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Assessing the use of ICT systems and their impact on construction project performance in the Nigerian construction industry

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Abstract

Purpose – The use of information and communication technology (ICT) for business processes has witnessed exponential growth over the past two decades. This paper aims to explore the level of use of ICT infrastructure in the Nigerian construction industry and analyse the implications for construction management practice.

Design/methodology/approach – Using quantitative questionnaire survey, data from 148 respondents were analysed with the help of descriptive and inferential statistics as well as multiple regression analysis.

Findings – Findings establish project managers, site managers and quantity surveyors as the primary users of ICT with regards to the variety of ICT devices in the Nigerian construction industry, while the foremen are the least users. Besides, word processing/accounting systems, electronic communication systems and project management systems are the three top rated in terms of frequency of use, while quality as well as cost impacts of ICT infrastructure use are established as the most important factors contributing to overall project performance.

Originality/value – The study establishes causal relationships between ICT infrastructure use and project performance within the context of Nigeria's construction industry.

Keywords Construction project management, ICT, Information and communication technologies, Nigeria, Regression model, Modeling, Level of use, Project delivery

Paper type Research paper

1. Introduction

The use of information and communication technology (ICT) also known as information technology (IT) in the construction industry is becoming indispensable in such areas as design, project planning and scheduling, cost control and budgeting, computer-aided facilities management, among others, thus creating many opportunities for a more efficient and effective project execution within the industry. While studies on ICT in the construction industry have focused on diffusion of ICT (Samuelson, 2008), contextual influences on its application and use (Croker and Rowlinson, 2007; Jacobsson and

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Linderoth, 2010), others have examined the concept from the perspective of industrialised countries like USA (Adriaanse *et al.*, 2010), Canada (Rivard, 2000; Rivard *et al.*, 2004), Sweden (Jacobsson and Linderoth, 2012) and Asia (Yang, 2007; Yang *et al.*, 2012; Kang *et al.*, 2013). Several other studies have been reported on the use and impact of IT on firm's performance in the construction industry (Lee, 2002; Seungki, 2003; Santhanam, 2003; El-Mashaleh *et al.*, 2006; Aldhmour and Shannak, 2009; Gaith *et al.*, 2009) and on project performance (Kang *et al.*, 2006; Rasli *et al.*, 2011). Despite this extensive research across countries, there are only a few studies that have been carried out from the perspective of developing countries such as Nigeria. This study argues that research on ICT in the construction industry within the context of developing countries can potentially provide several new insights. The reason being that what might be considered by an organisation as major challenges to the adoption and use of ICT in a developing economy like Nigeria could be clearly different from that in a developed economy like UK where the ICT industry are already matured with different regulatory framework and cultural constraints. As with other developed and developing nations, construction is vital to Nigeria's economic development which is why it produces nearly 70 per cent of the nation's fixed capital formation and accounts for 1.4 per cent of the country's gross domestic product (GDP) (VETIVA, 2011, World Bank, 2013). Nigeria is the most populous nation in Africa, with a young population of 140 million by the 2006 population census (National Population Commission, 2006) and presently an estimated 160 million based on 2006 projection of 2.3 per cent annual growth rate. The country's economy had a GDP growth of 7.37 per cent in the third quarter of 2012 (World Bank, 2013), while its GDP is now the largest in sub-Saharan Africa (ahead of South Africa). Though Nigeria is an oil-producing country, 2012 statistics show that agriculture (42.62 per cent) is the largest contributor to GDP, followed by trading (18.81 per cent), services (16.7 per cent) and crude oil, petroleum and gas (13.42 per cent). In the third quarter of 2012, the annual contribution of telecommunications (including postal communication) to GDP was estimated at 6.73 per cent (National Bureau of Statistics, 2012). A research fully devoted to how the use of ICT is making impact on construction activities in Nigeria will serve as benchmark for comparison with other parts of the globe and also instil confidence on the desire to achieve project success in the construction industry.

It is reported that the adoption and usage of ICT in Nigeria's construction sector have been slow and sluggish. While this may presently not be the case, we argue that studies on ICT have mainly been on impact of ICT on professionals and the industry (Oyediran and Odusanmi, 2005; Oladapo, 2006, 2007) with none on its impact on project performance. Oladapo (2007), in particular, assessed the use and impact of ICT in Nigeria's construction industry and revealed the most significant determinant of the level of ICT as the attitude of CEOs/senior managers to benefits of the technology, while the three top benefits were "improved quality of work", "makes complex tasks easier to perform" and "saves time". While the outcome of the research and others have provided interesting insights on the use of ICT in Nigeria's construction industry, this present study extends that body of knowledge by providing more detailed investigation into the level of use of ICT, its impact on construction project performance and implication for construction management practice in general. To the best of our knowledge, such contribution has not been made before. Knowledge of perceived impact of ICT on project performance is vital to establish clear relationship between attributes of ICT infrastructure use and overall project performance. This can potentially enhance future deployment of ICT within the industry and provide decision makers with rational empirical results that could exacerbate the effectiveness of ICT in the construction industry. Besides, by studying impact of ICT usage on overall project performance and difference in perception across different occupational groups such as consultants/contractors, an enhanced understanding of the diffusion of ICT and improvement on the general benefits flowing from its use within the Nigerian construction industry could be achieved.

Given the background above, the overall aim of this research is to explore the level of use of ICT infrastructure in the Nigerian construction industry and analyse the implications for construction management practice. The specific objectives are to examine the general level of use of IT services by professionals in the Nigeria's construction industry, examine the impact of ICT infrastructure use on overall project performance using factor analysis and regression modeling and test two hypotheses on difference in perception among respondents on the use and impact of ICT on project performance using Kruskal–Wallis and Mann–Whitney U-tests. A quantitative questionnaire survey approach is proposed to analyse data from practising consulting and contracting companies in three Nigeria's strategic cities of Lagos, Port Harcourt and Abuja.

2. Literature review

2.1 Information and communication technology in the construction industry

ICTs are implanted in networks and services that affect the flow of information which may cover internet service provisions, telecommunications and broadcasting, libraries and documentation centres, commercial information providers, network-based information services and other related information and communication activities. Blurton (1999) defines ICTs as a diverse set of technological tools and resources used to communicate and create, disseminate, store and manage information. In this study, ICT is defined as the application of decision support tools, which uses electronic machines and programs for processing, storage, analysis, control, transfer and presentation of construction information data during the whole life of a construction project (El-Ghandour and Al-Hussein, 2004).

Over the decades, the traditional means of communication, for example, face-to-face meetings and exchange of paper documents in form of technical drawings, specifications and site instructions have restrained the application of ICTs in the construction industry. In recent times, the shift from traditional paper-based to digital-based information has greatly enhanced the deployment of ICT in construction projects. Construction project development is faced with increased specialisation, cost demands and technical complexity which require effective information and communication exchange to achieve end results (Wong and Sloan, 2004). The mutual nature of construction activities necessitates the timely transfer of relevant information among the multidisciplinary project teams to realise project objectives. This information exchange can be accomplished through specification of the resulting product, which is regarded as design information, and the initiation and control of activities required for constructing the facility known as management information (Rivard *et al.*, 2004). The advancements in ICTs have recorded tremendous impact in the methods of practice of all construction activities including procurement, schedule, tendering and other on-site activities.

Numerous ICT-based methods have been developed to facilitate best performance in construction. These methods include computer-aided drafting (CAD), spreadsheet and word processors, building information modelling (BIM), Internet software and e-procurement. CAD systems provide drawing entities with powerful construction, editing and database techniques to provide drawings and models of what buildings would look like when completed (Dace, 2007). Spreadsheet and word processors are used as office tools to process information. BIM software is used to show the concepts of design in a form which represents physical and real images of the building (Dace, 2007). BIM can be applied to visual illustration, assistance, planning/utilisation, scheduling/ sequencing, cost estimating, integration of subcontractor and supplier models, systems coordination, layout and fieldwork, prefabrication, operations and maintenance. E-procurement in construction involves the use of internet to transact businesses relating to completion of a project.

Several other studies have documented and analysed the use of ICT devices in real-time construction projects (Taylor, 2007; Hewage *et al.*, 2008). The general submission from these studies is that even though ICT is claimed to have recognisable potential in the industry, its use and diffusion is still very limited. According to Jacobsson and Linderoth (2010), this is perhaps attributable to the fragmented nature of the industry and apparent lack of integration between design and construction processes, the industry spending more time on technical matters while at the same time overlooking the organisational context and the interests of various professional groups when dealing with problems of existing ICT solutions and the setting of different sets of principles, rules, knowledge domains for different professional groups leading to difficulties in coordination and cooperation. Although Adriaanse *et al.* (2010) are of the view that potential benefits of ICT applications in the future can only be realised when mechanisms influencing the use of ICT applications are well understood and solutions found to eliminate potential barriers, it is worth stating that the use of ICT devices has provided innovative companies particularly in Nigeria's construction sector with new opportunities for fostering the process of collaboration, coordination, communication and information.

The review above indicate that the ICT devices commonly in use in construction sector are under word processing and accounting systems, costing and estimating systems, project management software and budgeting and cost monitoring systems. Others include electronic communication systems such as the use of emailing, videoconferencing and Web camera; design software such as architectural and engineering design tools, quality management systems (QMS); and environmental systems. What is however unclear is the extent of usage of these devices among construction professionals within the industry in Nigeria.

2.2 Impact of information and communication technology usage on project performance

A number of studies have investigated the impact of ICT usage on construction project performance. Recently, Kang *et al.* (2013) investigated the indirect impact of IT use via best practice on construction project performance and revealed a direct impact of 3D CAD use on project cost growth, meaning that it has negative impact on cost performance. O'Connor and Yang (2004) had earlier investigated associations between project success and technology usage at project and phase levels. Their findings suggest that several technologies contribute to project cost and schedule success, although for certain types of projects. Yang (2007) explored the links between technology usage and project outcomes and discovered that data/information-intensive and management work function characteristics may greatly influence the cost and schedule performance of a project. Kang *et al.* (2008) found that IT use enhances schedule performance while its impact on cost performance is relatively weak. Additionally, while Thomas *et al.* (2004) found a positive impact of ICT on safety performance, El-Mashaleh (2007) found no such impact. In a study by Rasli *et al.* (2011) on the effects of IT infrastructure capability on project performance in the Malaysia construction industry, factor analysis, impact ratio and correlation analysis were used to investigate the relationship between IT infrastructure capability and project performance. In it, five constructs of IT infrastructure, namely, IT integration capability, IT collaboration capability, IT data management capability, IT security and IT utility capability, and four constructs of project performance, namely, project time, project cost, project scope and project quality were subjected to Pearson correlation analysis. All the five constructs of IT were significantly and positively correlated with the four constructs of project performance (cost, time, quality and scope). Several other studies have indicated positive impact of ICTs usage in improving coordination processes, completion time of tasks and operations, enhancing collaboration level, facilitating accessibility and improving effect of costs, scheduling and quality of construction projects in developed countries (Thomas *et al.*, 2004; Yang, 2007).

A close examination of these studies shows that while there are significant positive impacts of ICT usage on many of the project performance indicators, the reported benefits are clearly inconsistent. Researchers such as Devaraj and Kohli (2003) have adduced reasons for the inconsistent results to be among others mismanagement of IT, sample size and data source issues and choice of dependent variables. With regards to the choice of dependent variables, this study specifically focuses on one dependent variable of "overall project performance". It is to measure the overall performance of projects in terms of time, cost, quality, schedule and client satisfaction. It is important to point out that while multiple sets of indicators are widely preferred for measuring latent variables, it has been argued that single-item observable variables can be used if there are no significant disagreement over meaning of the variable and that it is distinct and easily understood (Hair *et al.*, 2010). Respondents are asked to rate the overall performance of their projects as a result of ICT usage. The questions were very straight forward, closed ended and free of any ambiguity.

2.3 An overview of information and communication technology usage in the Nigeria construction industry

The concept of ICT usage in the context of Nigeria's construction industry has generated guided optimism over the past decades among researchers and practitioners. This is mainly attributable to massive infrastructure challenges facing all sectors of the economy. However, several studies have highlighted the pace at which it is making impact on the activities in the sector. In one of the earliest studies, Achuenu (1999) investigated the use of computer applications in the Building industry using two cities of Abuja and Jos in Nigeria and discovered that the overall average percentage of computer applications in executing construction management jobs in Nigeria is 62 per cent. The result also indicated that the larger multinational construction companies possess, the more likelihood of using computer applications. Although the study made useful insights, it can hardly be generalised for the Nigerian construction industry, as it surveyed only construction companies leaving out consultants who are also viable stakeholders in the industry. In another study by Oladapo (2006), research was carried out to assess the impact of ICT on architectural, engineering and quantity surveying practices in the Nigeria's construction industry. Findings from the study revealed that the three main areas of impact are making jobs easier for the profession, facilitating decision-making and savings in operational costs in that order. The results also indicate a high level of computerization of professional services among firms (99.1 per cent) used for the survey, while power supply is the main obstacle to the diffusion of ICT in the Nigeria's construction industry according to the findings. Oyediran and Odusanmi (2005) investigated the level of computer usage among Nigerian quantity surveyors and revealed a high level of IT literacy among the professionals. Oladapo (2007) however assessed the level of ICT usage using questionnaire survey of CEOs and senior managers of construction and consulting companies as well as research institutions. Findings from the study revealed that the level of use of computers is very high with architects leading in the computerization of design, quantity surveyors leading in the costing software and contractors leading in accounting and work scheduling. Najimu (2011) assessed the level of adoption of e-business practices by Nigerian construction contractors and discovered that there is less than 40 per cent adoption in all areas investigated.

While these studies have provided useful insights into the level of ICT usage in Nigeria's construction industry, none have investigated perceived impacts of the ICT usage on overall project performance, and what the perceived impacts mean in practice. For instance, are there any underlying relationships in the attributes of ICT infrastructure usage impacts? If yes, which factor(s) significantly predict overall project performance? Besides, there is the need to conduct agreement analysis across various occupational groups to establish the degree of agreement or disagreement among respondents to strengthen validity of the research. This was not done in previous studies.

3. Research methods

3.1 Data collection

Data for this study were collected through a structured questionnaire. It involved a field survey in which numerical list of firms was drawn from the population of construction companies registered with the Federation of Construction Industry and practicing consulting firms drawn from the register of Nigeria's corporate affairs commission. Using systematic random sampling and based on the result of tossing a coin, the selection was commenced with the first number in the arithmetic progression of odd numbers (Aibinu and Jagboro, 2002). It was adopted for this study because according to Leedy (1980) and Udofia (2011), it is the most appropriate technique when the issue of bias is likely to affect outcome of the result. This way, 240 consisting of 84 consultancy and 156 construction contracting companies were selected for the survey.

Target respondents were mainly experienced consultants, construction and project managers as well as other stakeholders who have participated in the execution of both commercial and public infrastructure projects that involved deployment of ICT infrastructure in their execution. In other words, they are stakeholders with requisite experience in the use of ICT in their organisations and are all affiliated to their professional bodies. Such specific bodies include Council of Registered Builders of Nigeria, Architects Registration Council of Nigeria, Quantity Surveyors Registration Council of Nigeria and Council of Registered Engineers of Nigeria. The practitioners were from firms located in three strategic cities of Port Harcourt in the south – south geopolitical zone of Nigeria and home of major oil multinationals in the country, Lagos in the south-west and former capital of Nigeria, and Abuja, the current capital and construction hub of the country at the moment.

The process of questionnaire development and administration involved three steps. First, a draft copy of the questionnaire was developed, pilot-tested through interviews with select group of experts and senior practitioners in the construction industry before it was revised based on the outcome of the content validity process. The content validity was carried out to ensure that questions are clear, relevant and free of any ambiguity, as suggested by Saunders *et al.* (2009) if a good response rate is to be achieved. To ensure a good response rate and to ensure ethical considerations are met, an introductory letter was first sent to the organisations to indicate their willingness to participate in the survey and nominate a respondent with requisite knowledge about the use of ICT, and capable of providing useful and reliable information. This means that views of respondents represent the general view of the companies they represent. Interestingly, all the 240 organisations responded to this request. Respondents were given three weeks to complete the questionnaire, while an additional one week was extended to those who did not respond within the period. However, 148 returned valid responses representing a response rate of 62 per cent.

3.2 Measures

The questionnaire was in four parts. Part 1 sought background information about respondents, while respondents were asked to indicate the frequency of use of ten ICT services using a five-point Likert scale of 1 = never used, 2 = used very rarely, 3= used rarely, 4 = used frequently, 5 = used very frequently in Part 2. Part 3 asked respondents to rate the degree to which the use of ICT infrastructure has impacted on effective execution of projects in their organisations using a five-point Likert scale of 1 = totally disagree, 2 = disagree, 3 = somehow agree, 4 = agree, 5 = totally agree. Part 4 asked respondents to rate perceived impact of ICT use on overall project performance using a five-point Likert scale of 1 = very poor, 2 = poor, 3 = somehow successful, 4 = successful, 5 = very successful. It is important to add that the five-point scale used for all measures in this study did not include a neutral response category and is considered appropriate if respondents have knowledge and experience about the concept under investigation (Shiu *et al.*, 2009) which is the case in this study.

3.3 Variables

In an effort to achieve the objectives of the study and to reflect theme of the research problem, two major categories of variables, namely, ICT services and ICT infrastructure use impacts were selected after pilot-testing, while a single point dependent variable of overall project performance was used for the study. They are presented below (Tables I and II).

Code	ICT services
IS01	Word processing/accounting systems
IS02	Costing/estimating software
IS03	Project management systems
IS04	Budgeting/cost monitoring systems
IS05	Electronic communication systems
IS06	Design software systems
IS07	Quality management systems
IS08	Environmental management systems
IS09	Resource tracking systems
IS10	Purchasing and tendering systems

Table I. ICT services constructs

Code	ICT infrastructure use impacts
Independent variables	
IU01	It has enabled good and quality communication of ICT services across staff to share software and other data resources
IU02	It has enabled my company to improve faster coordination through group working and knowledge sharing with other stakeholders in Nigeria's construction industry
IU03	It has enabled us to put in place policies, procedures and technical measures to prevent unauthorised access, theft or physical damage to our information systems
IU04	It has made quality of my work become much higher
IU05	It has helped me to make decisions that reduces the company's costs
IU06	It has helped me to make decisions that positively affect quality of our products and processes
IU07	Use of ICT systems has led to less errors and misunderstanding
IU08	It has helped me to make decisions that reduce the company's environmental impacts
IU09	It has enabled my company to incorporate components of sustainable construction practices thereby reducing our carbon foot prints
IU10	Too much communication and information flow through computers has provided multimedia support through videoconferencing
IU11	In my workplace, use of ICT has increased and made my work faster in accordance with project time schedule
IU12	Use of ICT in my company has increased use of IT vendors thereby allowing us to leverage on vendors' cost-efficient systems
IU13	Use of ICT at my workplace has bolstered confidence in the general application of ICT devices
Dependent variable	
PP01	Overall project performance

Table II. ICT infrastructure use impact constructs

3.4 Data analysis

Data collected were analysed in three main steps. *First*, demographics of respondents were analysed using basic descriptive statistics such as frequency counts and percentages. *Second*, to analyse the frequency of use of ICT applications by respondents, the approach used by Jacobsson and Linderoth (2012) was adopted. In it, the frequency of use was divided into three categories in which + = high frequency (mean value > 3.5); 0 = medium frequency (2.5 < mean value < 3.5); and − = low frequency (mean value < 3.5), while an overall mean of frequency of use for each system was computed and ranked. *Third*, to examine impact of ICT use reflected in the general attitudes towards ICT use, relative importance index (RII) of items' ratings for each group of respondents (consultants and contractors) was computed and ranked, while weighted average of each item for all groups was also computed and ranked to represent perception of the groups. Scores entered by respondents were transformed into RII values using equation (1):

$$RII = \frac{\sum w}{AN} \tag{1}$$

Where w is the weighting allocated to each factor by respondents which ranges from 1 to 5, A is the highest weight (5 for this study), N is the total number of respondents (148 in this study), and RII is the relative importance index. The same approach was used in similar studies of Aibinu and Jagboro (2002), Cheung *et al.* (2004), Iyer and Jha (2005) and Ugwu and Haupt (2007).

Thereafter, factor analysis was performed to reduce the 13 items to a smaller number of latent factors before multiple regression analysis (MRA) using the stepwise method was performed to explore the relative influence of the factors extracted from factor analysis on overall project performance (Chan *et al.*, 2001; Lam *et al.*, 2008). Chan *et al.* (2001) for example used stepwise regression analysis to examine influence of six extracted factors from 31 independent variables on overall project performance, while Lam *et al.* (2008) used MRA to examine influence of 12 extracted project success factors from 42 independent variables on single dependent variable of project success index.

Prior to analysis, Cronbach's alpha (α) was used to examine the internal consistency of the constructs under the headings of the ICT services and ICT infrastructure impacts. Alpha values greater than 0.7 are regarded as sufficient (Pallant, 2010). The results of the consistency test for the survey were in the range of $0.78 < \alpha < 0.877$ providing evidence that all factors have high internal consistency and therefore are reliable. However, before conducting factor analysis and MRA, all variables under ICT infrastructure impacts and overall project performance were examined for potential outlier and normality. For the independent variables (ICT infrastructure impacts), the standardised scores of all cases were within an acceptable range of $\pm$ 2.54 at $p < 0.01$, two-tailed test meaning that no univariate outlier was found. Normality of all the 13 attributes was checked by significant test for skewness and kurtosis. According to Chan *et al.* (2001), the observed values of skewness and kurtosis should be tested against null hypothesis of zero because values of skewness and kurtosis are zero when a distribution is normal. The test statistics result for skewness and kurtosis were within an acceptable range as most of the values are close to zero at $p < 0.01$, two-tailed test with the exception of variable IU08 with a kurtosis value of 1.223 (Table X), meaning that they are normally distributed. For the dependent variable, the standardised score was within $\pm$ 2.94 at $p <$ 0.01 indicating that no case of univariate outlier was found while the skewness and kurtosis values were reasonable acceptable.

3.5 Research hypotheses

Two hypotheses were postulated for the third objective of this study. The first states that the perception of *consultants* on ICT infrastructure use impacts *and* the impact of

ICT infrastructure use on construction project performance is not significantly different from perception of *contractors*. The second states that there is no significant difference in perception on ICT infrastructure use impact factors *and* impact of ICT infrastructure use on construction project performance when respondents are divided into natural groups (such as location, job description, years of experience and professional affiliation). The first hypothesis was analysed using Mann–Whitney U-test, while the second was analysed using Kruskal–Wallis analysis of variance (ANOVA).

3.6 Sample characteristics

Majority of respondents (64.9 per cent) were from the construction companies, while 52 were from the consultancy firms. They all hold managerial positions ranging from top level managers (33.8 per cent), through middle level managers (56.1 per cent), to low level managers (10.1 per cent). In terms of job description, they were almost evenly spread across the seven groups used for the survey. For instance, 35 were project managers, 24 were architects, 23 were quantity surveyors, while 22 were engineers. Others include administrative managers (17), site managers (15) and foremen (12). A cross-tabulation of job description against type of organisation (Table III) shows that most of the architects and engineers were representatives of the consulting companies, while most of the project managers, administrative managers and quantity surveyors were representatives of the construction companies. All site managers and foremen were from the construction companies. It is also instructive to observe that over 80 per cent of respondents had more than 10 years working experience in their jobs, while 61.5 and 38.5 per cent saw their degree of computer literacy and knowledge of ICT as high and very high, respectively. In terms of location, 41.2 per cent responded from Lagos, 35.8 per cent responded from Port Harcourt, while 23 per cent responded from Abuja, the capital.

4. Results and discussion

4.1 General usage of information and communication technology services

To explore the level of use of ICT services in the construction industry, respondents were asked to rate the frequency of use of ten ICT systems/devices using a five-point scale of 1 = never used, 2 = used rarely to 5 = used very frequently. The result of analysis is presented in Table IV.

It shows that project managers, site managers and quantity surveyors were the primary users of ICT with regards to the variety of ICT devices in the construction industry, while the foremen were the least users. In terms of specific ICT device or system, word processing/accounting systems received the highest frequency of use rating across all the groups. This is followed by electronic communication systems and project management systems in that order. Resource tracking systems as well as purchasing and tendering systems received significantly low ratings among all respondents. Besides, the result also indicates that administrative managers were the highest users of word processing/accounting systems; quantity surveyors were the highest users of cost/estimating software, project management systems and budgeting/cost monitoring devices; and architects were the prime users of electronic communication systems and design software systems. It is also discovered that QMS and environmental management systems (EMS) received impressive frequency of use rating among respondents.

Table III.
Cross-tabulation result of type of organisation against job description

Type of organisation	Project manager	Administrative manager	Site manager	Engineer	Architect	Quantity surveyor	Foreman	Total
Consultancy	10	3	0	14	14	11	0	52
Construction contracting	25	14	15	8	10	12	12	96
Total	35	17	15	22	24	23	12	148

Table IV. Result of groups' use of ICT systems

Code	ICT services/ professional groups	Project manager	Administrative manager	Site manager	Engineer	Architect	Quantity surveyor	Foreman	Av. mean	Rank
IS01	Word processing/accounting systems	4.22 (+)	4.47 (+)	4.20 (+)	4.43 (+)	4.29 (+)	4.39 (+)	4.00 (+)	4.30	1
IS02	Costing/estimating software	3.63 (+)	3.59 (+)	3.53 (+)	2.90 (0)	2.75 (0)	4.35 (+)	3.31 (0)	3.45	4
IS03	Project management systems	4.20 (+)	3.88 (+)	4.13 (+)	3.86 (+)	3.79 (+)	4.39 (+)	4.15 (+)	4.07	3
IS04	Budgeting/cost monitoring systems	3.83 (+)	3.23 (0)	3.53 (+)	2.71 (0)	2.96 (0)	3.87 (+)	3.15 (0)	3.38	5
IS05	Electronic communication systems	4.31 (+)	3.88 (+)	4.20 (+)	4.19 (+)	4.38 (+)	4.00 (+)	4.23 (+)	4.19	2
IS06	Design software systems	3.11 (0)	2.88 (0)	2.67 (0)	4.33 (+)	4.42 (+)	2.43 (−)	3.15 (0)	3.32	6
IS07	Quality management systems	3.31 (0)	3.00 (0)	2.93 (0)	2.90 (0)	3.00 (0)	3.00 (0)	2.77 (0)	3.03	7
IS08	Environmental management systems	3.14 (0)	2.82 (0)	2.80 (0)	2.71 (0)	2.83 (0)	3.09 (0)	2.77 (0)	2.92	8
IS09	Resource tracking systems	1.83 (−)	1.65 (−)	1.67 (−)	1.76 (−)	2.13 (−)	1.91 (−)	1.43 (−)	1.61	10
IS10	Purchasing and tendering systems	1.74 (−)	2.00 (−)	1.47 (−)	1.86 (−)	2.04 (−)	2.26 (−)	1.08 (−)	1.83	9

Notes: (+) Implies high frequency of use; (0) implies moderate frequency of use; (−) implies low frequency of use; and Av. implies average

4.2 Impact of information and communication technology infrastructure use

To first empirically examine impact of ICT use reflected in the general attitudes towards ICT use, respondents were asked to rate the degree to which the use of ICT infrastructure has impacted on effective execution of projects using a five-point scale of 1 = totally disagree to 5 = totally agree. Table V shows the RII and rankings of items' ratings for each group of respondents (consultants and contractors) and the overall RII and rankings for all groups taken together.

Based on the ranking (R) of the weighted average RII for the two groups, "It has made quality of my work become much higher" (RII = 0.870), "Enhanced good and quality communication of ICT services across staff" (RII = 0.846) and "It has helped me to make decisions that positively affect quality of our products and processes" (RII = 0.841) were the top three rated. Besides, "Use of ICT systems has led to less errors and misunderstanding" (RII = 0.636), "Provided multimedia support through videoconferencing" (RII = 0.632) and "Use of ICT has increased and made my work faster in accordance with project time schedule" (RII = 0.562) were the three least rated factors.

Factor analysis was then performed to determine the nature of underlying relationships among the 13 ICT impact factors using Varimax rotation. According to Norusis (1993), it comprises a two-stage process of factor extraction and factor rotation. Factor extraction determines the factors through principal component analysis, while at the second stage, factor rotation eliminates medium loadings by maximizing the number of high and low loadings to make factor interpretation more accurate (Udofia, 2011). The result of factor analysis for the 13 independent variables is presented in Table VI.

The Kaiser–Meyer–Olkin which is a measure of sampling adequacy was 0.628 in this analysis, a value greater than the threshold of 0.5 as recommended by Kaiser (1974). Data from Table VI indicate that five components accounting for over 70 per cent of total variance explained were extracted, while both Kaiser's criterion (Eigen value > 1) and percentage of total variance explained > 5 per cent (King, 1969) were met meaning that a model with five factors is considered adequate to represent the data. Result of factor rotation showing factor loadings, the rotated components and naming of the components are presented in Table VII.

It shows that three factors were significantly loaded on Component 1 and named Quality impacts, four factors were significantly loaded on Component 2 and named Time impacts, while two factors were loaded on Component 3 and named Cost impacts. Component 4 is named sustainability impacts as two factors significantly loaded on it, while Component 5 is named security impacts with two factors significantly loaded on it.

To explore the relative influence of the factors extracted from factor analysis on overall project performance, a stepwise MRA was performed between overall project performance of construction projects as the dependent variable and the five extracted impact factors from factor analysis as the independent variables. MRA is a statistical technique used to analyse the relationship between a single dependent variable (overall project performance) and several independent variables (five extracted impact factors). This is done through a process of formulating a mathematical equation that represents the behaviour of the phenomenon being investigated. Therefore, to compare across regression equations involving different number of independent variables, the adjusted

Code	ICT use impacts	Consultants RII	R	Contractors RII	R	All groups RII	R
IU01	Enhanced good and quality communication of ICT services across staff	0.846	4	0.847	2	0.846	2
IU02	Enhanced faster coordination through group working and knowledge sharing	0.848	3	0.821	5	0.829	5
IU03	Prevented unauthorised access, theft or physical damage to our IT systems	0.727	8	0.746	9	0.739	9
IU04	It has made quality of my work become much higher	0.858	1	0.877	1	0.870	1
IU05	It has helped me to make decisions that reduces my company's overall costs	0.735	9	0.744	10	0.741	8
IU06	It has helped me to make decisions that positively affect quality of our products and processes	0.842	5	0.839	3	0.841	3
IU07	Use of ICT systems has led to less errors and misunderstanding	0.650	11	0.631	11	0.636	11
IU08	It has helped me to make decisions that reduced my company's environmental impacts	0.792	6	0.765	7	0.774	7
IU09	Enhanced sustainable construction practices thereby reducing our carbon foot prints	0.785	7	0.806	6	0.799	6
IU10	Provided multimedia support through videoconferencing	0.658	10	0.619	12	0.632	12
IU11	Use of ICT has increased and made my work faster in accordance with project time schedule	0.596	13	0.544	13	0.562	13
IU12	Enhanced leveraging on vendors' cost-efficient systems through IT outsourcing	0.598	12	0.748	8	0.695	10
IU13	It has bolstered confidence in the general application of ICT devices	0.854	2	0.825	4	0.835	4

Table V. Relative importance index (RII) and rankings of the 13 ICT impact factors

coefficient of determination (adjusted R^2) is calculated to reflect the goodness of fit of the model (Lam *et al.*, 2008). The regression equation can be expressed as:

$$Y_1 = \beta_0 + \beta_1 X_N + C$$

Where:

- Y = dependent variable;
- X_N = set of independent variables for 1 to N;
- β_1 = regression coefficient;
- β_0 = the intercept; and
- C = residual value which is the difference between actual and predicted values of the dependent variable.

Result of the regression analysis is presented in Table VIII. It shows that standardised coefficients of the five factors were significantly differed from zero at $p \leq 0.001$. Quality

Table VI.
Result of variance explained by the 13 impact factors

Component	Eigenvalue	(%) of variance explained	Cumulative % of variance explained
1	1.817	23.977	23.977
2	1.507	16.593	40.570
3	1.371	15.544	56.114
4	1.252	9.630	65.744
5	1.079	5.301	71.045
6	0.971	4.855	75.900
7	0.912	4.481	80.381
8	0.802	3.841	84.222
9	0.767	3.747	87.969
10	0.745	3.234	91.203
11	0.629	3.167	94.370
12	0.617	2.899	97.269
13	0.420	2.731	100.000

Table VII.
Result of rotated component matrix from principal component analysis

Impact code	Component 1	Component 2	Component 3	Component 4	Component 5
IU01	0.875				
IU04	0.718				
IU06	0.639				
IU02		0.825			
IU07		0.633			
IU10		0.608			
IU11		0.594			
IU05			0.792		
IU12			0.776		
IU08				0.824	
IU09				0.773	
IU03					0.666
IU13					0.601

Table VIII.
Stepwise multiple regression result

Component from factor analysis	Independent variable: (ICT use impact factors)	Standardized coefficients (β)	p-value	Adjusted R^2
1	Quality impacts	0.526	0.000	0.381
3	Cost impacts	0.441	0.000	0.212
4	Sustainability impacts	0.382	0.000	0.104
2	Time impacts	0.307	0.001	0.053
5	Security impacts	0.244	0.001	0.017

Note: Dependent variable: overall project performance impacts contributed most significantly to prediction of overall project performance (adjusted $R^2 = 0.381, p < 0.001$), while cost impacts followed closely with adjusted R^2 of 0.212 at $p < 0.001$. Almost 60 per cent of the overall project performance variance was explained by these two factors, while sustainability impacts, time impacts and security impacts accounted for 10, 5 and 2 per cent of variance in the overall project performance, respectively.

4.3 Hypotheses testing

Mann–Whitney U-test was conducted to test the hypothesis which states that perception of *consultants* on ICT infrastructure use impacts *and* the impact of ICT infrastructure use on construction project performance is not significantly different from perception of *contractors*. Mann–Whitney U-test, a non-parametric test, has the obvious advantage of not possessing restrictive assumptions of normality or homogeneity of variance (Ikediashi *et al.*, 2012). In it, hypothesis is rejected for all p-values less than 0.05 and accepted for all values greater than 0.05. Table IX shows the results which provide the mean rank, sum of ranks, U-value and p-value (which is significant at $p < 0.05$).

The results show that the hypothesis is accepted for 12 of the 13 impact factors ($p > 0.05$) and overall project performance ($0.256 > 0.05$). The hypothesis is however rejected for "enhanced leveraging on vendors' cost effective IT systems" ($0.000 < 0.05$).

Kruskal–Wallis test is a non-parametric technique used to test difference between several independent groups in distributions which are not normally distributed (Pallant, 2010). Based on chi-square distribution, the decision rule for Kruskal–Wallis test statistic is that the null hypothesis is accepted if the significant level presented as asymptotic significance is greater than 0.05 (5 per cent level of significant difference), otherwise the null hypothesis is rejected and alternate hypothesis is accepted. It was used in this study to determine whether the mean of significance of each of the 13 ICT impact factors was equal across the respondents (in terms of job description, professional affiliation, years of experience, etc.). The result of analysis is presented in Table X.

The result indicates that the second hypothesis is accepted for 11 of the 13 impact factors and overall project performance, while it is rejected for "Enhanced good and quality communication of ICT services across staff" ($0.000 < 0.05$) in terms of both professional affiliation and location and "Provided multimedia support through videoconferencing" ($0.040 < 0.05$) in terms of years of experience.

4.4 Discussion

The result on the general level of use of ICT services in the Nigerian construction industry suggests that project managers, site managers and quantity surveyors (predominantly on-the-site managers) were the primary users of ICT with regards to the variety of ICT devices in the construction industry. They received very high mean values on 5 of the 10 devices used for the study, while the foremen were the least users. This is fairly inconsistent with finding of Jacobsson and Linderoth (2012) where it is reported that offsite managers (mainly architects and engineers) are the primary users of ICT systems, while the result tallied with their findings that foremen are the least users of ICT systems in the construction industry. It is worth noting however that this descrepancy may be attributed to the fact that the work of Jacobsson and Linderoth

Factor (both dependent and independent variables)	Type of organisation	Mean rank	Sum of ranks	U-value	$p > 0.05$
Enhanced good and quality communication of ICT services across staff (IU01)	Consultancy	74.35	3866.00	2488.00	0.966
	Contracting	74.58	7160.00		
Enhanced faster coordination through group working and knowledge sharing (IU02)	Consultancy	79.62	4140.00	2230.00	0.228
	Contracting	71.73	6886.00		
Prevented unauthorised access, theft or physical damage to our IT systems (IU03)	Consultancy	71.63	3724.50	2346.50	0.513
	Contracting	76.06	7301.50		
It has made quality of my work become much higher (IU04)	Consultancy	69.33	3605.00	2227.00	0.231
	Contracting	77.30	7421.00		
It has helped me to make decisions that reduces my company's overall costs (IU05)	Consultancy	73.16	3804.50	2426.50	0.767
	Contracting	75.22	7221.50		
It has helped me to make decisions that positively affect quality of our products and processes (IU06)	Consultancy	74.51	3874.50	2945.50	0.998
	Contracting	74.49	7151.50		
Use of ICT systems has led to less errors and misunderstanding (IU07)	Consultancy	78.85	4100.00	2270.00	0.314
	Contracting	72.15	6926.00		
It has helped me to make decisions that reduced my company's environmental impacts (IU08)	Consultancy	79.13	4114.50	2250.50	0.236
	Contracting	71.99	6911.50		
Enhanced sustainable construction practices thereby reducing our carbon foot prints (IU09)	Consultancy	70.19	3650.00	2272.00	0.285
	Contracting	76.83	7376.00		
Provided multimedia support through videoconferencing (IU10)	Consultancy	80.19	4170.00	2200.00	0.189
	Contracting	71.42	6856.00		
Use of ICT has increased and made my work faster in accordance with project time schedule (IU11)	Consultancy	81.23	4224.00	2146.00	0.141
	Contracting	70.85	6802.00		
Enhanced leveraging on vendors' cost-efficient systems through IT outsourcing (IU12)	Consultancy	53.93	2804.50	1426.50	0.000*
	Contracting	85.64	8221.50		
It has bolstered confidence in the general application of ICT devices (IU13)	Consultancy	78.32	4072.50	2297.50	0.369
	Contracting	72.43	6953.50		
Overall project performance (PP01)	Consultancy	79.33	4125.00	2245.00	0.256
	Contracting	71.89	6901.00		

Note: n(constancy) = 52; n(contracting) = 96; p is significant at $p < 0.05$

Table IX.
Mann–Whitney U-test result

(2012) focused on Swedish construction companies, while this present research investigated the concept within the context of consultancy and construction companies in Nigeria. Besides, findings also indicate that word processing/accounting systems are the most used set of ICT devices in the industry. This is consistent with the findings of Achuenu (1999), Oladapo (2007) and Usman and Said (2012) and confirms that the use of ICT in Nigeria's construction industry is still largely dominated by basic ICT

Table X. Results of Kruskal–Wallis and skewness and kurtosis normality tests

Variable	Job description		Professional affiliation		Years of experience		Location		Skewness	Kurtosis
	Chi-square	*p*-value	Chi-square	*p*-value	Chi-square	*p*-value	Chi-square	*p*-value		
Enhanced good and quality communication of ICT services across staff (IU01)	7.452	0.281	10.863	0.028*	2.302	0.512	20.911	0.000*	0.845	−0.113
Enhanced faster coordination through group working and knowledge sharing (IU02)	1.543	0.957	5.615	0.230	3.882	0.275	1.915	0.384	−0.308	−0.065
Prevented unauthorised access, theft or physical damage to our IT systems (IU03)	7.604	0.269	7.732	0.102	2.420	0.490	3.339	0.188	−0.369	0.342
It has made quality of my work become much higher (IU04)	5.532	0.478	3.965	0.411	7.140	0.068	0.343	0.842	−0.494	−0.675
It has helped me to make decisions that reduces my company's overall costs (IU05)	4.496	0.610	0.470	0.976	5.667	0.129	3.780	0.151	−0.075	−0.650
It has helped me to make decisions that positively affect quality of our products and processes (IU06)	6.179	0.403	1.708	0.789	1.892	0.595	1.818	0.403	−0.181	0.565
Use of ICT systems has led to less errors and misunderstanding (IU07)	3.335	0.766	1.095	0.895	2.145	0.543	4.592	0.101	0.117	0.441
It has helped me to make decisions that reduced my company's environmental impacts (IU08)	2.476	0.871	2.100	0.717	7.589	0.055	1.588	0.452	0.530	1.223
Enhanced sustainable construction practices thereby reducing our carbon foot prints (IU09)	3.145	0.790	3.866	0.424	6.419	0.093	5.011	0.082	0.001	0.060
Provided multimedia support through videoconferencing (IU10)	6.553	0.364	2.545	0.637	8.327	0.040*	1.464	0.059	−0.165	0.218
Use of ICT has increased and made my work faster in accordance with project time schedule (IU11)	2.832	0.830	4.877	0.300	6.030	0.110	4.401	0.065	−0.046	−0.584
Enhanced leveraging on vendors' cost-efficient systems through IT outsourcing (IU12)	9.429	0.151	5.014	0.286	2.588	0.460	0.845	0.656	−0.676	0.000
It has bolstered confidence in the general application of ICT devices (IU13)	5.957	0.428	2.713	0.607	2.174	0.537	0.455	0.796	−0.039	2.454
Overall project performance (PP01)	10.884	0.092	0.274	0.991	5.337	0.149	0.105	0.949	−0.110	−0.593

Notes: p is significant at $p < 0.05$; $* = p < 0.05$;

applications such as desktop, laptops, notebooks and pay roll systems. Electronic communication systems and project management systems closely followed at second and third, respectively. There is no gain saying that the increased volume of Internet connectivity and usage in Nigeria has impacted on the use of electronic communication systems in the Nigeria's construction industry. This is because it is used to exchange large volume of data electronically from one office to another and to and from project sites. Such areas include use of emailing, wireless technology devices, intranet and extranet as well as Facebook and Twitter. What is however interesting is the coming of project management systems at the third place. It means that the Nigerian construction industry is beginning to embrace the use of project management software for construction and project management practices. Such devices include MSproject, Primavera Project planner, computer-aided facilities management software and BIM. The finding that administrative managers were the most frequent users of word processing/accounting systems is largely expected. This is because they are responsible for the day-to-day running of the company offices and project sites and as such deploy most of these tools for paper works and salaries. Besides, quantity surveyors were the most frequent users of cost/estimating software, project management systems and budgeting/cost monitoring devices, while architects were the prime users of electronic communication systems and design software systems. A plausible explanation for this is that quantity surveyors are the cost managers and as such use these tools more often to prepare bill of quantities for consultants and cost control monitoring of work for contractors among other duties. Likewise, architects and engineers are responsible for architectural, structural and services design of projects and as such largely deploy design software of many sorts for this purpose.

Findings also reveal that "It has made quality of my work become much higher" with RII = 0.870, "Enhanced good and quality communication of ICT services across staff" with RII = 0.846 and "It has helped me to make decisions that positively affect quality of our products and processes" with RII = 0.841 were the top three rated factors by respondents. It is interesting to note that all the three attributes relate to quality impacts. This is consistent with findings of Jacobsson and Linderoth (2012) who argued that quality is a vital success factor in the construction industry, and ICT is contributing to its development in the sector. While ranking the benefits of using ICT in the Nigerian construction industry, improved quality of work was rated first in the findings of Oladapo (2007). What this implies is that respondents perceive that quality of work (in such areas as easier access to general improved quality of work at the workplace; good and quality communication across staff; and faster decision-making when it comes to quality of project outcomes) has been triggered by increased use of ICT. However, "Use of ICT systems has led to less errors and misunderstanding" (RII = 0.636), "Provided multimedia support through videoconferencing" (RII = 0.632) and "Use of ICT has increased and made my work faster in accordance with project time schedule" (RII = 0.562) were the three least rated factors according to the rating of respondents. The possible interpretation is that although the use of ICT has led to less errors and misunderstanding, respondents do not see it as having significant impact on the management of construction projects; and even though multimedia systems such as videoconferencing is very common in main stream manufacturing and other sectors of the Nigerian economy, it is not popular in the construction sector. What is however surprising is the relatively low importance attached to the fact that ICT has increased and made work faster.

Five underlying factors extracted from principal component analysis were named quality impacts, time impacts, cost impacts, sustainability impacts and security impacts. Project quality is of fundamental concern and significance to clients and managers in the construction industry. The type of measures adopted to ensure conformance to quality at pre, during and post construction stage of projects is therefore extremely important. Time is of great essence in the management of construction projects, and time impact of ICT use involves using ICT systems that match the project resources with project work tasks over (Rasli *et al.*, 2011) with a view to ensuring timely completion of projects. Cost impact of ICT infrastructure use includes such areas as use of cost monitoring mechanisms that will help to drastically reduce project cost overrun to barest minimum. A major concern in the Nigerian construction industry has been the problems of cost and time overrun on account of the growing rate of delays and the impact on the final project sum. An ambitious deployment of ICT has the potential of buffering the impact. Sustainable construction has continued to attract global concern on account of the threat posed by climate change and commonly exacerbated by construction related activities such as carbon dioxide emissions, environmental implication of using building materials and ecological value of the environment. Sustainability impact of ICT use therefore involves the use of EMS, health and safety systems among others. Finally, security is critical in today's insecure world of hacking and other cyber-related fraud. Besides, security impact of ICT use is crucially important in most Nigerian construction sites that are notoriously unsafe, as it will instil security alertness and confidence through the use of mobile phone and internet.

To explore the relative influence of the factors extracted from factor analysis on overall project performance, a stepwise MRA was performed. The multiple regression results indicate that quality impact of ICT use is the most important factor contributing to overall project performance. This is particularly instructive, as it tallied with the outcome of RII analysis in which quality attributes of ICT impact as the most important factors were rated first, second and third by respondents. This has profound practical implications. It shows that ICT is making considerable impact on quality of construction project delivery in Nigeria, and that despite the enormous challenges faced in the Nigeria's construction industry, there is potential for continuous development and deployment of ICT in the industry. As indicated by the regression findings, cost impacts of ICT use were found to be the second key factor contributing to overall project performance. Given the huge interest generated by researchers and practitioners on the concept of how to manage project cost, the significance of ICT as a worthy means of combating project cost control has been confirmed in this research. However, this contradicts the finding of Oladapo (2007) which ranked cost saving as a benefit of ICT in the Nigerian construction industry sixth of seven factors. One way of explaining this is that the time difference between this current research and that of Oladapo (2007) is seven years. It is possible that respondents' knowledge and usage of ICT have tremendously changed over the period. Although the significance of the other three factors (sustainability impact, time impact and security impact) was found to be much lower that quality and cost impacts, their influence on overall project performance should never be ignored.

Results of the study reveal that the first hypothesis is accepted for 12 of 13 impact factors. This implies that respondents when grouped under consultants and contractors do not see any difference or dissimilarity in their perception of ICT infrastructure use impacts *and* the impact of ICT infrastructure use on construction project performance. The hypothesis is however rejected for "enhanced leveraging on vendors' cost effective IT systems". A plausible explanation for this outcome is that most outsourcing practices are carried out among construction contractors than do the consultancy firms. Therefore, while respondents from contractors may agree that ICT usage has led to leveraging on sub-contractors' cost-effective ICT systems, respondents from consultancy firms may not have shared that opinion. The second hypothesis was accepted for 11 of the 13 impact factors and overall project performance, while it is rejected for "Enhanced good and quality communication of ICT services across staff" in terms of both professional affiliation and location, and "Provided multimedia support through videoconferencing" in terms of years of experience. The reason for this outcome may not be unconnected with the earlier assertion and the fact that different occupational/natural groups may be using different types of ICT systems, while the impact of those devices could depend on how well the systems or devices are supporting their work tasks effectively.

5. Conclusion

Based on a questionnaire survey of 148 respondents, this research explored the level of use of ICT infrastructure in the Nigerian construction industry and analysed its impact on construction project performance. Data collected were analysed using descriptive and inferential statistics, as well as MRA. Mann–Whitney U-test and Kruskal–Wallis ANOVA were used to test the hypotheses postulated for the study.

The study established project managers, site managers and quantity surveyors as the primary users of ICT with regards to the variety of ICT devices in the Nigerian construction industry, while the foremen were the least users. Besides, word processing/accounting systems, electronic communication systems and project management systems were the top three rated in terms of frequency of use, while resource tracking systems as well as purchasing and tendering systems received significantly low ratings among all respondents. The practical implication of this finding is that an improved knowledge of ICT by frontline managers in the construction management practice could potentially enhance full deployment of ICT in the industry especially in Nigeria where there are several potentials of ICT yet to be exploited. The study also established antecedents of quality impacts of ICT use as the overall most important factor and also the most important factor contributing to overall project performance of construction projects. The result has profound practical implications. First, it shows that quality as an important feature of the construction project success factor in satisfying stakeholders is a major motivator for the increased use of ICT. Second, in an apparent response to wide spread notion that the issue of quality of construction projects in Nigeria has led to collapse of structures, colossal waste of both human and material resources, this finding demonstrates the resolve of respondents who are major stakeholders to use ICT to address this trend. Cost impacts of ICT use were found to be the second key factor contributing to overall project performance. This finding affirms what previous studies have shown which indicate that improved use of ICT reduces organisation's net cost of construction projects. The agreement analysis conducted using Mann–Whitney U-test and ANOVA indicates that there was generally good level of agreement across all respondents about what constitutes ICT infrastructure use impacts *and* the impact of ICT infrastructure use on construction project performance.

More is now known as a result of this research about the present state of ICT use in the Nigerian construction industry, which can serve as a basis of comparison with other developing and developed countries. Besides, it has highlighted the key factors and relationships of ICT use that may impact on overall project performance. It is hoped that stakeholders at the strategic levels in the industry will build upon this by encouraging the continuous deployment of ICT systems to make the desired impact on all indicators of construction project performance in the industry.

This research has an obvious limitation. It was carried out using a single-point dependent variable of overall project performance. Future research could be explored using structural equation modelling to examine the impact of ICT use on project performance operationalised as time performance, cost performance and quality performance.

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