph of construction projects. As emphasised by Assaf and Al-Hejji (2006), time extension refers to the surpassing of predetermined project completion dates specified in the contract or agreed upon by the parties involved (Simon-Eigbe *et al.,* 2022). This extension can include delays that go beyond the deadlines specified in the contract or the project delivery dates that have been agreed upon by both parties (Aibinu & Jagboro, 2002). The presence of time overruns presents substantial obstacles to the implementation of project development plans, resulting in a range of negative consequences. The consequences encompass conflicts between project owners and contractors, increased project expenses, reduced productivity and revenue, and the possibility of contract terminations (Tumi *et al.,* 2009).

Simon-Eigbe *et al.* (2022) emphasised that the five most important factors influencing time management within the construction sector include material shortages, rework, equipment, delays in supervision, absenteeism, and interfaces. However, one of the basic requirements for a successful construction project is that the project must be completed within the contract period (Clough *et al.,* 2015). Hence, good planning and good customer payments are the basic remedies to avoid time-outs (Simon-Eigbe *et al.,* 2022; Tumi *et al.,* 2009).

Quality performance

Quality in construction is typically defined as the strict adherence to predetermined requirements, which outline the expected characteristics of the product, process, or service as specified in contracts (Simon-Eigbe *et al.,* 2022). The essence of "quality" is the consistent delivery of outcomes that meet or surpass predefined standards for a specific purpose. Therefore, "performance" can be defined as the attainment of established benchmarks for quality (Arah *et al.,* 2003). To convert the requirements and expectations of customers into specific and measurable criteria for construction projects, it is crucial to establish a thorough comprehension of the project specifications (Bamisile, 2004). Performance metrics that focus on quality are centred on assessing factors such as the number of defects and the expenses related

to upholding quality standards (Simon-Eigbe *et al.,* 2022). The focus on measuring performance based on quality highlights the importance of following specific requirements and achieving outcomes that satisfy the expectations of stakeholders in the construction sector. Hence, the effectiveness of a project is evaluated based on its ability to be completed within the expected timeframe, meet established standards of quality, and effectively manage costs (Costello & Garrett, 2008).

Effect of Lean on Construction Project Performance

The incorporation of lean principles into construction practices has sparked widespread interest because of its potential to improve project performance (Aziz & Hafez, 2013). A thorough review of the existing literature reveals compelling evidence of the benefits of lean construction on various aspects of project execution. Studies such as Negrão *et al.* (2017), Zimina *et al*. (2012) and Aziz and Hafez (2013) have also demonstrated the impact of lean practices on project cost management. The findings consistently show that lean implementation reduces costs by minimising rework, reducing material waste, and optimising resource utilisation (Aziz & Hafez, 2013). Moreover, lean techniques, such as pull planning and just-in-time delivery, help to improve schedule adherence and reduce project duration (Wu *et al.,* 2019). Furthermore, studies have shown that lean construction improves project quality and safety performance (Oladiran, 2017; Wu *et al.,* 2019). Also, improved stakeholder collaboration, error prevention, and communication lead to higher quality outcomes, while promoting risk awareness and proactive hazard mitigation improves workplace safety. Hwang *et al*. (2014) and Goshime *et al.* (2019) indicated that lean practices have been linked to increased levels of satisfaction among stakeholders, including clients, contractors, and subcontractors. Furthermore, long-term relationships and collaborative partnerships among stakeholders are nurtured through the timely, cost-effective, and quality-compliant completion of projects. There are no readily available studies carried out specifically in Nigeria for construction project performance improvement taking into cognisance the perspective of the industry practitioners on cost, time, quality, health and safety, and stakeholders' satisfaction as project performance parameters which are essential in determining project performance (Nwaki & Eze, 2020; Unegbu *et al.,* 2023).

RESEARCH METHODOLOGY

This study utilised a quantitative methodology, specifically a questionnaire-based survey, to investigate the impact of lean construction techniques on the performance of construction projects in Nigeria, with a specific focus on Abuja, Lagos, and Kaduna State. This study strategically selected Abuja, Lagos, and Kaduna State as focal points because Abuja, being the capital city of Nigeria, represents a hub of significant construction activity, often involving large-scale projects that could benefit from lean construction methodologies to enhance efficiency. Furthermore, Lagos and Kaduna are currently experiencing immense urban development and infrastructure construction, making it an ideal location to assess the applicability and impact of lean construction practices in a bustling metropolitan environment. In addition, an exhaustive examination of extant scholarly works was undertaken to ascertain the impact of lean construction methodologies on cost-effectiveness. Following this, the results obtained from this comprehensive analysis were consolidated to develop a survey tool, which was subsequently disseminated to pertinent industry stakeholders.

Participants were requested to indicate their degree of concurrence or dissent with respect to the identified influences in terms of cost, time, quality, health and safety and stakeholders' satisfaction with five-point Likert scale. However, to determine the internal consistency and reliability of the questionnaire, the study employed the Cronbach Alpha Reliability Test (CART) using the equation 1. The test returned a value of 0.982, which is more than the acceptable threshold of 0.70 as postulated by Oyewobi *et al*. (2023) and Okanlawon *et al.* (2023).

To overcome the challenges associated with accurately defining the research population, researchers have employed a variety of non-probability sampling methods, including snowball sampling, quota sampling, and purposeful sampling, to choose participants (Mweshi & Sakyi, 2020). Therefore, this study utilised purposive sampling, intentionally choosing participants who possessed specific characteristics that were in line with the research objectives. Purposive sampling, also known as purposive sampling, is a qualitative research methodology that does not rely on probability for the selection of participants (Douglas, 2022). It involves deliberately choosing participants or cases that have specific characteristics or qualities that are relevant to the research goals (Cash *et al.,* 2022). The choice of this method was made because it can accurately identify individuals who have relevant knowledge, expertise, or experiences related to the research topic.

A total of 350 questionnaires were electronically disseminated to the designated professionals through the utilisation of Google Forms. However, only 294 responses were fully completed by the participants, verified, and considered suitable for further statistical analysis. The collected data was analysed using the Mean Item Score (MIS) as a measure of descriptive statistics. The study also employed the Kruskal-Wallis test to determine the variation in the opinion of the respondents based on their location using Equation 3.

The analysis was conducted using Statistical Package for Social Science (SPSS) version 26 and Microsoft Excel.

$$\propto = \frac{\eta}{1}\left(1 - \frac{\Sigma iVi}{Vt}\right) \qquad \textbf{Equation (1)}$$

Where:
n = the number of items
Vt = the variance of the total scores
Vi = the variance of the item scores

$$H = \frac{12}{N(N+1)}\sum_{j=i}^{k}\frac{R^2}{n_j} - 3(n+1) \qquad \textbf{Equation (2)}$$

Where:
N = total number observations across group
K = number of groups
R_j = sum of ranks for group j
n_i = number of observations in group j

RESULTS AND DISCUSSION

Demographic Information

Table 1 presents the demographic information of the respondents. The demographic breakdown reveals that 43% of participants hold positions as project managers, while 27% are in roles as site managers. The sample consists of 16% quality assurance managers, 8% equipment managers, and 6% safety managers. The distribution of project managers within organisations indicates a preference for individuals who can proficiently manage enquiries, implying a higher level of comprehension of lean concepts among them. Furthermore, the survey revealed that 58% of participants possess either an HND or BSc degree, while 33% have achieved a Master degree. This indicates that the respondents have the necessary academic qualifications to understand and answer the survey questions. Furthermore, the table shows that the participants' professional backgrounds are well-suited to the research, with 38% being Quantity Surveyors, 26% being Engineers, 18% being Builders, and 14% being Architects. The presence of this diversity indicates that the respondents have the necessary expertise that can be applied to the study. In addition, the employment sectors exhibit diversity, with 37% of individuals employed in building, 14% in civil engineering projects, 3% in large-scale engineering projects, 30% involved in both construction and civil works, and 16% engaged across all sectors. The distribution of the results highlights the participants' thorough grasp of the lean approach, confirming the reliability of their answers. Furthermore, a significant 52% of participants assert that they have worked in their field for ten years or longer, which emphasises the dependability and precision of the study's data.

Table 1: Demographic Information

Demographic Variables	Frequency	Percentage
Position in the organisation		
Project Manager	126	43
Site Manager	79	27
Quality Assurance Manager	47	16
Safety Manager	18	6
Equipment manager	24	8
Academic Qualification		
OND	21	7
HND/BSC	171	58
Master	97	33
PhD	5	2
Years of Experience		
1 – 3years	35	12
4 – 6years	62	21
7 – 9years	44	15
10years and above	153	52
Location of Respondents		
Abuja	95	32.31
Lagos	123	41.84
Kaduna	76	25.85
Total	**294**	**100**

Descriptive Statistics for the Influence of Lean Construction Techniques on the Performance of Construction Projects

Table 2 presents the results of the descriptive statistics results using Mean Item Score (MIS). It also presents the results of the opinion variations of the respondents on the influence of lean construction techniques on the performance of construction projects in Nigeria. The table revealed that root cause analysis which is a methodical approach used to identify the underlying causes of problems or issues (Okes, 2019). It is particularly effective in improving project performance by addressing the fundamental issues at their source (Chuang & Howley, 2013) and is the topmost-ranked lean construction technique that influences the performance of construction projects in Nigeria with an MIS of 3.92. TPM helps in preventing equipment breakdowns that will affect completion time in delayed projects (Xiang & Feng, 2021).

Total Productive Maintenance (TPM) is regarded as the systematic utilisation of machinery, equipment, personnel, and supporting procedures to uphold and enhance the reliability of production and the excellence of systems (Jain *et al.,* 2014) which is ranked second with an MIS value of 3.91. These implies that TPM has a significant impact on the performance of construction projects in Nigeria, ranking just below root cause analysis in terms of importance. This finding is in line with the study of Zolkafli *et al.* (2021), Chaurey *et al.* (2023), and Au-Yong *et al.* (2022). The table also showed that 5S (Sort, Straighten, Shine, Standardise, and Sustain) ranked third with a mean item score of 3.89. This suggests that implementing 5S principles results in significant improvements in cost management, resource utilisation, and overall project efficiency (Cash *et al.,* 2022). Furthermore, the widespread adoption of 5S demonstrates its practicality and adaptability to a variety of construction contexts, cementing its position as a preferred lean technique among industry professionals. This finding is in line with the study of Al-Aomar (2011). It also highlights the importance of systematic organisation, cleanliness, and standardisation in improving cost performance and operational excellence in Nigerian construction projects. The finding also resonates with the conclusion of Enshassi *et al.* (2019) and Gómez-Cabrera *et al.* (2020). The study also revealed that team preparation, Just-in-Time (JIT), Bottleneck Analysis, Poka-Yoke (Error Proofing) and Heijunka (Level Scheduling) ranked fourth, fifth, sixth, seventh and eighth with a mean item score of 3.89, 3.88, 3.88, and 3.88, respectively. These findings suggest that lean construction techniques have a notable impact on construction project performance in Nigeria, although their importance is slightly lower than that of root cause analysis and Total Productive Maintenance (TPM). The finding of this research is in line with the study of Kong *et al.* (2018), which stated that to achieve long-term success in the construction industry, it is essential to incorporate Just-in-Time (JIT) delivery practices into customer service. JIT delivery entails supplying materials, equipment, and resources exactly when they are required during the construction process, resulting in waste reduction, decreased inventory costs, and improved efficiency (Akintoye, 1995; Singh *et al.,* 2013). Hence, by implementing JIT delivery in customer service, construction companies can enhance client satisfaction by ensuring projects are completed on time, minimising delays, and optimising resource usage (Babalola *et al.,* 2019b; Forbes & Ahmed, 2010). This approach not only benefits the company financially but also promotes sustainability by minimising environmental impact and fostering positive client relationships.

The study also revealed that the average ranked lean construction technique that influences construction performance is continuous flow with a mean item score of 3.85. The study further revealed that fail-safe for quality, Kanban (Pull System), and kaizen are ranked lowest with an MIS of 3.79, 3.84, and 3.80, respectively. This suggests that, while continuous flow is moderately influential, these techniques may have a less significant impact on construction project performance in Nigeria. Nonetheless, they help to improve overall efficiency and quality management in construction projects, albeit to a lesser extent than other lean construction techniques identified in the study. This finding is in line with the study of Damij and Damij (2021).

Based on the results of the Kruskal Wallis presented in the table, it was revealed that the significant value of all the variables is higher than 0.005 indicating a shared perception among the respondents regarding the severity of the influence of lean construction techniques on the performance of construction projects in the study area.

Table 2: Descriptive Statistics Results and the Variation in the Opinion of Respondents Based on their location

LCT	Lean Construction Techniques/Tools	Cost		Time		Quality		H&S		Satisfaction		Overall		KW
		Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	
LCT1	5S (Sort, Straighten, Shine, Standardise, and Sustain)	4.02	1	3.85	9	3.98	2	3.85	7	3.73	18	3.89	**3**	0.111
LCT2	Concurrent Engineering	3.98	3	3.84	10	3.91	9	3.85	7	3.82	7	3.88	**10**	0.413
LCT3	Construction Process Analysis	3.95	5	3.86	8	3.94	6	3.86	6	3.75	16	3.87	**12**	0.325
LCT4	Check Sheet	3.85	15	3.83	11	3.97	3	3.85	7	3.73	18	3.85	**18**	0.751
LCT5	Six Sigma	3.96	4	3.8	13	3.91	9	3.84	8	3.73	18	3.85	**19**	0.074
LCT6	Pareto Analysis	3.93	6	3.8	13	3.96	4	3.88	4	3.71	19	3.86	**17**	0.219
LCT7	Check Points and Control Points	3.83	17	3.82	12	3.88	11	3.81	11	3.76	15	3.82	**35**	0.816
LCT8	Failure Mode and Effects Analysis (FMEA)	3.89	10	3.77	15	3.94	6	3.83	9	3.76	15	3.84	**30**	0.337
LCT9	Continuous Flow	3.85	15	3.89	6	3.95	5	3.75	15	3.8	9	3.85	**20**	0.224
LCT10	FIFO line (First In, First Out)	3.86	14	3.87	7	3.97	3	3.80	12	3.77	14	3.85	**21**	0.146
LCT11	Jidoka/Automation	3.84	16	3.83	11	3.91	9	3.82	10	3.78	12	3.84	**29**	0.199
LCT12	Kanban (Pull System)	3.80	20	3.79	14	3.85	14	3.8	12	3.73	18	3.79	**38**	0.215
LCT13	Kaizen	3.80	20	3.73	17	3.84	15	3.84	8	3.81	8	3.80	**37**	0.791
LCT14	The Last Planner	3.84	16	3.85	9	3.99	1	3.90	2	3.84	5	3.88	**9**	0.235
LCT15	Heijunka (Level Scheduling)	3.77	21	3.93	2	3.98	2	3.9	2	3.81	8	3.88	**8**	0.149
LCT16	Poka-Yoke (Error Proofing)	3.92	7	3.85	9	3.93	7	3.86	6	3.82	7	3.88	**7**	0.963
LCT17	First Run Studies	3.85	15	3.85	9	3.85	14	3.82	10	3.83	6	3.84	**28**	0.253
LCT18	Time and Motion Study	3.85	15	3.91	4	3.85	14	3.80	12	3.78	13	3.84	**27**	0.745
LCT19	Bottleneck Analysis	3.87	13	3.9	5	3.94	6	3.87	5	3.83	6	3.88	**6**	0.334
LCT20	Total Productive Maintenance (TPM)	3.99	2	3.96	1	3.87	12	3.87	5	3.86	3	3.91	**2**	0.106
LCT21	Visual Management	3.86	14	3.8	13	3.86	13	3.84	8	3.85	4	3.84	**26**	0.122
LCT22	Synchronize/Line Balancing	3.88	11	3.86	8	3.87	12	3.83	9	3.84	5	3.86	**16**	0.350
LCT23	Work Structuring	3.92	7	3.86	8	3.88	11	3.83	9	3.88	2	3.87	**11**	0.578
LCT24	Multi-Process Handling	3.81	19	3.92	3	3.86	13	3.79	13	3.77	14	3.83	**31**	0.806
LCT25	5 Whys (Why, what, where, who, when)	3.85	15	3.87	7	3.93	7	3.77	14	3.77	14	3.84	**25**	0.034
LCT26	Fail-Safe for Quality	3.8	20	3.9	5	3.79	18	3.79	13	3.68	20	3.79	**39**	0.262
LCT27	Daily Huddle Meetings	3.82	18	3.93	2	3.79	18	3.81	11	3.73	18	3.82	**34**	0.149

LCT28	Preventive Maintenance	3.9	9	3.85	9	3.86	13	3.82	10	3.8	9	3.85	**22**	0.718
LCT29	Quality Function Development (QFD)	3.83	17	3.9	5	3.82	17	3.82	10	3.78	13	3.83	**32**	0.946
LCT30	SMART Goals	3.9	9	3.9	5	3.87	12	3.83	9	3.82	7	3.86	**16**	0.174
LCT31	PDCA (Plan, Do, Check, Act)	3.91	8	3.89	6	3.88	11	3.81	11	3.79	10	3.86	**15**	0.990
LCT32	Setup Reduction	3.87	12	3.84	10	3.83	16	3.89	3	3.74	17	3.83	**33**	0.873
LCT33	Work Standardisation	3.93	6	3.82	12	3.89	10	3.82	10	3.73	18	3.84	**24**	0.884
LCT34	Suggestion schemes	3.89	10	3.87	7	3.88	11	3.85	7	3.79	10	3.86	**14**	0.107
LCT35	Statistical Process Control	3.87	12	3.85	9	3.89	10	3.9	2	3.79	10	3.86	**13**	0.767
LCT36	Just-in-Time (JIT)	3.9	9	3.9	5	3.93	7	3.87	5	3.78	11	3.88	**5**	0.650
LCT37	Team Preparation	3.99	2	3.83	11	3.93	7	3.9	2	3.81	8	3.89	**4**	0.586
LCT38	Muda Walk	3.89	10	3.76	16	3.83	16	3.77	14	3.76	15	3.80	**36**	0.182
LCT39	Value Stream Mapping	3.88	11	3.79	14	3.91	9	3.83	9	3.8	9	3.84	**23**	0.458
LCT40	Root Cause Analysis	3.96	4	3.89	6	3.92	8	3.92	1	3.89	1	3.92	**1**	0.224

KW = Kruskal Wallis Sig Value

CONCLUSION

This study aimed to assess the perspective of lean construction techniques on the performance of construction projects in some selected states in Nigeria in terms of cost, time, quality, health and safety, and stakeholders' satisfaction. The findings revealed that all the lean construction techniques have an influence on the overall performance of construction projects, with root cause analysis, Total Productive Maintenance (TPM), 5S (Sort, Straighten, Shine, Standardise, and Sustain), Team Preparation, and Just-in-Time (JIT) ranking topmost. This finding emphasises the importance of incorporating lean principles into construction management practices, particularly in a developing country like Nigeria, where optimisation is critical for long-term project success. However, while the study does provide useful insights into the perspective of lean construction techniques on construction project performance, it is critical to recognise the complexities of real-world implementation.

Given these potential complexities, it is clear that a more in-depth understanding of the specific contextual dynamics is required to effectively implement lean principles. Thus, it is strongly advised that future research efforts not only delve deeper into these nuanced factors but also actively engage in practical experimentation to test and refine lean practices in the Nigerian construction context. Furthermore, by conducting additional research and practical trials, stakeholders can gain valuable insights into the adaptability and sustainability of lean practices in Nigeria's unique socioeconomic landscape. This comprehensive approach will not only broaden the knowledge base but will also pave the way for better-informed decision-making and successful implementation strategies in the field of construction management. The study covers only Abuja, Lagos, and Kaduna; therefore, generalisation of results should be done bearing in mind that outcomes might differ with other locations. These were also based on the perspectives of construction experts with varying experiences, the results might differ with different categories of construction industry professionals.

REFERENCES

Abdelhamid, T. S., El-Gafy, M. & Salem, O. (2008). Lean construction: Fundamentals and principles. *American Professional Constructor Journal*, 4, 8-19.

Adamu, S. & Adulhamid, R. (2016). Lean construction techniques for transforming Nigeria project delivery process: A case study report. *Indian Journal of Science and Technology*, 9(48), 1-4.

Aibinu, A. & Jagboro, G. (2002). The effects of construction delays on project delivery in Nigerian construction industry. *International Journal of Project Management*, 20(8), 593-599.

Akintoye, A. (1995). Just-in-time application and implementation for building material management. *Construction Management and Economics*, 13(2), 105-113.

Al-Aomar, R. A. (2011). Applying 5S LEAN Technology: An infrastructure for continuous process improvement. *International Journal of Industrial and Manufacturing Engineering*, 5(12), 2638-2643.

Amade, B., Ononuju, C. N., Obodoh, D. & Okorie, C. E. (2019). Barriers to Lean Adoption for Construction Projects. *The Pacific Journal of Science and Technology*, 20(1), 153–166.

Amini, S., Rezvani, A., Tabassi, M. & Malek Sadati, S. S. (2023). Causes of cost overruns in building construction projects in Asian countries; Iran as a case study. *Engineering, Construction and Architectural Management*, 30(7), 2739-2766.

Anıgbogu, N. A., Ahmad, Z. B. & Molwus, J. J. (2019). Cost Overruns on Federal Capital Territory Authority Road Construction Projects. *FUTY Journal of the Environment*, 139(1), 1-14.

Antunes, R. & Gonzalez, V. (2015). A production model for construction: A theoretical framework. *Buildings*, 5(1), 209-228.

Arah, O. A., Klazinga, N. S., Delnoij, D. M., Asbroek, A. T. & Custers, T. (2003). Conceptual frameworks for health systems performance: a quest for effectiveness, quality, and improvement. *International Journal for Quality in Health Care*, 15(5), 377-398.

Assaf, S. A. & Al-Hejji, S. (2006). Causes of delay in large construction projects. *International Journal of Project Management*, 24(4), 349-357.

Au-Yong, C. P., Azmi, N. F. & Myeda, N. E. (2022). Promoting employee participation in operation and maintenance of green office building by adopting the total productive maintenance (TPM) concept. *Journal of Cleaner Production*, 352, 131608.

Aziz, R. F. & Hafez, S. M. (2013). Applying lean thinking in construction and performance improvement. *Alexandria Engineering Journal*, 52(4), 679-695.

Babalola, O., Ibem, E. & Ezema, I. (2019a). Lean construction: an approach to achieving sustainable built environment in Nigeria. *Journal of Physics: Conference Series*.

Babalola, O., Ibem, E. O. & Ezema, I. C. (2019b). Implementation of lean practices in the

construction industry: A systematic review. *Building and Environment*, 148, 34-43.

Bajjou, M. S., Chafi, A. & Ennadi, A. (2018). Development of a Conceptual Framework of Lean Construction Principles: An Input-Output Model. *Journal of Advanced Manufacturing Systems*. https://doi.org/10.1142/S021968671950001X

Bajpai, A. & Misra, S. C. (2022). Barriers to implementing digitalization in the Indian construction industry. *International Journal of Quality & Reliability Management*, 39(10), 2438-2464.

Bamisile, A. (2004). Building production management. *Lagos: Foresight Press Ltd*.

Belassi, W. & Tukel, O. I. (1996). A new framework for determining critical success/failure factors in projects. *International Journal of Project Management*, 14(3), 141-151.

Bertelsen, S. (2004). Lean Construction: Where are we and how to proceed. *Lean construction journal*, *1*(1), 46-69.

Bolland, N. V. J. G. (2018). *The hunt for efficiency in the construction industry: food for thought for real estate developers* Massachusetts Institute of Technology.

Cash, P., Isaksson, O., Maier, A. & Summers, J. (2022). Sampling in design research: Eight key considerations. *Design studies*, 78, 101077.

Chaurey, S., Kalpande, S. D., Gupta, R. & Toke, L. K. (2023). A review on the identification of total productive maintenance critical success factors for effective implementation in the manufacturing sector. *Journal of Quality in Maintenance Engineering*, 29(1), 114-135.

Cherian, A. (2020). The construction industry in the perspective of an economic boost of the United Arab Emirates (UAE). *Int. Res. J. Eng. Technol*, 9001, 270-276.

Chuang, S. & Howley, P. P. (2013). Beyond root cause analysis: An enriched system oriented event analysis model for wide application. *Systems Engineering*, 16(4), 427-438.

Čiarnienė, R. & Vienažindienė, M. (2012). Lean manufacturing: theory and practice. *Economics and Management*, 17(2), 726-732.

Clough, R. H., Sears, G. A., Sears, S. K., Segner, R. O. & Rounds, J. L. (2015). *Construction contracting: A practical guide to company management*. John Wiley & Sons.

Costello, A. & Garrett, G. A. (2008). *Getting Results: The Six Disciplines of Performance-based Project Management*. Wolters Kluwer.

Damij, N. & Damij, T. (2021). An approach to optimizing Kanban board workflow and shortening the project management plan. *IEEE Transactions on Engineering Management*.

Doskočil, R. & Lacko, B. (2019). Root cause analysis in post project phases as application of knowledge management. *Sustainability*, 11(6), 1667.

Douglas, H. (2022). Sampling techniques for qualitative research. In *Principles of social research methodology* (pp. 415-426). Springer.

El-Wafa, M. M. A. & Mosly, I. (2024). An extensive examination of the barriers faced by contractors leading to project delays. *Global Journal of Engineering and Technology Advances*, 18(03), 152-167.

El Khatib, M., Nakand, L., Almarzooqi, S. & Almarzooqi, A. (2020). E-Governance in Project Management: Impact and Risks of Implementation.

Enshassi, A., Saleh, N. & Mohamed, S. (2019). Application level of lean construction techniques in reducing accidents in construction projects. *Journal of Financial Management of Property and Construction*, 24(3), 274-293.

Fadeke, A., Olorunfemi, B. & Aghimien, D. (2016). *Assessment of Lean Construction Practice in the Nigerian Construction Industry*.

Forbes, L. H. & Ahmed, S. M. (2010). *Modern construction: lean project delivery and integrated practices*. CRC press.

Gao, S. & Low, S. P. (2014). The Toyota Way model: an alternative framework for lean construction. *Total Quality Management & Business Excellence*, 25(5-6), 664-682.

Gómez-Cabrera, A., Salazar, L. A., Ponz-Tienda, J. L. & Alarcón, L. F. (2020). Lean tools proposal to mitigate delays and cost overruns in construction projects. *Proceedings of the 28th Annual Conference of the International Group for Lean Construction (IGLC28)*, Berkeley, CA, USA,

Goshime, Y., Kitaw, D. & Jilcha, K. (2019). Lean manufacturing as a vehicle for improving productivity and customer satisfaction: A literature review on metals and engineering industries. *International Journal of Lean Six Sigma*, 10(2), 691-714.

Haque, B. & James-Moore, M. (2004). Applying lean thinking to new product introduction. *Journal of Engineering design*, 15(1), 1-31.

Hwang, P., Hwang, D., & Hong, P. (2014). Lean practices for quality results: a case illustration. *International Journal of Health Care Quality Assurance*, 27(8), 729-741.

Ithana, L. M. (2020). *Payment Processes as Factors Impede the Successful Implementation of Construction Projects at WT Business Group in Namibia* Botho University.

Jain, A., Bhatti, R. & Singh, H. (2014). Total productive maintenance (TPM) implementation practice: a literature review and directions. *International Journal of Lean Six Sigma*, *5*(3), 293-323.

Kaliba, C., Muya, M. & Mumba, K. (2009). Cost escalation and schedule delays in road construction projects in Zambia. *International Journal of Project Management*, 27(5), 522-531.

Koc, E., Pantazis, E., Soibelman, L. & Gerber, D. J. (2020). Emerging trends and research directions. *Construction 4.0*, 460-476.

Kong, L., Li, H., Luo, H., Ding, L. & Zhang, X. (2018). Sustainable performance of just-in-time (JIT) management in time-dependent batch delivery scheduling of precast construction. *Journal of Cleaner Production*, 193, 684-701.

Mansfield, N. R., Ugwu, O. & Doran, T. (1994). Causes of delay and cost overruns in Nigerian construction projects. *International journal of project Management*, 12(4), 254-260.

Mellado, F. & Lou, E. C. (2020). Building information modelling, lean and sustainability: An integration framework to promote performance improvements in the construction industry. *Sustainable Cities and Society*, 61, 102355.

Moyano-Fuentes, J. & Sacristán-Díaz, M. (2012). Learning on lean: a review of thinking and research. *International Journal of Operations & Production Management*, 32(5), 551-582.

Musarat, M. A., Alaloul, W. S. & Liew, M. (2021). Impact of inflation rate on construction projects budget: A review. *Ain Shams Engineering Journal*, 12(1), 407-414.

Mweshi, G. K. & Sakyi, K. (2020). Application of sampling methods for the research design. *Archives of Business Review, 8*(11).

Negrão, L. L. L., Godinho Filho, M. & Marodin, G. (2017). Lean practices and their effect on performance: a literature review. *Production Planning & Control*, 28(1), 33-56.

Nikakhtar, A., Hosseini, A. A., Wong, K. Y. & Zavichi, A. (2015). Application of lean construction principles to reduce construction process waste using computer simulation: a case study. *International Journal of Services and Operations Management*, 20(4), 461-480.

Nuako, F., Ghansah, F. A. & Adusei, T. (2024). Critical success factorsfor cost overrun minimization in public construction projects in developing countries: the case of Ghana. *Construction Innovation*.

Ofori, G. (2015). Nature of the construction industry, its needs and its development: A review of four decades of research. *Journal of Construction in Developing Countries*, 20(2), 115.

Okanlawon, T. T., Oyewobi, L. O. & Jimoh, R. A. (2023). Evaluation of the drivers to the implementation of blockchain technology in the construction supply chain management in Nigeria. *Journal of Financial Management of Property and Construction* doi 10.1108/JFMPC-11-2022-0058

Okes, D. (2019). *Root cause analysis: The core of problem solving and corrective action*. Quality Press.

Oladiran, O. J. (2017). An investigation into the usage of lean construction techniques in Nigeria. *Journal of Construction Project Management and Innovation*, 7(1), 1712-1725.

Osamudiamen, B., Ihensekhie, A. & Oghomwen, S.-E. (2022). Factors Affecting Project Performance of Building Construction Projects in Federal Capital Territory (FCT) Abuja, Nigeria. *Current Journal of Applied Science and Technology*, 41(35), 44-53.

Oyewobi, L., Okanlawon, T. T., Ibrahim, K. & Jimoh, R. A. (2023). Influence of blockchain adoption barriers and drivers on potential application areas in the construction lifecycle: partial least squares structural equation modelling (PLS-SEM) approach. *Engineering, Construction and Architectural Management*, DOI 10.1108/ECAM-07-2023-0746

Pan, W. & Pan, M. (2023). Rethinking lean synergistically in practice for construction industry improvements. *Engineering, Construction and Architectural Management*, 30(7), 2669-2690.

Patanakul, P. (2014). Managing large-scale IS/IT projects in the public sector: Problems and causes leading to poor performance. *The Journal of High Technology Management Research*, 25(1), 21-35.

Paul, A. C., Yahaya, S. N., Zaki, M. Y. & Jatau, T. S. (2019). An appraisal of Lean Construction methods implementation by construction firms in Kaduna state, Nigeria. Paper presentation at the Environmental Design and Management International Conference.128-137.

Pidgeon, A. & Dawood, N. (2023). BIM adoption issues in infrastructure construction projects: analysis and solutions. *Digitalization in Construction*, 173-200.

Pienkowski, T., Cook, C., Verma, M. & Carrasco, L. R. (2021). Conservation cost-effectiveness: a review of the evidence base. *Conservation Science and Practice*, 3(5), e357.

Shane, J. S., Molenaar, K. R., Anderson, S., & Schexnayder, C. (2009). Construction project cost escalation factors. *Journal of Management in Engineering*, 25(4), 221-229.

Simon-Eigbe, B., Aiminhiefe, M. & Bamidele, B. (2022). Factors Affecting Project Performance of Building Construction Projects in Federal Capital Territory (FCT) Abuja, Nigeria. *Current Journal of Applied Science and Technology*, 44-53. https://doi.org/10.9734/cjast/2022/v41i353960

Singh, C. D., Singh, R., Mand, J. S. & Singh, S. (2013). Application of lean and JIT principles in supply chain management. *International Journal of Management Research and Business Strategy*, 2(1), 85-98.

Tam, C., da Costa Moura, E. J., Oliveira, T. & Varajão, J. (2020). The factors influencing the success of on-going agile software development projects. *International Journal of Project Management*, 38(3), 165-176.

Taye, M. (2016). *Assessment of time and cost overruns in construction projects (case study at defense construction enterprise)* St. Mary's University.

Tumi, S. A. H., Omran, A. & Pakir, A. H. K. (2009). Causes of delay in construction industry in Libya. The International Conference on Economics and Administration,

Umar, M.K., Shehu, M. A. & Ija, M. I. (2022). Lean construction principles in public project delivery in Abuja, Nigeria. *International Journal of Engineering Sciences and Computing (IJESC)*, 12(5), 29540-29547.

Wu, X., Yuan, H., Wang, G., Li, S. & Wu, G. (2019). Impacts of lean construction on safety systems: A system dynamics approach. *International Journal of Environmental Research and Public Health*, 16(2), 221.

Xiang, T. Z. & Feng, C. J. (2021). Implementing total productive maintenance in a manufacturing small or medium-sized enterprise. *Journal of Industrial Engineering and Management*, 14(2), 152-175. https://doi.org/10.3926/jiem.3286.

Zimina, D., Ballard, G. & Pasquire, C. (2012). Target value design: using collaboration and a lean approach to reduce construction cost. *Construction Management and Economics*, 30(5), 383-398.

Zolkafli, U. K., Zakaria, N. & Danuri, M. S. M. (2021). The adoption of total productive maintenance (Tpm) concept for maintenance procurement of green buildings in Malaysia. *International Journal of Sustainable Construction Engineering and Technology*, 12(1), 40-55.