Influence of digitalisation adoption level on construction project delivery in Nigeria

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Abstract

Purpose – The rate of project failure across the globe seems to reinforce poor performance as a norm. However, engagement with construction digitalisation (CD) represents a departure point for improving project performance. Amidst researchers' recent empirical engagement with CD, the knowledge of the relationship model between CD and project delivery (PD) is abysmal. As a result, developing a business case for CD in developing countries has been slow due to the dearth of empirical evidence. This paper aims to investigate the influence of digitalisation on project performance.

Design/methodology/approach – Anchored on cross-sectional survey research design using a questionnaire survey in which a total of 183 copies of structured questionnaires were randomly distributed to medium- and large-sized construction firms operating in Abuja, Nigeria's federal capital. A total of 126 valid responses were received giving an overall response rate of 68.8%. The responses were analysed using mean item score, principal component analysis and multiple linear regression.

Findings – Findings from the regression analysis reveal that digitalisation has varying levels of impact on PP measured using quality, time and cost. The relationship model with time performance is weak ($r = 0.526$, $r^2 = 0.277$); on cost performance, the significant model is also weak ($r = 0.502$, $r^2 = 0.252$) and moderate on quality ($r = 0.663$, $r^2 = 0.439$). CD influences project cost, time and quality performance despite the weak relationship model. The results indicate that the most effective benchmark of CD is quality performance.

Originality/value – This study established the relationship between digitalisation and construction PD within the construction industry context, an area lacking research attention in emerging economies. This study is the first study in emerging economies that established the influence of digitalisation on construction PD statistically.

Keywords Construction industry, Digitalisation, Project performance, Multiple linear regression modelling, Nigeria

Paper type Research paper

1. Introduction

The construction industry (CI) across the world plays a significant part in the development of national economics. In Nigeria, the CI accounts for 6.17% of the GDP in the first quarter of 2019 (National Bureau of Statistics, 2019). In 2022, projections are that over 60% of the total GDP will be digitised and digital platforms will produce about 70% of the innovative value

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(World Economic Forum, 2019). However, despite this global digitalisation impetuses, the CI scored lowest in terms of digitalisation rate when compared with other industries (McKinsey and Company, 2017). Due to the laggard digitalisation of construction processes, the CI has suffered a downturn in GDP (McKinsey and Company, 2017). Nigeria's GDP declined from 692520.88 NGN million to 532693.68 NGN million in 2021 (National Bureau of Statistics, 2021). In addition, despite the CI's contribution to GDP, construction projects suffer poor delivery in terms of time, cost and quality. To improve construction project delivery (PD), there is a need to digitalise construction processes. The digitalisation of construction processes is needed to improve PD and save $1.7bn yearly. It is the application of digital tools such as Internet of Things (IoTs), Building Information Modelling (BIM), 3D printing, drones, cloud/mobile computing and AR. It is predicted to improve PD in the CI (Sutton, 2018).

From the construction context, digitalisation refers to the transformation of traditional processes and paper-based practices associated with construction. Digitalisation has many advantages, such as enabling unified objects and individuals to participate in information sharing and achieve objectives collaboratively (Hermann *et al.*, 2016). BIM is revolutionary in the CI. The digitalisation of the CI will improve project performance, reduce waste, increase accuracy and reduce transaction costs. Cloud computing, BIM, drones, virtual reality, RFID, big data, augmented reality and robots are key components of the CI (Hossain and Nadeem, 2019). The IoTs, 3D technology, digitalisation, predictive analytics, 3D printing and cloud computing are revolutionising the CI, allowing for greater accuracy and unified information (Xiao *et al.*, 2018; Ikuabe *et al.*, 2020). Technology such as augmented reality and virtual reality can improve the delivery of construction projects, while mobile technologies such as smartphones, tablets and portable intelligent hotspots are essential for collaboration, communication and the eradication of tailbacks. Robots are also gaining attention in construction operations, and digitalisation offers strategic competitive benefits to better client satisfaction and improves project delivery (Madakam *et al.*, 2019). Adekunle *et al.* (2020) asserted that construction projects should meet client satisfaction and project goals set from inception. Meshram *et al.* (2020) asserted that the reason for performance is to deliver projects within project duration, budget, professionally and safely by profitable construction companies. Successful construction projects are delivered based on cost, time, client satisfaction, cost-effectiveness and efficiency.

Tanga *et al.* (2020) explored the benefits of adopting digital tools in construction, finding that competitive advantage and time-saving are the major benefits. Li and Li (2021) conducted a systematic review that identified several benefits, including improved project planning and scheduling, increased collaboration and enhanced project performance. Digitalisation can improve project performance, reduce risks and enhance stakeholder communication (Alashwal and Al-Ghassani, 2020). Wang *et al.* (2021) examined the application of digital twin technology in construction PD and its potential to improve project planning, design, construction and operation. Li *et al.* (2020) analysed the impact of digitalisation on construction PD in China and found that the use of digital technologies can significantly improve project planning and management, enhance project performance and reduce project risks. This study seeks to address the gap between digitalisation and PD, which is the missing link in the literature statistically. Digital tools such as BIM, drones, the IoTs, 3D printing and robots disrupt the current market, but the relationship is the missing link in the literature statistically. Therefore, this study seeks to address this gap and contribute knowledge to an area that lacks research attention.

Despite the numerous potentials of digitalisation articulated in literature, low awareness and adoption have hindered the full adoption of digitalisation in the CI (Ikuabe *et al.*, 2020). Studies have explored digitalisation across the globe. However, existing studies examined conceptual issues such as the adoption of digitalisation and its benefits (Karadayi-Usta, 2021), digitalisation (Kalavendi, 2017), digitalising the industry (Hossain and Nadeem, 2019) and novel technologies in construction (Igwe *et al.*, 2019). Among these growing engagements, the level of adoption of digital tools in Nigeria is abysmally reported regionally, e.g. in South Africa (Ikuabe *et al.*, 2020). The studies with an interest in modelling the role and impact of digitalisation are scanty. This study contributes to the knowledge of CD by detailing the empirical relationship between the use of digital tools and construction PD. The study seeks to bridge the gap in the dearth of explanatory studies in CD. The objectives of this study are to establish the level of CD in the research environment and model the influence of digitalisation on construction PD. The finding of the study will improve the adoption of digital tools by prioritising the relevant digital tools linked to construction PD.

2. Methodology

In exploring the influence of digitalisation on project performance, this study adopted a survey design in generating quantitative data from construction firms operating in Abuja, Nigeria. Abuja is the capital of Nigeria and the construction hub of the nation with several firms' head offices situated in Abuja. The city has witnessed rapid development in the utilisation of technologies when compared with other parts of the country (Ikediashi *et al.*, 2022). Furthermore, the capital city is home to the highest population of construction firms and professionals in the construction industry in Nigeria. The study is delimited to medium- and large-scale contracting firms that have contributed significantly to infrastructural development. This study focuses on staff strength in establishing firm characteristics. Medium-sized firms have a staff strength of $50 \leq 200$ and large-sized staff strength of >200 (Ogbu and Olatunde, 2019). Through the questionnaire approach, a wide range of respondents was engaged. The population of the study consists of 250 registered construction firms operating in Abuja and was obtained from the registry of the Federation of the construction industry (FOCI). A sample size of 183 was achieved using the Taro Yamane formula. Previous studies such as Ekung *et al.* (2019) and Ikediashi *et al.* (2022) utilised the Yamane formula to determine the sample size. Taro's formula is represented as:

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

where "n" is the sample size, "N" is the population (105) and "e" is the level of confidence (95%).

The 183 questionnaires were randomly distributed in the study area. The study adopted a questionnaire data collection method. The questionnaire approach is useful in covering a wide range of respondents. The questionnaire consists of three sections; the first section consists of respondent information, the second section is centred on digitalisation tools and their level of use and the last section is focused on project performance. The respondents were required to rate the digitalisation tool and their perceived degree of impact on project performance on a five-point Likert scale, where 1 = very low, 2 = low, 3 = indifferent, 4 = high and 5 = very high. Ikediashi *et al.* (2022) adopted a five-point Likert scale to determine the critical barriers to BIM for facilities management, hence the reason for the adoption in this study. Before the questionnaire survey, the study adopted the pilot study in operationalising digitalisation in the construction industry. Ten questionnaires (each questionnaire consisting of 15 variables on digital tools) were randomly distributed to IT experts in construction firms, and feedback from the survey (variables with a mean score above 3.00) was used to improve the final draft for administration. The respondents that participated in the survey are knowledgeable about digital trends. Furthermore, Cronbach's test of reliability was performed at 0.70 alpha suggesting the variable are reliable for generalisation and Cronbach's alpha value between 0.70 and above shows strong internal coherency and dependability. The results of the study showed a Cronbach's alpha value of

0.823 > 0.70 for digitalisation tools and 0.80 > 0.70 was achieved for construction PD on three items. Therefore, the inter-item consistency and instrument reliability is significant since both values are above 0.70. This value indicates a high level of consistency and is within the acceptable threshold of "good" reliability. The study distributed 183 copies of the study questionnaire while 126 were retrieved and deemed fit for analysis, producing a response rate of 68.8%. This response rate is appropriate for producing a valid statistical sample proficient to support the findings and conclusion of the study. This level of response is appropriate to produce a valid statistical sample competent to support the findings and conclusion of the study compared to prominent studies in the region (e.g. 65.8%, Ikediashi *et al.*, 2022).

Data generated were analysed using mean item scores and ranked to identify significant digital tools. Factor analysis was performed to reduce digital tools into a smaller structure, while multiple linear regression was adopted to model the relationship between construction processes' digitalisation and project performance. Multiple linear regression is required when a study seeks to demonstrate if a causal relationship exists between two or more variables. Below are the model specifications used in predicting the relationship between digitalisation and project performance. The "p" below indicates project delivery indicator.

$$Y = \beta 0 + \beta_1 Xi_1 + \beta_2 Xi_2 + \beta_3 Xi_3 + \beta_4 Xi_4 + \beta_5 Xi_5 + \beta_n Xi_n + \epsilon_i$$

$$\begin{aligned} P = \beta 0 &+ \beta_1 \text{ Building information Modelling } + \beta_2 \text{ Internet of Things} \\ &+ \beta_3 \text{ Construction Software's} + \beta_4 \text{ 3D Printing } + \beta_5 \text{ Big Data } + \beta_6 \text{ Big Data} \\ &+ \beta_7 \text{ Laser Scanning } + \beta_8 \text{ 3D Modelling } + \beta_9 \text{ Augmented Reality} \\ &+ \beta_{10} \text{ Virtual Reality } + \beta_{11} \text{Drones } + \beta_{12} \text{ Robots} \\ &+ \beta_{13} \text{ Mobile Computing/Technologies } + \beta_{14} \text{ Cloud computing} \\ &+ \beta_{15} \text{ Radio Frequency Identification } + \epsilon_{i\ -} \end{aligned}$$

3. Data analysis and finding

3.1 Sample adequacy

The study scrutinised the adequacy of the sampling using Kaiser–Meyer–Olkin (KMO) and Bartlett's test of sphericity. Field (2005) opined that a fitting sample ought to have a KMO value greater than 0.5. However, this study produced close to one (0.729 > 0.50). KMO close to one depicts the order of correlation is comparatively compact, and dimension decreasing will produce dependable factors. KMO values between 0.70 and 0.80 are considered good (Field, 2005). Contrastingly, Bartlett's test designates that the samples are interrelated. Bartlett's test of sphericity was conducted to establish if the correlation matrix is not an identity matrix. From the result, the null hypothesis (correlation matrix is not an identity matrix) is rejected at 0.000 < 0.005. This reveals that the correlation matrix is not an identity matrix but tends to exhibit few relationships among the variables. Bartlett's test is, therefore, highly significant.

3.2 Descriptive results on digitalisation and project performance of construction projects

The study first set out to establish the level of adoption of digitalisation of construction firms in the study area. The study extracted 15 constructs from the literature. Mean item score and principal components analysis were used in achieving objective one. The data were analysed descriptively using Mean Item Score (MIS), the study adopted the cut-off point of 3.00 to determine the significance of the problems; the use of this threshold in construction management research is likewise prevalent (Okonkwo *et al.*, 2022). The results in Table 1

Digital tools	Mean score	Rank
Drones	3.68	1st
IoT	3.67	2nd
BIM	3.62	3rd
Cloud computing (Google Drive, Google App Engine, Microsoft Office Live, Google Docs, and Dropbox)	3.59	4th
Mobile Computing/Technologies (smartphones, laptops, tablets and GPS devices)	3.53	5th
Construction Software (Incite, Project Centre, Aconex, Procore)	3.51	6th
Radio Frequency Identification (RFID)	3.49	7th
3D Modelling	3.46	8th
Virtual Reality	3.29	9th
Augmented Reality	2.96	10th
Big Data	2.82	11th
Blockchain	2.68	12th
Laser scanning	2.52	13th
3D printing	2.49	14th
Robots	2.38	15th

Source(s): Courtesy of authors, 2023

Table 1. Digitalisation tool adoption

show the study respondents' perception of the level of adoption of digital tools. The study results showed a high level of adoption on the top five ranked variables. Drones, IoT, BIM, Cloud Computing and Mobile phones were ranked 1st to 5th, respectively. The results show two sections of mean scores: those with scores of 3.29 above and those with 2.96 and below. Digital tools such as drones ranked 1st with a mean score of 3.68, IoT was ranked 2nd with a mean score of 3.67, BIM was ranked 3rd with a mean score of 3.62, cloud computing ranked 4th with a mean score of 3.59, while mobile computing was ranked 5th with a mean score of 3.53. Table 5 also shows a low level of adoption of the blockchain (12th); laser scanning (13th); 3D printing (14th); and robots ranked lowest (15th). Therefore, the top five adopted digital tools in the study area are drones, IoT, BIM, cloud computing, mobile computing and Blockchain, laser scanning, 3D printing and robots are the least adopted digital variables.

The study further examined the performance of construction projects in the study area. The performance indicators utilised in this study are limited to cost, time and quality. In measuring project success, cost, time and quality which are tagged "iron triangle" are critical indicators in measuring project performance. The data gathered from the field survey were analysed using the mean item score. The results show the descriptive perception of the respondents regarding the performance of the construction project executed in the study area. The results show that cost, time and quality achieved a mean score rating of above 3.00. The results show the best performance in terms of cost with a mean score of 3.50. Meanwhile, respondents are satisfied with the performance of construction projects in terms of time (3.48) and quality (3.38), respectively.

3.3 Exploratory factor analysis

The study further deployed exploratory factor analysis (EFA) to reduce the digital tools. EFA produced five principal components. These five factors produced an Eigenvalue greater than the 1.00 benchmark utilized in the analysis (5.832, 1.761, 1.358, 1.217 and 1.018, as shown in Table 2). Ekung *et al.* (2019) reported factors with Eigenvalue greater than 1.00. The 10 factors removed describe only an insignificant proportion of the digital tools adopted by construction firms in the study area. These 10 factors are responsible for an insignificant 24.482% variation in the sample, while 5 factors accounted for 75.52% of the variation in the all-inclusive sample.

Furthermore, the study analysed communality tests. The test was conducted to establish the commonness in the spread of the factors. This finding is significant to denote the number of factors to be extracted and in this situation is five. The five factors are valid since the average of the commonalities' total significance, as shown in Table 2 column two (11.328/15 = 0.75), is greater than 0.70 (Field, 2005). The study, therefore, retained the five factors as suggested by Field (2005). With factors less than 20 and commonalities after extraction greater than 0.70 (0.75), the five factors are retained. The five principal factors can be grouped from 15 digital tools recognised in the literature.

3.4 Principal factor analysis

The study further conducted factor rotation in suppressing loading less to make it easier with the interpretation. The five factors were loaded into a component matrix and scanned through various factor loading to indicate actors with significant loading. Factor one has a score of 0.787, this component relates to mobile computing/technologies (Table 3), the most significant loading in the second factor has a value of 0.805, this component is linked to the IoT. The third factor which is connected to construction software has a score of 0.785. The fourth critical issue relates to BIM has a score of 0.841 and the most significant component under the fifth factor relates to cloud computing (0.837). However, the most critical issue is the fourth factor with a score of 0.841. This study adopted a similar method of reporting principal factor analysis as revealed by Ekung *et al.* (2019).

3.5 The influence of digitalisation on construction project performance

The study adopted multi-linear regression to predict the relationship between digitalisation and project performance. The results presented in Table 4 show multiple correlation

Component	Total	Initial eigenvalues % of variance	Cumulative %
1	5.832	38.887	38.887
2	1.861	11.743	42.030
3	1.400	9.051	51.081
4	1.217	8.111	59.192
5	1.018	6.784	65.976

Note(s): Extraction Method: Principal Component Analysis
Source(s): Courtesy of authors, 2023

Table 2.
Total variance explained

	Components				
	1	2	3	4	5
BIM				0.841	
IoT		0.805			
Construction Software			0.785		
Mobile device	0.787				
Cloud computing					0.837

Note(s): Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization
a. Rotation converged in 18 iterations
Source(s): Courtesy of authors, 2023

Table 3.
Rotated component matrix

coefficient is significant. The "R" illustrate the quality of prediction of time, which in this situation R is 0.526 and signifies a moderate degree of correlation. The R^2 value shown in Table 4 signifies the variation in time, in this case, is 0.277. This implies that the predictors explain about 27.70% of the time performance. The results also denote that digital tools are explainable by only 27.70% of the variation in time performance. The unexplained 72.30% variation in the time performance of construction projects implies that there are other factors associated with time which were not captured in the hypothetical model. The adjusted R^2 is not reliable (0.202 = 20.2%). The finding signifies that the predictor variables recognized in the model contribute poorly or insignificantly to the total regression strength.

The ANOVA table which shows how crucial the regression equation fits the data is presented in Table 5 and established that the regression represents a good fit with an F-value (6.287) $p < 0.000$. This implies that digital tools (predictors) recognized in the model meaningfully predict time (dependent variable). Therefore, the regression model is suitable for the study's data.

Furthermore, the unstandardised beta shown in Table 6 indicates the extent to which the dependent variable differs from the predictor variables when other variables are held constant.

The regression model indicates that all predictor variables have a positive value. The analysis also showed that at a 5% level of significance, only two out of the five factored digital

Model	R	R square	Adjusted R square	Std. error of the estimate
1	0.526[a]	0.277	0.202	0.910

Note(s): a. Predictors: (Constant) factored digital tools
Source(s): Courtesy of authors, 2023

Table 4. Model summary

Model		Sum of squares	Df	Mean square	F	Sig
1	Regression	20.648	5	4.130	6.287	0.000[b]
	Residual	78.821	120	0.657		
	Total	99.468	125			

Note(s): a. Dependent variable: time
b. Predictors: (Constant), factored digital tools
Source(s): Courtesy of authors, 2023

Table 5. Analysis of variance (ANOVA) for time performance

Model		Unstandardized coefficients		Standardized coefficients		
		B	Std. Error	Beta	T	Sig
1	(Constant)	0.984	0.474		2.075	0.040
	BIM	0.041	0.087	0.044	0.470	0.639
	IoT	0.273	0.087	0.270	3.121	0.002
	Construction Software	0.244	0.088	0.248	2.765	0.007
	Mobile device	0.071	0.073	0.087	0.968	0.335
	Cloud computing	0.153	0.079	0.169	1.941	0.055

Note(s): a. Dependent variable: time
Source(s): Courtesy of authors, 2023

Table 6. Co-efficient of Regression for Time regression model

tools are statistically most significant. These include IoT (sig. 0.002) and construction software (sig. 0.007). However, it is not unexpected that these two factored digital tools are significant, this is because delivering construction projects within the scheduled period (time) is a vital asset available to construction firms and professionals. This also implies that these significant digital tools will positively influence the delivery of construction on time. Eliminating time overrun could be achieved by fully adopting these significant digital tools. In order words, BIM, mobile devices and cloud computing are insignificant p(0.639, 0.335 and 0.055 > 0.05).

The multiple linear regression analysis was also performed to predict the cost. The model properties show the multiple correlation coefficient R is significant. The R illustrate the prediction of cost, which in this situation R is 0.502 and this signifies a moderate degree of correlation. The R^2 value shown signifies the total variation in cost and this case is 0.252. This implies that the predictors could explain about 25.20% of the cost and in this case, it is very low. The results also denote that digital tools are explainable by only 25.20% of the variation in cost performance. The unexplained 74.80% variation in the cost performance of construction projects implies that other factors associated with quality were not captured in the hypothetical model. The adjusted "R" square is not reliable (0.192 = 19.20%) since it is below average. The finding signifies that the predictor variables recognized in the model contribute poorly and insignificantly to the total regression strength. Furthermore, the ANOVA results show how crucial the regression equation fits the data. The results established that the regression represents a good fit with an F-value (6.549) $p < 0.000$. This implies that digital tools (predictors) recognized in the model meaningfully predict cost (dependent variable). Therefore, the regression model is suitable for the study's data.

Furthermore, from cost perspective, the unstandardised beta indicated the extent to which the dependent variable differs from the predictor variables when other variables are held constant. The regression model shows no negative values. However, an implication is that increase in the utilisation of digital tools would lead to delivering construction projects within the estimated cost thereby eliminating cost overrun which has been a major problem in construction projects. The analysis further showed that at a 5% level of significance, only three out of the five factored digital tools are statistically most significant. These include BIM (sig. 0.009), construction software (sig. 0.000) and mobile devices (sig. 0.011). However, it is not unexpected that these three factored digital tools are significant, this is because delivering construction projects within the budgeted cost is a vital asset available to construction firms and professionals. This also implies that these significant digital tools will positively influence the delivery of construction projects within budgeted costs. Eliminating cost overrun could be achieved by fully adopting these significant digital tools. In order words, smart connectivity (IoT) and cloud computing are insignificant p (0.608 and 0.316 > 0.05).

Furthermore, multiple linear regression analysis was also performed to predict quality. The model properties show the multiple correlation coefficient R is significant. The "R" illustrate the value of prediction of quality, which in this situation R is 0.663 and this signifies a high degree of correlation. Therefore, the hypothesis model yielded multiple coefficients of determination (R) = 0.663 (66.3%), which shows a moderate correlation between digital tools and quality performance. The R^2 value signifies the total variation in quality, and in this case, is 0.439. This implies that the predictors could explain about 43.9% of quality performance. The results also denote that digital tools are explainable by only 43.9% of the variation in quality performance. The unexplained 56.1% variation in the quality performance of construction projects implies that other factors associated with quality were not captured in the hypothetical model. The adjusted "R" square is reliable (0.398 = 39.8%) although it is below 50%. This result signifies that the predictor variables recognized in the model contribute remarkably to the total regression strength. The ANOVA results show how crucial the regression equation fits the data. The results established that the regression represents a good fit with an F-value (11.506) $p < 0.000$. This implies that digital tools (predictors) recognized in the model meaningfully predict quality (dependent variable). Therefore, the regression model is suitable for the study's data.

The results further showed the unstandardised beta from quality of project delivery perspective, and it indicates the extent to which the dependent variable differs from the predictor variables when other variables are held constant. The regression model indicates that all predictor variables have a positive value. The implication is that an increase in utilisation/adoption of digitalisation would lead to an increase in quality performance. The analysis also showed that at a 5% level of significance, only four out of the five factored digital tools are statistically most significant. These include BIM (sig. 0.044), IoT (sig. 0.000), construction software (sig. 0.028) and cloud computing (sig. 0.006). However, it is not unexpected that these four factored digital tools are significant, this is because delivering construction projects within specific standards and quality is a vital asset available to construction firms and professionals. This also implies that these significant digital tools will positively influence the quality of delivery of construction projects. Therefore, effective quality could be achieved by fully adopting these significant digital tools.

3.6 Discussions

The study shows high application of the adoption of drones, IoT and BIM in the CI. Hossain and Nadeem (2019) asserted that BIM, drones and IoT are the current technologies in the CI. This reinforces the global acceptability of the use of these digital tools. The usage of drones in business operations has given numerous sectors a new lease on life. This explains why drones were well embraced and came in first with a mean score of 3.68. Real-time data is provided by merging drones with IoT. The IoT provides networks that are accessible and linked to different platforms (Ikuabe *et al.*, 2020). BIM is a standard for sharing information and communication among project stakeholders and participants. An increase in the adoption of digitalisation offers many benefits such as increased production and productivity. From a perspective of PD, construction projects performed very well as cost, time and quality indicators performed above the mean score of 3.00. Meshram *et al.* (2020) asserted construction projects would be delivered within the project duration, within the estimated budget.

The influence of digitalisation routes on the cost performance of construction projects in the study area is generally very weak, despite having a significant correlation ($r = 0.502$, r2 = 0.252). Digital tools such as BIM, construction software and cloud computing are statistically significant because they are likely to influence the cost. The digitalisation of the construction industry offers timesaving, enhanced quality and increased speed of work in construction PD will be achieved. The finding of the study shows digitalisation influences time performance with an (F-value of 6.287 $p < 0.000$). In terms of quality performance, digitalisation has a moderate relationship with the quality of PD indicators with a significant correlation ($r = 0.663$, $r^2 = 0.643$). However, reducing errors and increasing operational efficiency leads to a higher quality of PD using digitalisation (Alashwal and Al-Ghassani, 2020; Wang *et al.*, 2021).

4. Conclusion

Developing nations like Nigeria are lagging in their response to digitalisation due to low levels of awareness and adoption. For the CI in Nigeria to benefit from digitalisation, the industry must examine the level of usage. This study explored the level of adoption of digitalisation and established the influence of digitalisation on construction project performance in Abuja, Nigeria. The critical finding of the study ranked drones, IoT and BIM as the top three most adopted digital tools in the study area. From a project performance perspective, the study limited performance indicators to cost, time and quality. The finding of the study shows the best performance in terms of cost, and respondents are satisfied with the performance of construction projects in terms of time and quality. The study shows digitalisation has a weak influence over time and cost performance. Integrating digitalisation will increase costs, as digital tools are expensive and require specific skills to operate. Digitalisation has a moderate and significant influence on quality performance. This implies that adequate digitalisation would eliminate time overrun and standardisation of quality products. Stakeholders must produce a roadmap for expediting the uptake of related technologies in construction organisations.

The extended knowledge of digitalisation and construction project performance could assist construction firms and professionals to improve performance. Digitalisation and construction project performance are interdependent, and stakeholders must collaborate to produce an action plan for digitalisation in construction. The study focused on digitalisation adoption in Abuja, Nigeria, and does not represent all construction firms in Nigeria. Further studies should take into consideration construction firms based on SMEs in major cities in Nigeria. The result is limited by the subjective nature of its data which was collected based on an ordinal level of measurement. These effects could be explained by the low 'R-value', which is not significantly greater than the average (0.663). The result of the study can be improved by using a similar approach with an alternate data strategy (pure quantitative data). Therefore, future studies could investigate these areas. The digitalisation of construction PD has significant implications for both research and practice in the construction industry. It can improve efficiency, reduce costs and increase collaboration. New digital technologies such as BIM, VR and AR can improve project visualisation, project management and reduce errors. However, additional training and education are needed for workers to adopt these technologies.

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