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INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) APPLICATION ON CONSTRUCTION SUPPLY CHAIN MANAGEMENT: EVIDENCE FROM NIGERIA

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With the advent of information and communication technology (ICT) these days, construction supply chain management (CSCM) related activities can be achieved seamlessly via real-time information dissemination and sharing with a view to reducing conflicts and delays. This study therefore, sorts to examine the effects of ICT on CSCM. To achieve the purpose of this study, a quantitative research approach was adopted for the study. Based on the outcome of the literature review, some hypotheses were proposed in relation with ICT and CSCM. Data for the study were collected from practitioners within the Nigerian construction industry via a purposive/convenience sampling technique. A total of 214 questionnaires were distributed based on the Krejcie and Morgan's method, while 203 were retrieved and used for further analysis. Structural equation modeling (SEM) was used to test the hypotheses. The results of the study reveal that ICT had a significant relationship with CSCM. The constructs associated with ICT, viz; deployment of web based & other software and portals, use of internet applications and web based technologies, use of mobile devices & personal digital assistants, and integrating radio frequency & identification (RFID) technology had a significant and positive relationship with CSCM. A better implementation of ICT is the key to enhancing the successful delivery of construction projects to fruition.

Keywords: construction projects, construction supply chain management, information and communication technology, Nigeria, structural equation modelling

INTRODUCTION

The coming into existence of the internet in the early 90s brought with it a new beginning that is hinged on the deployment of information and communication

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technology (ICT) in virtually all human endeavours. Hence, most organisations in other developed climes of the world have to a greater extent deployed ICT in carrying out their various day to day activities with a view to supporting extant inter and intra-firm relationships (Adzroe and Awuzie, 2018; Tserng et al., 2005). The construction industry as opined by (Wang et al., 2007), is extremely complex, this complexity is due to the fact the entire project development process generally consist of several phases requiring a myriad of specialized services as well as the involvement of numerous participants. Hence, to control and coordinate construction project activities effectively becomes extremely difficult owing to the involvement of various participants with diverse backgrounds.

Rivard (2000) opined that the main purpose of ICT is to facilitate the sharing and management of information that posses a lot of potentials that would accrue to the construction industry via information processing (Sarosa and Zowghi, 2003). According to Gaith et al. (2012), the use of ICT in construction is expected to expand given the fact that organizations are beginning to realize the importance and role of ICT in achieving and maintaining a competitive advantage in the industry (Wikforss and Löfgren, 2007). Xue et al. (2007) posited that in time past, there has been an increase in the globalization of markets and as such, the ability of firms to concentrate on their core competencies invariably gave rise to increase in supply chain coordination via supply chain management (SCM).

A myriad of definitions have been offered with respect to SCM, hence, within the context of this paper, SCM could be adduced as "an integrated and collaborated supply chains be it an upstream or downstream, inter or intra organization with the same goals and objectives for long term relationship integration" (Abd Shukor et al., 2011 p.112). While Ribeiro and Lopes (2001), defined supply chain (SC) as consisting of series of individual activities or processes that constitutes in the transformation of raw materials into finished products that could be purchased by a client. They (Ribeiro and Lopes, 2001) further stated that a SC with regards to construction can be inferred to be a process /series of activities that transforms raw materials into finished deliverables like roads or buildings and services for possible use by a client. Akintoye et al.(2000), sees SCM as the process of strategically managing the flow and storage of materials, parts and finished inventories from the suppliers, via the firm and to final consumers. The various definitions that have been proposed by various scholars as opined by Akintoye et al. (2000), virtually indicates that SCM prescribes in clear terms more of an organizational restructuring process that is extended to the entrenchment of a company-wide collaborative culture.

As opined by Tserng et al. (2005), most professionals handling construction projects on site, need access to the site to manage the project because most of the construction projects are operated in the remote areas of the construction sites. Hence, the use of desktops or even notebooks may not be convenient for the construction sites largely due to inconveniences associated with handling. Most on-site practitioners generally handle various types of digitally-related types of information, such as reports, drawings, checklists, and specifications. The use of sheets of paper and/or field notes becomes the order of the day. The resultant effect of this is a gap in time and space between the site and the office, which often leads to low efficiency, delays and other problems that might affect the entire project. Achimugu et al.(2009) opined that ICT's use has diffused rapidly in other developed climes, but its diffusion has been generally slow in developing climes and as such this has led to a widening gap in ICT viz the digital divide amongst the two climes. The construction industry according to Xue et al. (2007), is characterized with high level of fragmentation, cost and schedule overruns, disputes and conflicts, as well as low level of productivity compared to other industries. They (Xue et al.,2007) further opined that these are the major characteristics and causes of performance-related problems confronting the construction industry. Contractors most times rely more on interactions via telephone or fax when communicating with suppliers, subcontractors and designers. In most cases these transactions are frequently lost or misunderstood between sites and offices, and among all participants, when these facilities are malfunctioning or not existing at all. This often leads to ineffectiveness and inconveniences in the discharge of their job functions (Wang et al., 2007).

Hence, the need for this study to take a look at these aspects. The objectives of this study are to examine and analyze the effects of the deployment of ICT on CSCM. Thus, the following hypotheses were postulated with a view to testing the relationship between the variables.

- Hypothesis H1: Deployment of web based and other software and portals positively affects CSCM.
- Hypothesis H2: Use of internet applications and web based technologies positively affects CSCM.
- Hypothesis H3: Use of mobile devices & personal digital assistants positively affects CSCM.
- Hypothesis H4: Integrating radio frequency & identification (RFID) technology positively affects CSCM.

LITERATURE REVIEW

ICT in construction

ICT to a greater extent has been responsible for driving the entire construction process from information generation through to transmission and interpretation with the intent to enable the realization of a construction project's objective. In a nutshell, it has contributed to transforming individuals and organisations activities (Onyegiri et al., 2011). As stated by Usman and Said (2012), construction firms deploy the use of technological devices in overcoming problems and improve on their construction activities. They (Usman and Said, 2012) further opined that ICT facilities also contribute to providing better communication amongst team members in construction projects. These to a greater extent are some of the benefits and values associated with the use of technology and ICT facilities in curtailing risk, waste of valuable time in a bid to achieve some specific objectives.

The construction industry according to Olalusi and Jesuloluwa (2013), depends to a larger extent on the use of huge amounts of information during the construction and the entire project life-cycle process. In such case, it becomes expedient that information is made readily available to the construction sites in such a way that data integration is enabled, task controlled, and communication amongst the various SC entities like the company and its suppliers, as well as the entire materials and resources are properly coordinated. This type of information as stated by Olalusi and Jesuloluwa (2013) contributes to the necessary support needed by project participants to carry out the construction phase of the project to fruition within the acceptable cost and schedule limits. Hence, the use of ICT facilities that are capable of improving information dissemination are fundamental in improving decision-making process during construction.

SCM and the construction industry

With the attendant increase in competition and technology enabled activities, most firms are beginning to see the need to adopt SCM as an integral component of their strategic competence, which in essence is believed would lead to achieving a competitive advantage (Othman and Rahman, 2010). SCM according to Amade (2017), is a process that strategically manages the movement, storage of materials, parts as well as finished inventories from the suppliers, via the firm and to the final consumers. The main focus of SCM as stated by Hai et al.(2012) is to maintain a collaborative relationship amongst the SC members with a view to maximizing competitive advantage and achieving a more profitable outcome for the entire SC entity. Vrijhoef and Koskela (2000) reiterated that SCM originated and flourished in the manufacturing industry, and one of the visible signs of SCM was observed from the just-in-time (JIT) delivery system, which is a subset of the Toyota Production System. According to Voordijk and Vrijhoef (2003), SCM has been adjudged as an emerging field of study as well as a potential source of enhancing the performance of the construction industry. Given the specific nature of construction SCs and the attendant industrial and economic context, there's need for the inclusion of particularly, the temporal and fragmented nature of project-based multi-organizational construction SC, compared to the permanent production-based organizations such as that of the manufacturing industries (Voordijk and Vrijhoef, 2003).

The deployment of SCM to the construction industry is a recent phenomenon that is challenging largely due to the nature of the industry and its hectic nature in terms of specialisation of work packages as well as the fragmentation of the entire process amongst the SC partners (Othman and Rahman, 2010). According to Othman and Rahman (2010), when comparing the construction industry with other industries such as manufacturing, the construction industry involves a range of component parts with a unique site or project requirements. Given the immoveable nature, product and size of construction products, it product is usually assembled at a particular point of consumption (Othman and Rahman, 2010). With this development, it is not usually possible to assume a single firm would possess the power or ability to single-handedly coordinate the entire SC, but each member of the SC can influence and be influenced by the entire SC (Othman and Rahman, 2010). The objective of SCM as stated by Robert et al.(1999), is to precipitate cost-effectiveness, efficiency and improve on services, enhance communication among SC components, as well as increase flexibility via improved delivery and response time. They further stated that, it is also necessary and important to achieve SCM in construction for purposes of improving inefficiency, avoid mistakes and delays, poor communication in construction processes.

It is imperative to state that there are a myriad of studies on the deployment of ICT in the construction industry, some of them are studies carried out in Nigeria

(Oladapo, 2006), Malaysia (Mui et al., 2002), Canada (Rivard, 2000; Rivard et al., 2004), New Zealand (Dorherty, 1997), Sweden, Denmark and Finland (Howard and Samuelson, 1998, Howard et al., 1998, Samuelson, 2002); Hong Kong (Futcher and Rowlinson, 1998, Futcher and Rowlinson, 1999); Saudi Arabia (O'Brien and Al-Biqami,1999); Australia (Masqood et al.,2004) amongst others. It also interesting to note that none of the above mentioned studies was conducted with a view to x-raying on the critical ingredients of CSCM on one hand. Secondly, the above mentioned studies did not deploy the use of structural equation modeling (SEM) approach in analyzing their findings. Hence this study intends to fill in this gap by adopting SEM in evaluating the influence of ICT on CSCM. As opined Molenaar et al. (2000), SEM is construed as an extension of a standardized regression model used in resolving problems associated with poorly measured independent variables and is mostly deployed on construction engineering and management related researches. While Byrne (2010) is of the view that SEM is an equivalent of a graphical and mathematical representation of a set of equations namely a dependent variable and a set of explanatory variables (Bollen and Long, 2010; Hair, et al., 1998; Jackson et al., 2005). SEM is more superior to other multivariate techniques like factor analysis, multiple regression and path analysis, hence its use in modern day researches (Ng et al., 2010).

CONCEPTUAL MODEL

Deployment of web based and other software and portals and CSCM-(DWBSP)

According to Viswanadham and Kumar (2006), ICT has altered the way information is stored and transferred from one place to another and the construction sector is no exception to this. Viswanadham and Kumar (2006) further opined that the use of information technology in construction is limited in the areas of accounting, project control, drafting, wireless communications etc. Example of firms that had utilized ICT resources in achieving transformational growth according to Viswanadham and Kumar (2006) include; Wal-Mart, Dell Computers etc. According to Tarantilis et al. (2008), web-based technologies are cost effective, efficient and of recent, have been the target of most development efforts. Web-access has been facilitated by recent advances in telecommunications and network technologies that have given rise to the creation of virtual private network (VPN) structures which connects various enterprise spatial entities. In the construction sector, computer aided design (CAD) has consistently helped in reducing cycle time, productivity and accuracy whenever there is need for a change in design. While other construction firms use productivity and cost reduction software applications like Primavera, CAD design tools, enterprise information portals for multi-project visibility and other costing and scheduling modules. E-business is another tool that is gradually becoming a primary means of trading in the European construction industry (Ribeiro and Lopes, 2009). This according to Ribeiro and Lopes (2009), is demonstrated by the proliferation of portals, such as the e-commerce and e-business sites in the industry.

Use of internet applications and web based technologies, and CSCM- (UIWBT)

ICT has been adjudged as one of the essential ingredients for organizational survival, success and enhancement of SCM activities via the supporting and integration of business processes across the various functional units (Yu, 2015). The importance of ICT according to AbTalib and Hamid (2014) in SCM cannot be underestimated as information has always been the pivot in the efficient management of logistics. With the introduction of personal computers, fiber optic networks, the internet explosion and the world wide web (WWW), the cost and availability of information resources enables easy and fast linkages which eliminates information related schedule delays within any SC (Handfield and Bechtel, 2002). These technologies as stated by Handfield and Bechtel (2002), are SC enablers, this implies that, they can be used in minimizing the level of paper works, improve communication, as well as minimize SC cycle times. While Ribeiro and Lopes (2009) on the other hand, were of the view that internet applications and web based technologies have emerged as the most effective means of achieving SC integration in the realization of construction projects. According to Xue et al.(2007), the construction industry is adjudged to be an information dependant industry given its diversity in terms of information generating procedures that are associated with detailed drawings and photos, cost analysis sheets, budget reports, risk analysis, charts, contract documents, and planning schedules. The internet on the other hand, plays a key role in fostering the integration of construction business processes across the construction SC by way of facilitating information flows necessary for coordinating construction activities. According to De Oliveira et al. (2011), supplier and customer oriented processes have been significantly affected by the advent of ICT. They opined that the consistent use of internet and ICT applications has led to creating a positive impact on information visibility amongst SC partners thus leading to an improvement in SC performance. Other critical benefits includes; the possibility of breaking organizational barriers by disseminating critical information and interacting on a near real-time on line basis across the SCs and the possibility of monitoring processes in order to reduce decision cycle processes thus allowing upstream suppliers and customers respond more abruptly and consistently.

Use of mobile devices, personal digital assistants and CSCM- (UMDPA)

ICT plays a significant role in controlling and managing construction projects successfully, especially in enhancing communication and coordination among SC partners (Tserng et al., 2005). According to Usman and Said (2012), mobile technology refers to a situation where a technology can move around with the user, but may not necessarily be online real-time; hence, users can download a software, send e-mail messages, and access web pages on their personal digital assistants (PDA), laptops, or other mobile devices. Tserng et al.(2005), reiterated that active communication and coordination needs to be sustained with a view to supporting effective sharing of resources and competencies in a construction SC network. Hence, introducing promising ICT facilities such as bar code scanners, PDAs, and data entry mechanisms, can be of outmost importance in improving the effectiveness and convenience of information dissemination in construction SC systems. As stated by Ward et al. (2004), standardized packages exist for use by mobile site workforces who are more often targeted towards pre-determined inspection and reporting tasks. Unlike what exist in the manufacturing sector, the construction site is more of a reactive environment, where unexpected changes to work regularly occur.

Integrating radio frequency & identification (RFID) technology and CSCM-(RFIDT)

RFID is an automatic device that identifies and captures data and it consist of three elements viz; a tag that is connected to a chip by an antenna; a reader emitting radio signals and receiving responses from tags, and a middleware that connects RFID hardware and enterprise applications (Sarac et al., 2009). According to Usman and Said (2012), RFID technologies makes use of active and passive tags in the form of chips or smart labels that can store unique identifiers and translate such information to electronic readers. The tag consists of a microchip that holds data with the aid of an electronic product code (EPC) and antenna that transmits data to a reader. The reader thereafter uses radio waves to read the tag and sends the EPC to computers in a SC (Usman and Said, 2012). Furthermore, Wang et al. (2007) reiterated that with the introduction of promising technologies like the RFID, and web portals, substantial improvements could be felt via the convenient flow of information in the construction SC control systems. While Sarac et al.(2009) were of the view that RFID technologies could also help in improving SCM activities viz; the reduction of inventory losses, increase in efficiency and speed of processes, while also improving information accuracy. Unlike bar codes, RFID can identify and track products and equipments on line real time without contact or line-of-sight, hence it can withstand harsh, and rugged environments. These advanced identification and communication characteristics of RFID as stated by Sarac et al.(2009), could help in improving product traceability and visibility among SCs. For instance, RFID can improve on accuracy, efficiency and increase the speed of processes. It can also decrease storage, cost of handling and distribution as well as improve on sales by decreasing the number of stockouts. The contribution of RFID to SCM is not only related to increasing the efficiency of the entire system, but also support the reengineering of the systems so that they become more efficient.

Figure 1 shows the 4 proposed research hypotheses alongside the conceptual model of positive impacts.

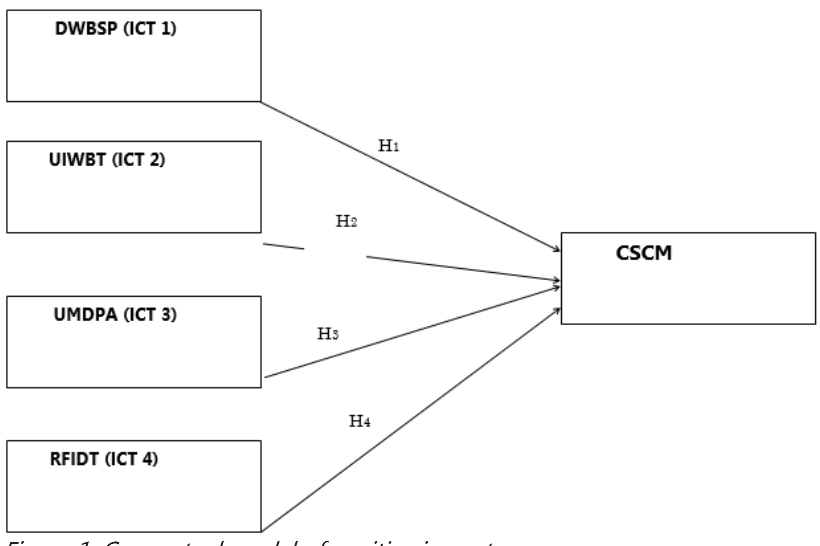

Figure 1: Conceptual model of positive impacts

RESEARCH METHODOLOGY

The study adopted a quantitative approach and specifically, a cross sectional research design method of research. While data was collected from some selected (targeted) construction firms located in Port-Harcourt, Rivers State, Nigeria who by their very nature are involved in construction SC related activities. A self-administered questionnaire was deployed for data collection. A total of 203 useable questionnaires were retrieved for analysis from a sample size of 214 using the Krejcie and Morgan methods of sample size determination (Krejcie and Morgan, 1970). The questionnaire had an introductory section and other demographic information. The questionnaire further included sections about the respondent's ICT and internet usage habits with particular reference to CSCM. To measure the constructs of the study, a five-point labelled Likert-type scale was used in measuring the level of agreement with respect to items measuring perceived use and attitude with regards to ICT and CSCM where 1 indicates 'strongly disagree' and 5 'strongly agree'. Data for the study was collected over a five-week period. Cronbach Alpha values for each of the four constructs were computed to measure the reliability of the items used in the research instrument after a thorough data editing using IBM Statistics SPSS Version 22.0. Exploratory factor analysis (EFA) was also used in discovering the underlying relationships existing between the items in the study's constructs. The results of the EFA gave rise to the different constructs in the study being retained. Statistical techniques such as the Structural Equation Modelling (SEM), the latent variables and the theoretical models that are built with EFA and Confirmatory Factor Analysis (CFA), and the different hypotheses formulated for the study were tested (Su and Yang, 2010).

Analysis and Results

A total of 208 responses were retrieved from the 214 questionnaires distributed amongst which 203 were found to be usable after a thorough data editing, which consist of the exclusion of the unwarranted responses and multivariate outliers. The data analysis process consists of three categories as explained below.

Data Screening

Data screening consists of sorting of data prior to the final data analysis. The stage consists of identifying missing values, outliers, and collinearity. Responses with missing values and outliers were initially excluded via a manual screening process before their collinearity statistics were assessed. According to Hatcher (2005), the extent to which two or more latent variables are correlated with each other is called multicollinearity.

Table 1: VIF value for multicollinearity

Variables	VIF values
DWBSP	2.443
UIWBT	2.675
UMDPA	2.245
RFIDT	2.315

Multicollinearity could lead to a lot of problems, one of which is the complication in interpretation and computation of relationships. Hence, this study chose CSCM as the dependent (observed) variable and the four ICT approaches to CSCM as the independent (latent) variables for multicollinearity via linear regression. From table

1 below, all the computed VIF values are less than 10, which is a clear manifestation that there is no case of a multicollinearity in the data set.

Reliability Analysis

In a bid to obtain high quality statistical data, the need to determine the validity and reliability of the measuring instrument becomes imperative (Bollen and Long, 2010). For the purpose of this study, the process of assessing the internal consistency of the instrument for data collection was conducted using the Cronbach alpha test (Ikediashi et al., 2013; Su and Yang, 2010). As stated by Hatcher (2005), the value of the coefficient (Alpha test) showing greater than 0.70, indicates a good representation of results of the instrument based on the considered population. Given the obtained Cronbach alpha coefficient of internal consistency of the set of questions on the questionnaire, (DWBSP to CSCM), the validity and reliability of the questionnaire on ICT and CSCM has been proven. One can deduce that the results of the research would be reliable.

Table 2: Cronbach's Alpha's Test of Latent variables, composite reliability, and average variance extracted

Constructs	Number of items	Cronbach's α	Composite reliability	Average variance extracted (AVE)
DWBSP	4	0.966	0.775	0.879
UIWBT	3	0.783	0.823	0.593
UMDPA	4	0.889	0.842	0.776
RFIDT	2	0.872	0.836	0.657

Factor Analysis

In applying factor analysis, the testing of the adequacy of the sampling was carried out (Measures of adequacy sampling) using the Kaiser-Meyer-Olkin (KMO) test and Bartlett test of sphericity. As a basis for recommendation, the accepted minimum value for KMO is 0.6, while the level of significance of the Bartlett's test is $p \leq 0.05$ (Bollen and Long, 2010; Hatcher, 2005). In this study, the result of the KMO coefficient is 0.683, an indication that the data collected are convenient for application and use for factor analysis. The Bartlett test of sphericity indicates that ($\chi 2 = 154.22$, $p < 0.000$), indicating that there are correlations among the items within the measurement instrument, thus indicating that the correlation matrix is not an identity matrix (Chai et al.,2015).

Correlation Matrix of the Variables

This aspect of the study examines the correlation existing amongst the 13 items on the questionnaire (variables) and CSCM in the construction firms.

Table 3. Inter-correlations among five ICT and CSCM within proposed model

Coefficients	DWBSP	UIWBT	UMDPA	RFIDT	CSCM
DWBSP	1.00				
UIWBT	0.38	1.00			
UMDPA	0.30	0.22	1.00		
RFIDT	0.01	0.45	0.33	1.00	
CSCM	0.65	0.65	0.00	0.27	1.00

For the purpose of this study sample, the correlation coefficients in the matrix in table 3 fulfill the eligibility level of 0.05. This signifies that a significant correlation exists between the 13 items on the questionnaire, and therefore the application of factor analysis is justified. The correlation matrix of five factors of ICT and CSCM is shown in table 3.

Exploratory Factor Analysis

An exploratory factor analysis (EFA) was conducted with a view to retrieving the key factors of ICT and CSCM in the selected construction firms. The relationship that exist between the identified variables, is such that on the basis of the identified correlations, the regrouping of the variables into smaller set of variables can be carried out with a view to representing a concise and understandable structure of the variables (Memon et al.,2013). The EFA analysis carried out on the set of 13 variables amongst the proposed groupings were established and the obtained results showing the factor loadings and communalities of the constructs as shown in table 4. Factor loading depicts the correlation coefficient existing between the original variable and the extracted factor. While the communality variable defines the proportion of total variance computed on the basis of common factors (Memon et al.,2013).

Table 4: Results of Exploratory Factor Analysis

Constructs		Factor Loadings	Communalities
ICT 1.1	DWBSP	0.822	0.952
ICT 1.2		0.819	0.951
ICT 1.3		0.792	0.967
ICT 1.4		0.791	0.967
ICT 2.1	UIWBT	0.791	0.879
ICT 2.2		0.733	0.861
ICT 2.3		0.654	0.796
ICT 3.1	UMDPA	0.652	0.684
ICT 3.2		0.625	0.848
ICT 3.3		0.605	0.961
ICT 3.4		0.602	0.972
ICT 4.1	RFIDT	0.587	0.861
ICT 4.2		0.509	0.744

Structural Model Assessment

With the aid of IBM Statistics SPSS version 22.0 software, the Path Model Analysis was carried out with particular reference to the outcome of the conceptual model in figure 1. The outcome of the structural model is shown in figure 2. The figure/value above the arrow indicates the value of the regression coefficients (β-path coefficient). It explains the strength of the relationship existing between the observed and latent variables and as such are related to the effect of DWBSP (ICT 1), UIWBT (ICT 2), UMDPA (ICT 3) and RFIDT (ICT 4) on the dependent variable CSCM. The figures/values appearing below the arrows indicate the values of the t-test. The coefficient of determination (R2), is shown on the symbol of the dependent variable. It shows the inclusion of the explained variance in total, that is, how the variations of the observed variable are explained by the predictor variable. Hence, it can be inferred that all the ICT variables have moderate effects on CSCM. Furthermore, it necessary to check for the significance of these results for the acceptance or rejection of the hypothesis. Table 5 shows the results of the parameter estimates and hypotheses tests. The results so obtained have sufficiently supported the proposed hypotheses as significant. This study determined the hypotheses according to a one-tailed test with a 95% confidence interval. Table 5 shows that DWBSP (ICT 1), UIWBT (ICT 2), UMDPA (ICT 3) and RFIDT (ICT 4) have positive and significant effects on CSCM, as all t-values are greater than 1.645 and P-values greater than 0.05.

Table 5: Parameter estimates and results of hypotheses

Constructs	ß-value	t-value	Results
DWBSP ⟶ CSCM	0.309	14.057	Supported
UIWBT ⟶ CSCM	0.274	15.287	Supported
UMDPA ⟶ CSCM	0.183	8.910	Supported
RFIDT ⟶ CSCM	0.078	4.571	Supported

Significant at p > 0.05

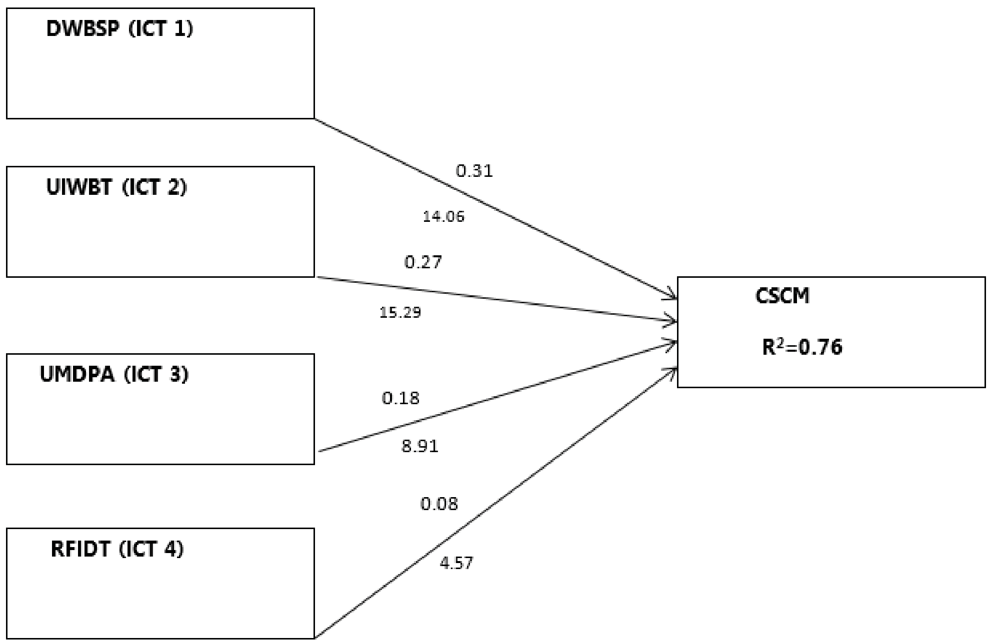

Figure 2: Structural model

Model Fit Measures

A Goodness-of-fit measure of structural models was carried out. Values of the most significant fits are displayed in table 6. Based on the outcome of the results, the values of the fit measures were analyzed based on which of the models satisfactorily or unsatisfactorily fits the initial data by way of comparing the obtained values with recommended values. The Root Mean Square Error of Approximation (RMSE) was obtained based on the approximate error that occurred due to the expected degree of freedom from the studied population. A low value of RMSEA implies a greater correspondence, in other words, the better the fitting of the model to the input data. Hence, the acceptable congruence is below 0.10 (Hatcher, 2005; Su and Yang, 2010).

The Goodness-of-fit index (GFI), determines the extent to which the model is more applicable compared to when the model does not exist. This indicator falls between the range (0-1), where 0 implies a poor and 1 signifies a perfect match. Acceptable values are the ones greater than 0.8 (Hatcher, 2005; Su and Yang, 2010).

The Adjusted Goodness-of-Fit Index (AGFI), CFI (Comparative Fit Index), IFI (Incremental Fit Index), NFI (normed Fit Index), NNFI (Non-normed Fit Index) and RFI (Relative Fit Index) indicates a situation where the considered model depicts a profound increase in correspondence. Values of AGFI, CFI, IFI, NFI, RFI, NNFI are considered acceptable if they are greater than 0.9 (Eybpoosh et al.,2011).

Parsimony of the proposed model is considered based on the average value of chi-square and degree of freedom ($\chi 2$ / d.f.). Fitting of the data is considered satisfactory if the value is greater than 1 and less than 3. Furthermore, the process confirms that the data are a good representative (Aibinu et al., 2010; Zainudin, 2012).

Table 6: Summary of Model Fit Measures

Fit Indicators	Model Estimates	Cut off values
Chi-square ($\chi 2$)	154.22	-
Degree of freedom (d.f)	78	-
Relative Chi-square ($\chi 2$ /d.f)	1.98	<3.0
Root Mean Square Error of Approximation (RMSEA)	0.087	0.08-0.10
Goodness-of-Fit Index (GFI)	0.92	>0.9
Adjusted Goodness-of-Fit Index (AGFI)	0.93	>0.9
Normed Fit Index (NFI)	0.90	>0.9
Non-Normed Fit Index (NNFI)	0.94	>0.9
Comparative Fit Index (CFI)	0.92	>0.9
Incremental Fit Index (IFI)	0.91	>0.9
Relative Fit Index (RFI)	0.94	>0.9

DISCUSSION OF RESULTS

Based on the outcome of the results, it can be seen that the reliability and validity of the measurement scale was achieved based on the estimates of the interconsistency of the instrument used in collecting data via the Cronbach alpha test. Based on the results shown in table 2, the values of Cronbach alpha coefficients for all 4 groups of questions are greater than the recommended value of 0.7, it can be concluded that there is an internal consistency of all 4 groups of the control model. These findings are in line with similar findings of (Su and Yang, 2010; Ikediashi et al., 2013). In testing the adequacy of sampling with the aid of factor analysis, the KMO and Bartlett test of sphericity was conducted. The value of KMO indicator was 0.683. Bartlett test of sphericity indicates a significance level of ($\chi 2$ = 152,22 p <0.000), implying that there are important correlation existing amongst the items within the measuring instrument, hence, majority of the correlation values lie between or above 0.50 (See table 3). It is evident that based on the outcome of the indicators, the data are deemed suitable for factor analytical approach. In deploying exploratory factor analysis as shown in table 4, 5 factors were extracted viz; DWBSP, UIWBT, UMDPA, RFIDT and CSCM. These findings illustrate the formation of the conceptual model for this study.

A structural model depicting the outcome of the hypotheses testing is as shown in figure 2. The findings show that the four hypotheses were confirmed, acceptable and statistically significant (H1, H2, H3 and H4). With the outcome of these hypotheses, the regression coefficients had positive values, and as such, the t-test values were higher than the recommended threshold value of 1.96. The underlisted results were obtained for the above mentioned hypotheses viz; H1 (β = 0.309; t = 14.057; p <0.05); H2 (β = 0.274; t = 15.287; p <0.05); H3 (β = 0.183; t = 8.910; p <0.05); and H4 (β = 0.078; t = 4.571; p <0.05). Hypothesis H4 (RFIDT) had the least β-value, even though that it is statistically significant, its value of t-test was still greater than recommended 1.96 (β = 0.078; t = 4.571; $p < 0.05$).

The first hypothesis was significant; it implies that deployment of wed-based software and portals (DWBSP) positively affects construction SCM. Tarantilis et al. (2008), also reported similar findings in their study. They opined that most web-based technologies are efficient, cost effective and recently has been the most sought out in terms of developmental efforts.

The findings further depicts that the coefficient of determination (R2) indicates that the influences of the latent predictors H1, H2, H3, and H4 on the latent endogenous variable CSCM may be calculated with 76% of the variance. The outcome of this finding is that the demand for ICT in CSCM may not be the same with other advanced climes; hence, there is need for another study to look at the main areas of RFIDT as this aspect of the study turned out a low β-value. As stated by Sarac et al.(2009), the applications of RFID technologies are still limited because the costs associated with it are still expensive. The implications of these results are from the theoretical and practical points of view. From a theoretical point of view, the use of RFIDT is a new variable that should be accorded ample attention in the study of CSCM and ICT application in the Nigeria construction industry. While from a practical point of view, project managers in charge of construction projects should not overlook the influence of RFIDT. This study confirms that RFIDT positively affects CSCM of the construction firms with the least value.

The findings of the structural analysis of the model are as depicted in figure 2 and table 6. The structural model of the Root Mean Square Error of Approximation (RMSEA) has a value of 0.087, implying that based on this value, a favorable congruence exist with the proposed model. The Goodness-of-Fit Index (GFI) value also depicts a good correspondence of the model, giving the resulting value of the indicator as 0.92. Hence, based on the values of RMSE and GFI indicators, it can be deduced that there is an absolute coincidence with the proposed model. The values of the indicators of the structural model are for AGFI = 0.93; NFI = 0.90; NNFI = 0.94; CFI = 0.92; IFI = 0.91 and RFI= 0.94. The values are deemed to be acceptable since they are above 0.90, thus indicating that the models depict a solid increase of concurrency. This finding agrees with that of Zainudin (2012), who opined that a model should at least meet one of the fitness requirements in terms of absolute, incremental and parsimonious fits. Parsimony of the proposed model is measured based on the relative value of chi-square ($\chi 2$ / d.f.) which equals 1.98 representing the recommended threshold value of between 1 to 3, which is a confirmation that the initial data are true representatives. Based on the outcome of the indicators of fitting of the structural model, it is imperative to characterize the model as absolutely appropriate. The conclusion in a general term is that all 13 variables can in a reliable and valid manner be described as being responsible for the 5 groups of variables based on the conceptual model shown in figure 1.

CONCLUSION

This study investigated the role of ICT in CSCM among some selected (targeted) construction firms in Port Harcourt, Rivers State, Nigeria. ICT can be used as a strategic tool to enhance CSCM practices, particularly in construction firms. Proper deployment of ICT has the ability to resolve various issues in the construction industry in Nigeria. ICT is linked to four key elements of CSCM which includes; DWBSP, UIWBT, UMDPA and RFIDT in construction firms which has a positive and seamless relationship with SCM. DWBSP, UIWBT, UMDPA and RFIDT increase the accuracy of ICT activities which ultimately enhances the overall firm's SCM performance particularly in the construction industry. Therefore, the Nigerian construction industry must commence the implementation ICT with a view to boosting up their CSCM. One noticeable limitation with this study is that, there's need to extend part of this study on most recent constructs of ICT as it relates to CSCM which would help in the development and validation of a robust model via a SEM approach.

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