The Fourth Industrial Revolution and Nigeria's Construction Sector: Lessons from the COVID-19 Experience

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Abstract

The outbreak of COVID-19 brought all sectors, including the construction industry, to a halt, resulting in the closure of construction sites worldwide. Leveraging the advantages of Fourth Industrial Revolution (4IR) technologies and the digital era could have mitigated some of the challenges faced by the construction industry, yet a certain level of e-readiness is required for its adoption and implementation. This study aims to ascertain the e-readiness of the Nigerian construction industry in adopting 4IR. The study's population consisted of construction professionals in Abuja, Kano, and Kaduna states of Nigeria, using a simple random sampling (SRS) method. The hybrid of VERDICT and CID e-readiness tools (Readiness for the Networked World) was adopted. Analysis of Variance (ANOVA) was used to compare the responses based on the respondents' firms' sizes. The results revealed significant differences in opinions among various groups (micro, small, medium, and large firms). The Tukey Post Hoc test showed that responses from small and medium-sized organizations did not differ significantly, with a computed significance (p) value of 0.0904. Similarly, respondents from medium and large firms had related views, with a calculated significance (p) value of 0.090. However, comparing responses from small to large firms revealed significant variations, with a calculated significance (p) value of 0.032. Additionally, ANOVA indicated no significant difference in opinions across the nine professional groups despite their different career backgrounds. The study recommends further research to develop a framework for adopting 4IR in the Nigerian construction industry.

Keywords: Fourth Industrial Revolution (4IR), E-readiness, Nigerian Construction Industry, Covid-19

INTRODUCTION

The COVID-19 pandemic caused significant disruptions in global business operations, particularly in construction asset procurement and facility management. Nigeria reported its first COVID-19 case in February 2020 and subsequently imposed lockdowns March, affecting key commercial areas and the construction sites to curb the virus's spread, as declared a global pandemic by the WHO.

The pandemic affected commercial activities and human health. In response, professional organizations like CIOB and RICS developed strategies to help construction firms transition

smoothly. The Construction Leadership Council's "Roadmap to Recovery" emphasized the need for the construction sector to "reinvent" itself, preserve firms, and collaborate for recovery (CIOB, 2020). African countries, including Nigeria, faced labour shortages, high national debt, and low infrastructure spending due to economic weaknesses (Hughes, 2020). The Nigerian economy, especially in Abuja and Lagos, was severely impacted. However, some construction sectors in Sub-Saharan Africa, including Nigeria, began exploring opportunities arising from the COVID-19 crisis, unlike many other nations.

Disruptions in the Construction Industry during the COVID-19 Pandemic

The COVID-19 pandemic caused significant disruptions in the construction industry worldwide, including Nigeria. Following the first reported case on February 27, 2020, the Nigerian government imposed lockdowns on March 30, 2020, affecting construction sites to prevent the virus's spread. These restrictions impacted commercial activities and human health, leading to project delays and workforce reductions. By September 2020, 6.7% of apprentices lost jobs, and 20% of the workforce was affected. Construction projects saw a 7.7% reduction in the directly employed workforce and a 26.7% decrease in agency and self-employed workers.

Professional organizations like CIOB and RICS developed strategies to aid construction firms. The Construction Leadership Council's "Roadmap to Recovery" emphasized reinvention and collaboration for recovery (CIOB, 2020). Amid economic challenges, such as labor shortages and national debt, some African construction sectors began exploring new opportunities. The Department of Petroleum Resources (DPR) enforced health regulations, leading to the demobilization of non-essential offshore staff.

Post COVID-19: Construction Industry Preparation for the Future

To ensure business continuity, flexible work arrangements like remote working became essential. The construction industry must embrace digital technologies to enhance productivity and resilience. Stakeholders, including quantity surveyors, architects, engineers, and contractors, need to adopt innovations such as building information modelling (BIM), prefabrication, wireless sensors, 3D printing, and automated robotics.

Fourth Industrial Revolution (4IR)

The rapid development of 4IR technologies has become crucial in addressing uncertainties like the COVID-19 pandemic, which significantly affected the $10 trillion construction sector (Bogue, 2018). Despite its importance, the industry has been slow to adopt technologies such as robotics, 3D printing, big data, blockchain, digital twins, augmented reality, and cyber-physical systems. These technologies offer benefits like customizable designs, waste reduction, and efficient resource use (Paul & Sanjayan, 2020).

However, challenges remain in organizational transformation, policy orientation, and technology adoption (Dwivedi *et al*., 2020). This study aims to assess the e-readiness of the Nigerian construction industry in adopting 4IR technologies to mitigate future disruptions.

METHODOLOGY

The study population comprised construction industry professionals working with consulting firms, contracting firms, and client organizations in Abuja, Kano, and Kaduna states of Nigeria. Given the impracticality of covering the entire population, a simple random sampling (SRS) method was employed. SRS involves selecting samples randomly from the population using

random number tables or an online random number generator, ensuring that each possible sample has an equal chance of being chosen.

The survey was conducted online via a Google Form, which was distributed through professional platforms such as WhatsApp, Telegram, and LinkedIn, as well as direct emails to reach a broader audience. According to Ott and Longnecker (2001), the central limit theorem holds true for normally distributed study samples when the sample size is 30 or more. This study received 81 valid responses, including 23 Quantity Surveyors, 12 Land Surveyors, 9 Architects, 17 Services Engineers, 7 Civil Engineers, 5 Estate Valuers, 3 Town Planners, and 5 Builders, thus meeting the criteria for the central limit theorem.

The questionnaire was divided into two sections. Section A contained seven questions aimed at gathering information about the respondents and their organizations, including their highest level of education, work experience, area of specialization, IT knowledge, and organization size. Participants were required to have prior knowledge of information and communication technology related to the construction industry. Section B assessed the level of e-readiness in the Nigerian construction industry and the country at large for adopting 4IR technologies.

The study adopted a hybrid of the VERDICT and CID e-readiness tools. VERDICT, as identified by Ruikar *et al*. (2006), includes four key components of e-readiness: management, process, people, and technology. Ayarici *et al*. (2009) further emphasized governance, people's practices, business processes, and technology deployment as significant influences on organizational e-readiness. The CID e-readiness tool defines 19 indicators of e-readiness, categorized into Networked Access, Networked Learning, Networked Society, Networked Economy, and Networked Policy. Participants rated their organizations on these components using a 5-point Likert scale based on their fair and unbiased judgment.

RESULTS AND DISCUSSION

The data from the questionnaire survey was analysed using SPSS (Statistical Package for Social Sciences) software. Descriptive statistics were employed to generate frequency counts, tables, and charts. Measures of central tendency (mean) and dispersion (variance and standard deviation) were calculated. Inferential statistics, specifically one-way ANOVA, were used to compare mean response scores, determining significant differences in respondents' opinions on e-readiness in the Nigerian construction industry. Tukey's HSD multiple comparison tests further confirmed these findings where applicable.

Distribution of Respondents by Organization Sizes

The survey included 81 respondents from various organization sizes within the Nigerian construction industry. The distribution was as follows:

a) Micro firms (≤10 personnel): 9 respondents (11.11%)

b) Small firms (11-50 personnel): 52 respondents (64.20%)

c) Medium firms (51-200 personnel): 15 respondents (18.52%)

d) Large firms (≥200 personnel): 5 respondents (6.17%)

This distribution validates the research, as it includes a diverse range of organizations, ensuring that the opinions collected represent the broader industry.

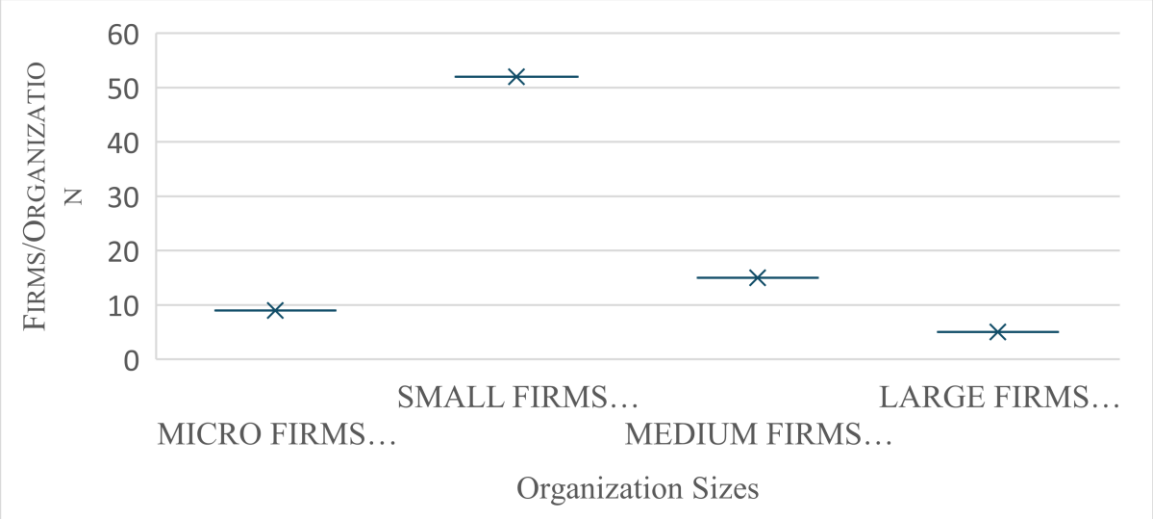

Figure 1: Distribution of Respondents by Organization Sizes

Description of Respondents by Specialization

The distribution of respondents based on their professional specialization is presented below. Quantity Surveyors constituted the largest group, with 23 out of the 81 respondents. This was followed by Services Engineers, who accounted for 17 respondents. Town Planners formed the smallest group, with only 3 respondents. This diverse representation across various specializations ensures comprehensive insights into the e-readiness of the Nigerian construction industry.

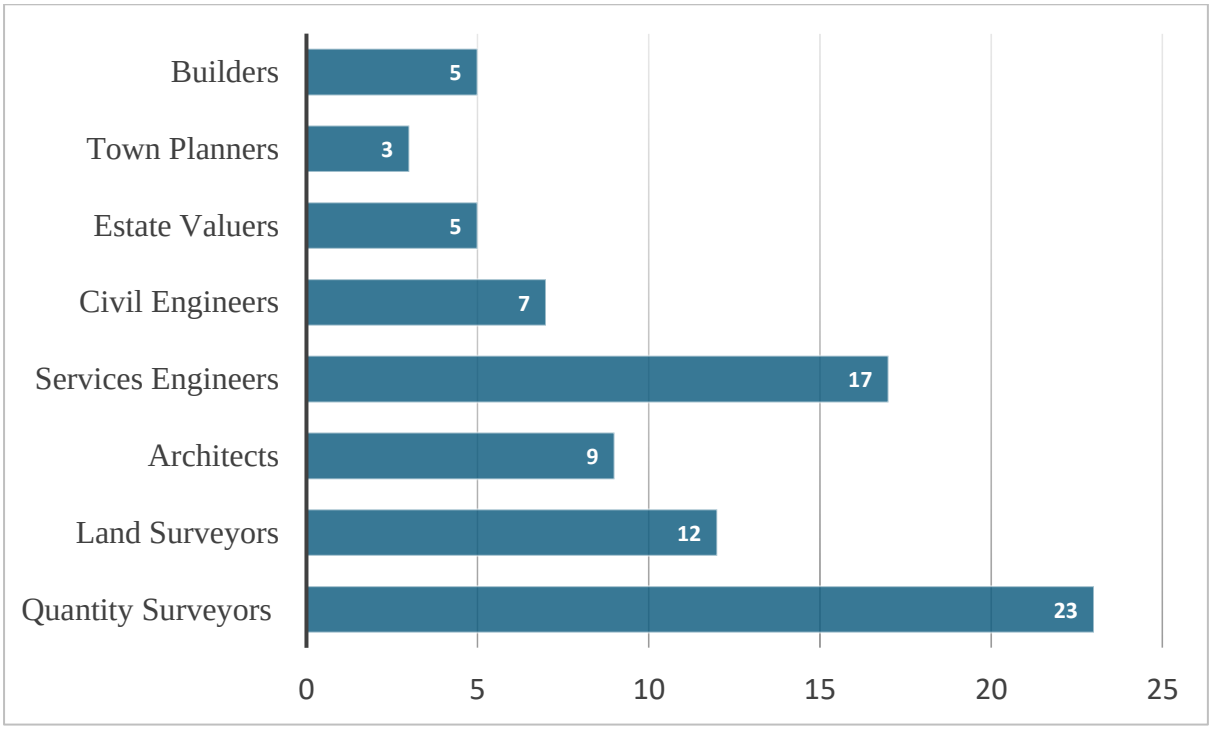

Figure 2: Distribution of Respondents by Specialization

Analysis of Results

The analysis aimed to determine the e-readiness of the Nigerian Construction Industry based on respondents' perceptions, using a scale where higher scores indicate greater preparedness as in table 1.

Table 1: Scale for e-readiness of the Nigerian Construction Industry

Scores	
1	Extremely low e-readiness
2	Low e-readiness
3	Moderate e-readiness
4	High e-readiness
5	Extremely high e-readiness

For instance, a score of "1.3" leans towards extremely low e-readiness but indicates areas needing urgent improvement, while a score of "4.6" leans towards extremely high e-readiness, indicating a mature and well-prepared organization.

One-Way ANOVA

Analysis of Variance (ANOVA) was employed to test for significant differences among the mean scores of responses across different categories. ANOVA is suitable for comparing means of more than two groups, determining if there are significant variations among them.

The tables below present the results of the one-way ANOVA, illustrating whether there are statistically significant differences in respondents' perceptions of e-readiness in the Nigerian Construction Industry. This statistical approach helps in understanding the readiness levels across various segments within the industry.

Table 2: Descriptive statistics of Anova

					95% Confidence Interval for Mean			
Organisation	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Micro size	9	3.9860	0.38715	0.05756	3.9878	4.5466	3.28	4.99
Small size	52	4.0034	0.41407	0.06717	3.8673	4.1395	3.19	4.62
Medium size	15	4.0426	0.38311	0.06215	3.9167	4.1686	3.30	4.61
Large size	5	4.2368	0.39825	0.06461	4.1059	4.3677	3.50	5.00
Total	81	4.0574	0.41277	0.08767	3.9343	4.7695	3.47	4.69

Table 3: Analysis of variance based on Organization Size

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.187	2	0.594	3.735	0.027
Within Groups	17.643	111	0.159		
Total	18.830	113			

The study analysed respondents' perceptions based on the size of their organizations to determine if firm size influences their views on the investigated issues, as shown in Tables 1 and 2. Analysis of Variance (ANOVA) was utilized to compare mean responses across different firm sizes, revealing significant differences among micro, small, medium, and large firms in relation to the study's questions. The ANOVA results indicated:

a) A calculated F ratio of 3.735, which exceeded the critical F value of 2.60 ($F(2,111) = 3.735$).

b) A significance level (p-value) of 0.027, which was below the threshold of 0.05.

These findings demonstrate that there are statistically significant differences in opinions among firms of varying sizes regarding e-readiness in the Nigerian Construction Industry. The results highlight the importance of considering organizational size when assessing readiness for adopting Fourth Industrial Revolution technologies.

Table 4: Tukey HSD

					95% Confidence Interval	
(I) Size of the firms	(J) Size of the firms	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
Small size firms	Medium size firms	-0.03921	0.09146	0.904	-0.2565	0.1781
	Large size firms	-0.23342	0.09146	0.032	-0.4507	-0.0161
Medium size firms	Small size firms	0.03921	0.09146	0.904	-0.1781	0.2565
	Large size firms	-0.19421	0.09146	0.090	-0.4115	0.0231
Large size firms	Small size firms	0.23342	0.09146	0.032	0.0161	0.4507
	Medium size firms	0.19421	0.09146	0.090	-0.0231	0.4115

The study examined how respondents' opinions varied based on the sizes of their organizations: micro, small, medium, and large firms. Further analysis was conducted using Tukey Post-Hoc multiple comparisons tests to pinpoint significant differences in their perceptions regarding the issues investigated. The Tukey Post-Hoc test results (Table 2) detailed significant differences among respondents' opinions:

Responses from small and medium-sized organizations did not differ significantly, with a computed p-value of 0.0904. Similarly, respondents from medium and large-sized firms showed related views, with a calculated p-value of 0.090. However, opinions between respondents from small and large-sized firms varied significantly, with a calculated p-value of 0.032.

Statistically significant differences, as indicated by Tukey Post-Hoc tests ($p < 0.05$), underscored that respondents from small-sized firms held similar views to those from medium-sized firms. Conversely, respondents from large-sized firms differed significantly in their opinions on the e-readiness of the Nigerian Construction Industry compared to both small and medium-sized firms.

These findings highlight the influence of organizational size on perceptions of e-readiness, emphasizing the need for tailored strategies to address the varying readiness levels across different sizes of firms within the industry.

Table 5: Descriptive statistics of Anova

	N	Mean	Std	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Q/Surveyors	23	4.0276	0.46553	0.07134	3.8665	4.2513	3.28	4.23
L/Surveyors	12	4.0783	0.47561	0.07336	3.9674	4.1863	3.15	4.59
Architects	9	4.0385	0.47832	0.07657	3.8747	4.3983	3.34	4.38
Services Engineers	17	4.0255	0.44053	0.07146	3.8807	4.1703	3.18	4.73
Civil Engineers	7	4.0071	0.41003	0.06652	3.8723	4.1419	3.24	4.59
Estate Valuers	5	4.0168	0.43387	0.07038	3.8742	4.1595	3.33	4.67
Town Planners	3	4.0524	0.39149	0.06351	3.9237	4.181	3.27	4.64
Builders	5	4.0774	0.40249	0.06529	3.9451	4.2097	3.33	4.51
Total	81	4.0358	0.41248	0.02992	3.9768	4.0949	3.18	4.73

Table 6: Analysis of variance based on Specialt

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.125	9	0.031	0.181	0.948
Within Groups	32.031	185	0.173		
Total	32.156	189			

The ANOVA conducted (Tables 5 and 6) revealed that there is no significant difference in opinions among the nine professional groups surveyed, despite their diverse backgrounds in Quantity Surveying, Land Surveying, Architecture, Services Engineering, Civil Engineering, Estate Valuation, Town Planning, and Building. The calculated F ratio was 0.181, which was lower than the critical F value of 2.60 ($F(4,185) = 0.181$). The significance level (p-value) was 0.948, exceeding the threshold of 0.05.

These results indicate that the professional background of respondents did not significantly influence their opinions regarding the e-readiness of the Nigerian Construction Industry. The lack of statistical significance suggests that across different professional roles within the industry, perceptions regarding readiness for adopting Fourth Industrial Revolution technologies were generally consistent.

CONCLUSION

From the survey of eighty-one respondents, the majority were from small firms (64.20%), followed by medium-sized (18.52%) and large firms (6.17%). Quantity Surveyors were the largest professional group (28.40%), followed by Services Engineers (20.99%), with Town Planners comprising the smallest group.

Analysis of Variance (ANOVA) indicated significant differences in opinions based on firm size, particularly between small and large firms ($p = 0.032$). However, there was no significant difference in opinions across different professional roles within the industry.

Overall, the study concludes that the Nigerian Construction Industry shows readiness to adopt Fourth Industrial Revolution (4IR) technologies, with most respondents indicating high to

extremely high levels of e-readiness. Further research is recommended to develop a specific framework for 4IR adoption tailored to the Nigerian construction sector. Additionally, future studies should assess e-readiness levels across different segments of the industry to identify areas needing improvement for equitable readiness across the sector.

References

Ayarici, Y., Khosrowshahi, F., Ponting, A. M., & Mihindu, S. (2009). Towards Implementation of Building Information Modelling in the Construction Industry. *Fifth International Conference on Construction in the 21st Century (CITC-V)*, May 20-22, 2009, Istanbul, Turkey.

Chartered Institute of Building (CIOB). (2020). CIOB welcomes "Roadmap to Recovery" for the construction industry. Retrieved from https://www.ciob.org/media-centre/news/ciob-welcomes-roadmap-recovery-construction-industry.

Construction Leadership Council. (2020). Construction sector - Site operating procedures. Protecting your workforce during coronavirus (Covid-19). Retrieved from https://www.constructionleadershipcouncil.co.uk/wp-content/uploads/2020/07/Site-Operating-Procedures-Version-5.pdf.

Construction Manager. (2020). Covid-19 causing extra 15% productivity loss on UK sites. Retrieved from https://www.constructionmanagermagazine.com/covid-19-causing-extra-15-productivity-loss-on-uk-sites/.

Global Data. (2020). Construction in Nigeria: COVID-19 sector impact. Retrieved from https://www.marketresearch.com/GlobalData-v3648/Construction-Nigeria-COVID-Sector-Impact-13237763/.

Hirschi, A. (2018). The fourth industrial revolution: Issues and implications for career research and practice. *The Career Development Quarterly, 66*(3), 192–204.

Hook, J. (2020). Engineering & construction in a post-COVID world: Weathering the storm. Retrieved from https://www.pwc.com/gx/en/issues/crisis-solutions/covid-19/engineering-construction-post-covid-world.html.

Hughes, L. (2020). The impact of Covid-19 on construction industry in Sub-Saharan Africa. Retrieved from https://www.arcadis.com/en/africa/ourperspectives/articles/the-impact-of-covid19-on-construction-industry-in-sub-saharan-africa/.

International Labour Organisation (ILO). (2020). COVID-19 and the World of Work: Impact and Policy Responses (ILO Monitor 1st Edition). Retrieved from https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents.

KPMG. (2020). Workforce, Workplace and HR Reshaping During Covid-19 Pandemic. Retrieved from https://www.lexology.com/library/detail.aspx?g=965bd525-c837-4663-8e0f-c63b7362bd0f.

Lemieux, V. L., & Lemieux, V. L. (2016). Trusting records: Is blockchain technology the answer? *Records Management Journal, 26*(2), 110–139.

Ott, R. L., & Longnecker, M. (2001). *An Introduction to Statistical Methods and Data Analysis* (5th ed.). Pacific Grove, CA: Duxbury.

Okonmah, N.-M., Abdulkareem, H., & Fagbohunlu, B. (2020, May). COVID-19: Nigerian construction and infrastructure industry. Retrieved from https://www.alukooyebode.com/insights/covid-19-nigerian-construction-and-infrastructure-industry/#

Ruikar, K., Anumba, C. J., & Carrillo, P. M. (2006). VERDICT--An e-readiness assessment application for construction companies. *Automation in Construction, 15*(1), 98-110.

Thornhill, A., Saunders, M., & Lewis, P. (2009). Research Methods for Business Students. London: Prentice Hall.

Weber, B., & Alfen, H. W. (2016). Infrastructure as an Asset Class: Investment Strategies, Project Finance and PPP. New York: John Wiley and Sons.

World Health Organization. (2020). Overview of public health and social measures in the context of COVID-19. Retrieved from https://www.who.int/publications-detail/overview-of-public-health-and-social-measures-in-the-context-of-covid-19.

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