Adoption of Lean Construction Practices and the Influence of Firm Size among Contractors and Consultants in North East Nigeria

Salihu Muhammad Mari[1], Umar Abdullahi[2], Napolean Daniel Usman[3]

[1]Department of Estate Management, Faculty of Environmental Sciences, Nigeria Army University Biu, Borno State, Nigeria

[2,3]Department of Building, Faculty of Environmental Sciences, Modibbo Adama University, Yola, Nigeria

ABSTRACT

Lean construction is widely promoted as a route to reducing waste and improving project delivery, yet evidence on how far firms in post-conflict, resource-constrained regions have adopted specific lean practices is scarce. This study identified the lean construction practices adopted by contractor and consultant firms in Adamawa, Bauchi, and Borno States, North East Nigeria, and tested whether adoption differs by firm size. A cross-sectional survey was administered to a proportionate stratified random sample of 187 registered firms drawn from a frame of 350; 154 questionnaires were returned and 149 were valid (82.4% response rate). Eight lean practice areas, measured by 24 items on a five-point scale, were analysed with means, standard deviations, rankings, and one-way ANOVA. Overall adoption was moderate (M = 3.46, SD = 0.735). Teamwork (M = 3.87), continuous improvement (M = 3.72), and waste reduction (M = 3.68) were the most widely practiced areas, whereas pull planning (M = 3.29), just-in-time delivery (M = 3.15), and value stream mapping (M = 2.98) lagged. Adoption differed significantly by firm size, $F(2, 146) = 9.87$, $p < 0.001$, $\eta^2 = 0.119$: large firms (M = 3.95) exceeded medium (M = 3.62) and small firms (M = 3.28). The results show a people–process divide in which behavioural lean practices are established but technical, flow-oriented tools are not. The study recommends targeted training in pull planning, just-in-time delivery, and value stream mapping, and capacity support for small firms.

KEYWORDS

Lean construction, adoption, firm size, contractors, consultants, North East Nigeria

I. INTRODUCTION

Construction firms in Nigeria continue to struggle with cost overruns, schedule delays, and quality deficiencies, and the problem is sharper in the North East, where firms are delivering post-conflict reconstruction under pressure. Lean construction, which applies the principles of waste elimination, smooth flow, and value creation to project delivery, is widely advanced as a response. Reviews show that awareness of lean in developing countries has grown

faster than its implementation, and studies of Nigerian firms have concentrated on awareness and barriers.

Two gaps remain. First, little is known about which specific lean practices firms in the North East have actually adopted, as distinct from which they know of. Second, adoption has seldom been compared across firm sizes, although small firms dominate the Nigerian industry and are known to face resource limits in implementing lean (Matt & Rauch, 2013). Studies also rarely cover contractors and consultants together, even though both shape how projects are delivered. This paper addresses these gaps for registered contractor and consultant firms in Adamawa, Bauchi, and Borno States.

The study answers two questions:

- Which lean construction practices have firms in the study area adopted, and to what extent?
- Does the extent of adoption differ among small, medium, and large firms?

II. LITERATURE REVIEW

A. Lean construction practices

Lean construction adapts the production philosophy developed in manufacturing to construction, treating a project as a flow of transformation, flow, and value-generation activities. In practice it is implemented through a set of tools and behaviours. This study examined eight practice areas: value stream mapping, pull planning, just-in-time (JIT) delivery, continuous improvement, visual control, teamwork, supply chain integration, and waste reduction. Value stream mapping documents material and information flows to separate value-adding from non-value-adding activity (Yu et al., 2009). Pull planning, usually applied through the Last Planner System, schedules work backwards from the needs of the next crew (Ballard & Howell, 2003). Visual management makes project status visible to the whole team (Tezel et al., 2016), and supply chain collaboration links firms with their suppliers to stabilise flow.

B. Adoption in developing countries and in Nigeria

Evidence from developing countries describes uneven adoption. In Morocco, continuous improvement and teamwork were the most widely practised lean elements, while the Last Planner System and value stream mapping were comparatively underused. Green and May (2005) noted that firms often first take up lean as a cultural philosophy before attempting systemic redesign of their processes. Nigerian studies identify limited awareness, weak top-management commitment, skills shortages, and resistance to change as the main obstacles. Very little of this work reports the extent of adoption practice by practice, and none that we are aware of does so for the three North East states studied here.

C. Firm size and adoption

The Resource-Based View holds that firms with greater financial, human, and organisational resources are better placed to build and sustain operational capabilities (Barney, 1991). Applied to lean, larger firms are expected to have dedicated project management functions, formal quality systems, and the funds to pay for training and external advice, while small firms face resource and know-how constraints (Matt & Rauch, 2013). Diffusion of Innovation Theory adds that practices that are simple, compatible with existing routines, and quick to

show results diffuse faster than complex ones (Rogers, 2003). Together, these perspectives predict that adoption will be higher for simpler, behavioural practices and higher among larger firms. The study therefore tested the hypothesis that mean lean adoption differs significantly across small, medium, and large firms.

III. METHODOLOGY

A quantitative, cross-sectional survey design was adopted within a positivist paradigm. The study covered Adamawa, Bauchi, and Borno States, three states of the North East geopolitical zone that are the focus of post-conflict reconstruction. The target population was all registered contractor and consultant firms operating in the three states. A sampling frame of 350 firms was compiled from the registers appropriate to each category: for contractors, the membership directories of the Federation of Construction Industry, the registers of the Bureau of Public Procurement and state procurement agencies, and the contractor lists of state ministries of works; for consultants, the registers of the Council for the Regulation of Engineering in Nigeria, the Architects Registration Council of Nigeria, the Quantity Surveyors Registration Board of Nigeria, and the Nigerian Institute of Quantity Surveyors; and, for building contractors and consultancies, the Nigerian Institute of Building and the Council of Registered Builders of Nigeria. Entries were merged, de-duplicated and verified against the Corporate Affairs Commission register.

Proportionate stratified random sampling was used, with states as strata and simple random selection within each state. Yamane's formula gave a sample of 187 firms, allocated as 41 (Adamawa), 76 (Bauchi), and 70 (Borno). One senior key informant per firm (managing director, general manager, principal partner, and head of practice, project manager, or lead consultant) completed the questionnaire (Kumar et al., 1993). The questionnaire was administered electronically by email and an online form, with two reminders and telephone follow-up over six months. In all, 154 questionnaires were returned (82.4%), and 149 were valid after multivariate outliers were removed. Table 1 gives the profile of the valid sample.

Table 1: Profile of Respondent Firms (N = 149)

Characteristic	Category	n	%
Firm type	Contractor	83	55.7
	Consultant	66	44.3
Firm size (SMEDAN, 2019)	Small (< 50 employees)	87	58.4
	Medium (50–199 employees)	42	28.2
	Large (≥ 200 employees)	20	13.4
State	Adamawa	30	20.1
	Bauchi	63	42.3
	Borno	56	37.6

The instrument was a structured questionnaire. Section B measured lean construction practices with 24 items, three for each of the eight practice areas, rated on a five-point scale of extent of adoption (1 = lowest extent, 5 = highest extent). Items were adapted from Koskela (2000), Aziz and Hafez (2013), and Bajjou and Chafi (2018). Content validity was established by a panel of five experts, and a pilot with 30 firms excluded from the main sample returned Cronbach's alpha values of 0.824 to 0.901. In the main study, the reliability

of the lean construction scale was high (α = 0.921; composite reliability = 0.938; AVE = 0.621), and alpha for each of the eight practice areas ranged from 0.835 to 0.891 (Hair et al., 2021). Means, standard deviations, and ranks were computed for items and practice areas, and one-way ANOVA with Tukey's HSD post-hoc test compared adoption across size categories; η^2 was used as the effect size, with ethical safeguards of voluntary participation, informed consent, and anonymity applied throughout.

IV. RESULTS

A. Extent of adoption of lean construction practices

Table 2 presents the results for the eight practice areas. Overall adoption was moderate (M = 3.46, SD = 0.735). Teamwork ranked first (M = 3.87, SD = 0.842), followed by continuous improvement (M = 3.72) and waste reduction (M = 3.68), all in the high range. Visual control (M = 3.54) was moderate to high, and supply chain integration (M = 3.41) was moderate. Pull planning (M = 3.29), JIT delivery (M = 3.15), and value stream mapping (M = 2.98) ranked lowest, and value stream mapping was the only area below the scale midpoint of 3.00. Standard deviations rose from 0.842 for teamwork to 1.124 for value stream mapping, which indicates that firms differ most in the practices that are least adopted.

Table 2: Adoption of Lean Construction Practice Areas (N = 149)

Practice area	Mean	SD	Rank	Adoption level
Teamwork	3.87	0.842	1	High
Continuous improvement	3.72	0.893	2	High
Waste reduction	3.68	0.917	3	High
Visual control	3.54	0.936	4	Moderate-high
Supply chain integration	3.41	1.028	5	Moderate
Pull planning	3.29	1.047	6	Moderate
Just-in-time delivery	3.15	1.093	7	Moderate
Value stream mapping	2.98	1.124	8	Moderate-low
Overall composite	3.46	0.735	–	Moderate

B. Item-level patterns

Table 3 lists the ten highest-rated items. The top-rated item was encouraging collaboration among all project team members (M = 4.12), followed by holding regular progress meetings (M = 3.98) and actively seeking ways to eliminate waste (M = 3.94). Every item in the top ten came from teamwork, continuous improvement, waste reduction, visual control, or supply chain integration, and one JIT item ranked tenth (planning material deliveries to actual site need, M = 3.29). No pull planning or value stream mapping item appeared in the top ten.

Table 3: Ten Highest-Rated Lean Construction Practice Items

Item	Mean	SD	Practice area
Encourage collaboration among all project team members	4.12	0.789	Teamwork

Hold regular meetings to monitor and discuss progress	3.98	0.821	Teamwork
Actively seek ways to eliminate waste in operations	3.94	0.847	Waste reduction
Implement worker suggestions for process improvement	3.89	0.865	Continuous improvement
Use visual tools to communicate project status to the team	3.76	0.902	Visual control
Maintain long-term relationships with key suppliers	3.71	0.924	Supply chain integration
Conduct structured reviews to identify waste sources on site	3.68	0.938	Waste reduction
Standardise work procedures across ongoing projects	3.54	0.961	Continuous improvement
Share project progress information across all stakeholders	3.48	1.014	Visual control
Plan material deliveries based on actual site need schedules	3.29	1.068	JIT delivery

C. Lean adoption by firm size

Adoption rose with firm size (Table 4). Large firms recorded the highest mean (M = 3.95, SD = 0.598), followed by medium firms (M = 3.62, SD = 0.641) and small firms (M = 3.28, SD = 0.783). A one-way ANOVA showed that the difference was statistically significant, $F(2, 146) = 9.87$, $p < 0.001$, $\eta^2 = 0.119$, a medium effect. Tukey's HSD tests showed that large firms adopted lean practices significantly more than medium firms ($p < 0.05$) and small firms ($p < 0.001$), and that medium firms adopted significantly more than small firms ($p < 0.05$). The hypothesis that adoption differs by firm size was therefore supported.

Table 4: Lean Construction Adoption by Firm Size

Firm size	n	Mean	SD	Adoption level
Small (< 50 employees)	87	3.28	0.783	Moderate-low
Medium (50–199 employees)	42	3.62	0.641	Moderate-high
Large (≥ 200 employees)	20	3.95	0.598	High
All firms	149	3.46	0.735	Moderate

V. DISCUSSION

A. A people-process divide

Moderate overall adoption (M = 3.46) matches the picture from other developing countries, where knowledge of lean has run ahead of implementation depth. The average, however, hides a clear divide. The practices that are firmly established are people-oriented: collaboration, regular coordination meetings, worker suggestions, and waste awareness. The practices that lag are technical and flow-oriented: pull planning, JIT delivery, and value stream mapping. This ordering resembles the Moroccan finding and supports the view that firms take up lean as a culture before they redesign processes (Green & May, 2005). Diffusion of Innovation Theory explains why: behavioural practices are simple, compatible with existing routines, and cost little, while mapping and pull scheduling are complex and

demand stable workflows, measurement, and trained staff (Rogers, 2003). Collectivist work norms may also make collaboration an easy practice to adopt. The low score for value stream mapping has a further consequence. Waste reduction scored high, but without systematic mapping of flows, waste reduction is likely to depend on site-level awareness and not on measured analysis of where waste arises. The same applies to JIT delivery and pull planning, which depend on reliable information about progress and material needs.

B. Firm size as a structural determinant

The significant, medium-sized effect of firm size is consistent with the Resource-Based View (Barney, 1991). Large firms are likelier to have dedicated project management staff, formal quality systems, and funds for training and external advice, and these are the resources lean implementation needs. Small firms, which make up 58.4% of the sample, scored only 3.28, in line with the resource and know-how constraints reported for small enterprises elsewhere (Matt & Rauch, 2013). Because small firms dominate the industry in the region, the aggregate level of adoption is held down by them.

C. Lean maturity

Taken together, the results suggest an early-to-intermediate stage of lean maturity, comparable to the middle levels of capability maturity frameworks, in which basic practices exist but standardised process analysis and advanced tools are incomplete. Progress would require technical training, analytical capability, and the information systems that tools such as pull planning rely on.

VI. CONCLUSION AND RECOMMENDATIONS

Contractor and consultant firms in Adamawa, Bauchi, and Borno States have adopted lean construction to a moderate extent. Adoption is strongest in teamwork, continuous improvement, and waste reduction and weakest in pull planning, JIT delivery, and value stream mapping, and it rises significantly with firm size. The study contributes practice-level evidence on lean adoption from an under-researched post-conflict region and shows that firm size is a significant differentiator.

The following recommendations follow from the findings:

- Firms should build on their collaborative base by introducing pull planning, JIT delivery, and value stream mapping in stages, starting with pilot projects.
- Professional bodies and training providers should include these three technical tools in continuing professional development for builders, quantity surveyors, engineers, and architects.
- Small firms should be supported through shared training, simple templates, and mentoring by larger firms, since resource limits are their main barrier.
- Public clients and procurement agencies in the region could reward evidence of lean practice in pre-qualification of contractors and consultants.

The study has limitations. It is cross-sectional and relies on the perceptions of one senior informant per firm, it covers only registered firms in three of the six North East states, and it did not compare contractors and consultants separately. Future research should test differences between the two groups, use project-level observation, and examine adoption over time.

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