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Construction Information Management System utilisation for Nigeria Construction Firm Performance: A Structural Equation Modeling

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ABSTRACT

The rate of technologies-driven construction practice across the globe is fast spreading with momentum suggesting organisations not scaling up their practices are likely to suffer insolvency in the future. The technical, social and policy dimensions for empowering information technology integration in developing countries are poor. The study aimed to measure construction firm performance and model the relationship between IMS utilisation and construction firm performance. The study adopted a quantitative survey strategy involving a questionnaire survey administered to 345 professional representatives of architectural firms, quantity surveying firms, building firms, engineering firms and construction contracting firms. Data analysis involved SPSS version 27 and applied test statistics were descriptive and Structural Equation Modelling. The results reveal that among the vastly utilised IMS applications are MS Word, Excel, MS Project and Primavera. The utilisation of project-specific websites, electronic document systems (or firm private servers), databases and masterbills/WinQ, BIM, PMIS, CDMS, ERP, GIS, CMS, and CDMS are not popular in the study. The study also revealed that the influence of utilising a Construction Information Management System (CIMS) on construction firm performance is 80%. The inference and conclusion show that CIMS is objective to stimulating significant positive transformation in construction firm performance. The study recommends upscaling CIMS utilisation through various strategies to grow construction firm performance in the region.

Key words: Information Management, Construction Management, Project Delivery, Web-Based Project Management

1. INTRODUCTION

Construction projects run more smoothly when information is gathered, stored, distributed, archived, deleted, or destroyed using construction information management systems [1]. For construction projects, this information is essential for planning, budgeting, and project completion. In the construction sector, information management is an essential part of the decision-making process. It guarantees stakeholders make the right choices at the appropriate time [2]. Masuin [3] asserts that the Construction Information Management System (CIMS) has developed into a conceptual framework for improved project performance. Properly created and handled construction information is evidently necessary for effective and efficient project performance [4].

For construction projects to be scheduled in a way that allows experts and shareholders to make informed decisions and fulfill their obligations in a way that is both appealing and cost-effective, precise and optimal data and information are necessary [5]. Effective use of time, resources, and experience by project teams to make choices and finish the project is made possible by construction information administration efficiency [2].

However, information management in the Nigeria construction sector is not well-regarded, as seen by the numerous large-scale initiatives that have gone over budget and failed deadlines [6]. Traditionally, the current situation in many construction organizations is that most construction firms do not have proper information management systems; most of them do not have adequate and accurate information about construction activities and documents in their organization. Currently, most firms still practice manual documentation of information obtained from construction workflows [7]. Hence, acquiring a sufficient amount of information for management decision is a time-consuming task. In addition, many construction projects have project teams that are geographically and temporally dispersed, working on multiple projects concurrently, navigating multiple organisational boundaries, collaborating with a variety of construction professionals, and managing a sizable number of participants in a project at once [8]. These teams are frequently assembled hastily in order to complete a construction project with constrained resources and time. The possibility for new mobile collaboration and integration channels presented by recent developments towards the convergence of internet-based technologies and cellular communications might lessen the effects of team members' physical dispersion [9]. Furthermore, there is a lack of regular communication between project managers, team members, and clients to exchange professional perspectives. To bridge this gap, this study is aimed to unveil the influence of construction information management system on the performance of construction firms with a view to model the relationship between construction information management system and construction firm performance by construction contracting firms in South-East, Nigeria.

2. LITERATURE REVIEW

2.1 Concept of Information Management Systems

A management information system is a technological tool designed to facilitate and mechanise decision-making, which was previously done more traditionally using gut instinct, rule of thumb, and firsthand knowledge [10]. Gathering, storing, and retrieving information at the right moment required a scientific system in order to increase responsiveness and expedite the decision-making process. As a result, management information systems were created [10]. The management and quality of information systems are essential to achieving company objectives. Without the best information systems, it is impossible to accomplish certain business objectives like increasing efficiency, developing new services or products, or strengthening market position [10]. Thus, it can be said that in order to develop and carry out company plans, management information systems are essential.

2.2 Relationship between IMS use and Project Performance

In the construction sector, most stakeholders have expressed great worry over the idea of project performance. It is required of projects to perform in order to meet goals [11]. When the goals are met to a satisfactory degree, a project is considered successful.
It has been suggested that project success and project objectives are related to project performance [11]. Several factors have been used to gauge the success of projects. Project success was evaluated by [12] using the following five dimensions:

- Meeting Design Goals
- Benefit to End Users
- Benefit to the developing organization
- Benefit to the defence and national infrastructure
- Overall success (a combined measure for project success)

Construction projects have three main goals: budget, schedule, and quality. These goals are the dimensions that have been chosen for this study's project performance measurement [13]. Due to the fact that project participants are better familiar with the three fundamental project objectives, measuring success based on these objectives is thought to provide successful outcomes. Project performance is measured in terms of time performance, cost performance, and quality performance since these objectives are well-known and understood [13].

2.2.1 IMS and Project Cost Performance

Cost control model is a method used to manage project costs. Common applications include Earned Value Management (EVM) and cost-volume-profit (CVP) models. The EVM model evaluates the cost performance of a project and predicts the final cost of a project by comparing actual cost, planned cost, and earned value [14]. The CVP model is to determine the profit and loss of the project and the best business strategy by analyzing the relationship between the cost, selling price and selling quantity of the project. The basic formula of the EVM model is:
Earned Value (EV) = budget to complete the work
Actual cost (AC) = Cost actually consumed
Planned Value (PV) = budgeted value of work done [14]
According to the three-dimensional model, the cost management method system is divided into three categories, from the abstract to the concrete level of reasoning, middle level and execution level [15]:

(1) Rational management method: Class I management method. It mainly includes strategic cost management, value chain management, life cycle cost management, etc. These three methods have strong abstract, overall and whole process characteristics, and can be used as a rational level to lead the cost management method system.

(2) Middle layer management method: Class II management method. It mainly includes supply chain cost management, quality cost management, environmental cost management, etc. This kind of method is not as abstract as Class I method, nor can it have strict calculation process or specific implementation process like Class III method, but it has certain operability and can be partially quantified. The cost occurrence and management control of middle-level management methods often span several stages of the whole life cycle or through the upstream and downstream of the value chain.

(3) Executive level management methods: Dish management methods mainly include target cost management, standard cost management and activity-based cost management, etc. These methods have strong operability, are easy to be quantitative and detailed implementation, and can be specific implementation of Class I and Class II methods.

By calculating and comparing EV, AC, and PV, the cost performance indicators of the project, such as cost deviation and schedule deviation, can be obtained [15].

Furthermore BIM is a cutting-edge technology that offers enormous benefits for project cost control. First of all, BIM technology can provide project cost management personnel with up-to-date information as soon as possible, continuously updated to reflect real-time project changes [16]. The problem of traditional project cost management being delayed primarily by delayed information may be effectively addressed by BIM technology, which can gather and communicate updated information to workers in a timely manner. Its use also results in the best possible project cost control [16]. The fundamentals of project costs demonstrate how building quality and prices may be controlled. BIM technology is an instrument that appears to be better at helping engineering personnel carry out the most efficient management since it is based on digitalized models.

Finally, it applies each component of project cost management to project costs in a fair and realistic manner. Projects differ in the particular conditions they face. In contrast to conventional project cost management, which bases its predicted price on prior real-world examples or experience, BIM technology bases its reasonable estimation of the overall cost on the particular costs needed for each component of the complete project amount [16].

2.2.2 IMS and Project Time Performance

Project schedule is essential to project management in order to produce desired outcomes. According to Kerzner [17], it is a timetable that lists all of the project's tasks and activities together with the resources needed to finish them and the deadlines for each. A project schedule is a clear and distinct list of all the tasks, responsibilities, and deadlines needed to finish a project on time. Two crucial project management tools for accurately forecasting activity durations, critical routes, non-critical paths, and project completion dates are the Gantt chart and network diagram [17].

Project management professionals have suggested many IMS techniques for effective schedule control, including Earned Value Management (EVM) and the use of Project Management Software (Microsoft Project) with a Gantt chart or network diagram.

2.2.2.1 PERT/CPM network graph model

The CPM network is a graphical model of an engineering project in which the job is represented by the arrow shaft, and the tail and arrow indicate the start and completion of the job, respectively [17]. The estimated time the job takes is called the duration of the job. PERT (Program Evaluation and Review Technique) evolved from two concepts, the first being the bar chart and the second being the constraints on the job. PERT (Program Evaluation and Review Technique) and CPM (Critical Path Method) are common engineering management models, which describe the relationship and timing of engineering activities by constructing network diagrams to determine the critical path and schedule [18]. In order to overcome the shortcomings of large differences between the analysis results and the actual situation, PERT network model takes the duration of process operation as a random variable according to the past construction experience, and applies probability and statistics theory to estimate the following three completion times [17]: (1) The most optimistic estimation time is a, that is, the shortest time required to complete the process under the most smooth construction conditions; (2) The most likely estimated time is c, that is, the time required to complete the process under normal construction conditions, and also the time estimated with the most chances of completion; (3) The most pessimistic estimated time is b, that is, the longest time required to complete the process under the most unfavorable construction conditions; Pessimistic time estimates include the delay caused by the in coordination of the construction preparation stage, the waste of time caused by the phenomenon of idle work, but do not include the impact of natural disasters and irresistible time delays caused by political events.

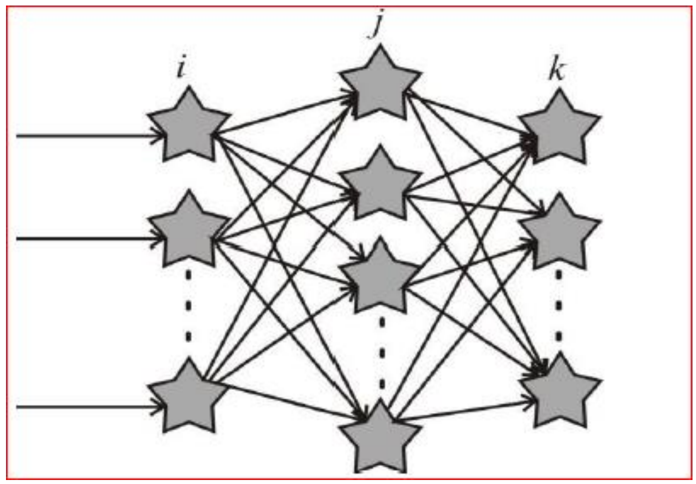

Figure 1: PERT/CPM network diagram [17]

In Figure 1, each node represents a project activity, and directed edges represent dependencies between activities. By calculating the earliest start time, the latest start time, and the float time for each activity, one can determine the critical path and the minimum duration of the entire project.

2.2.2.2 Gantt Chart

A Gantt chart is a scheduling tool that is widely used in project management to assist in organising, planning, and monitoring the many activities that are defined during the project's planning phase [19]. The network diagram is a model created to display the project's critical and non-critical pathways, activities, and durations [17].

2.2.2.3 The Web-Based Project Management System

A task that needs to be finished in a specific amount of time can be summed up as a project. Three main categories may be used to classify projects: manufacturing, management, and industrial (including civil engineering, construction, petrochemical, mining, and quarrying) [17]. Although the magnitude of projects varies, all of them share several noteworthy traits. These characteristics might include [17]:

i. Projects have to be finished in a certain amount of time.

ii. Projects aim to achieve clear, quantifiable, realistic, and achievable goals.

iii. Projects are finished within the allocated spending limit.

Some Popular Web Based Project Management Software are:

Microsoft Project

Microsoft created and markets a project management software programme called Microsoft Project (Figure 2). It is intended to help with schedule development, task assignment, progress monitoring, budget management, and workload analysis for project managers [20].

Budgets are created by the project using resource rates and assigned tasks. The programme determines the cost, which is equal to the work times the rate, when resources are allocated to tasks and assignment work is projected. This cost is then rolled up to the task level, any summary tasks, and ultimately the project level. Through the use of a shared resource pool, resource definitions (people, tools, and materials) may be shared between projects [20]. Every resource can have a calendar of its own, specifying the days and times when the resource is available. The expenses associated with assigning resources are determined by resource rates and are totaled and compiled at the resource level [21] The programme organises task work based on resource availability as specified in the resource calendars.

The programme generates critical path schedules; third-party add-ons for the critical chain and event chain methodologies are also available. Resources may be levelled in schedules, and Gantt charts are used to visualise chains. Furthermore, Microsoft Project has the ability to identify several user types. The access levels of these various user classes to projects, views, and other data may vary. Users share an enterprise global where custom objects like calendars, views, tables, filters, and fields are kept. Project comes in two editions as of 2021: Standard and Professional [21].

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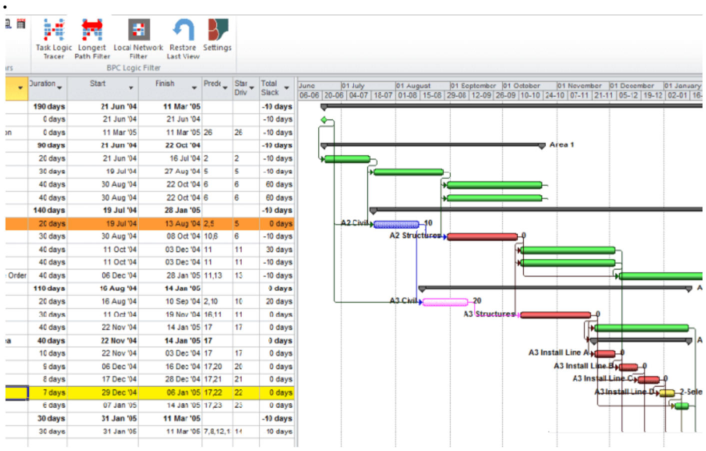

Figure 2: Layout of MS Project Application [21].

Primavera

Primavera is a programme for managing project portfolios in enterprises (Figure 3). In addition to integrating with other corporate software like Oracle and SAP's ERP systems, it offers collaboration and control features, risk analysis, opportunity management, resource management, scheduling, project management, and scheduling capabilities [22] Oracle Corporation purchased Primavera Systems Inc. in 2008 after it was introduced in 1983.

Because of its extensive project management capabilities, Primavera, particularly P6, is used for managing projects, programmes, and portfolios. This is a summary of how Oracle Primavera functions [23]:

- **Project planning and scheduling:** Primavera P6 offers Gantt charts, project tables and network diagrams as its main project planning and scheduling tools. These tools allow users to create scope, schedule and resource baselines.
- **Project portfolio management:** It can manage multiple projects in a program or portfolio at once with the enterprise project structure (EPS) tool.
- **Resource management:** Keep track and reallocate resources as needed by using customizable resource leveling forms.
- **Risk management:** Risk analysis features allow project managers to identify, track and resolve risks before they become issues.
- **Contract management:** Manage multiple projects, and get info from the database fast.
- **Project Reporting:** Report on timelines, resources and costs.

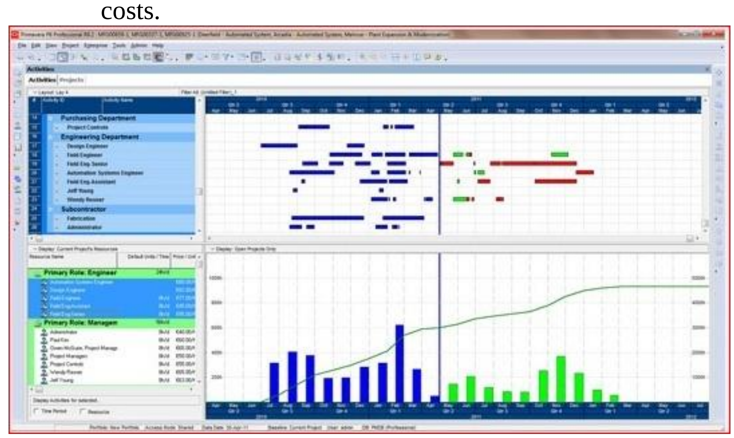

Figure 3: Layout of Primavera Software (IBM, 2020)

Redmine

Redmine is an open-source programme that offers small and medium-sized enterprises budgeting, customisation, problem tracking, learning, support, alerts, resource management, and standard project management features [24]. Traditional project management is Redmine's finest functional area. It uses platforms that are on-site, mobile, and internet. Its features include an issue tracking system, configurable role-based access control, news integration, document and file management, support for 34 languages, tracking of numerous projects, basic time tracking, web feeds and email notifications, and a Gantt chart and calendar for time monitoring [24].

Asana

Asana is a platform that helps teams manage projects and use email less by organising tasks and discussions together. To keep your teammates responsible and result-focused, manage team projects, assign and create tasks, comment on work in progress, connect files, and keep track of deadlines [24]. Teams of up to fifteen members can use it for free on the web, Android, and iOS. Bug tracking, teamwork, email integration, file sharing, idea and problem management, milestone and issue tracking, project planning, status and task monitoring, time and expenditure tracking, and milestone and issue tracking are some of its capabilities. Additionally [24] created a web-based system that aids organisations in finding qualified project managers prior to allocating projects to them; however, this method does not promote cooperative communication between stakeholders and project team members.

The front end and back end make up the intended system. The system's user interface, or what they can see, is part of the front-end. The front-end components comprise the several pages inside the system, such as the homepage, project members page, admin page, and login page. Moreover, there are links from these front-end pages to the system's database on the back-end. The front end and database were connected using the PHP programming language [24].

The web-based method addresses the issues of communication breakdown and unity. Additionally, the system bridges the communication gap between the project manager and the stakeholders by providing a platform for the stakeholders to track the system's development. Once a member of the system is joined to a new project, all involved parties can communicate with one another and monitor the project's development to effectively execute the stakeholder's expectations [24].

2.3 Research Gap

Many studies are notable for having built the system models by focusing on the management activities. While they touched on several aspects of project management, these studies did not fully explore them. In particular, these researches have not provided clarity on the management practices. This study attempts to develop an information management system model that general contractor companies can use by thoroughly addressing every facet of project management and taking other relevant factors into account. The model is meant to be utilised in the evaluation of the current construction project information management systems as well as in the creation of new information management systems with broader application.

3. RESEARCH METHODOLOGY

The research methodology is described in this section. The research design employed in this study was a descriptive survey. Additionally, this study uses surveys since they are inclusive and broad in their coverage, and they typically tend to bring things up to speed and correspond to the current condition of affairs. South Eastern Nigeria is the studied region. Due to the area's preponderance of construction businesses, this location was chosen with a purpose. Architects, quantity surveyors, civil engineers, structural engineers, mechanical engineers, electrical engineers, construction project managers, land surveyors, and developers working for construction companies in southeast Nigeria comprise the study's 1203 professional population.

The sample size was statistically determined using the formula of Taro Yamane. The formula is stated below
Where:

N = Population size
e = Level of significance
n = sample size
Thus:

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

Where:

n = sample size

N= Study population

e= 5% level of significance

1= constant

$$n = \frac{1203}{1 + 1203(0.05)2}$$

n = 300

Adding attrition of 10% gives a sample size of 345. Therefore, the sample size for the study is 345.

The study employed a standardized questionnaire using a five-point Likert scale to gather participant responses. The approach of the study is not novel, since it has been used by many authors. A distribution rate of 95.3% was obtained from the 329 questionnaires that were judged suitable for study out of the 345 respondents. In order to ensure that they were qualified to respond to questions based on their professional backgrounds, the study's respondents were frontline construction workers who were on active construction sites. Two statistical methods utilized in the data analysis process are descriptive statistics to address the study subject and structural equation modeling for the hypothesis. At the 5% threshold of significance, the test was run. In this work, multiple regression analysis was performed using the statistical software for social sciences (SPSS) version 27. Accordingly, the test is considered not significant if the alternative hypothesis is accepted and the null hypothesis is rejected if the power of text (p-value) or significance is less than α.

4. RESULTS

4.1 Demographic Profile of Respondents

Table 1: Demographic Profile of Respondents

	Frequency	Percent
Firm		
Architectural firm	48	14.6
Building firm	54	16.4
Engineering firm	42	12.8
Quantity Surveying firm	185	56.2
Size of firm		
< 5	102	31.0
5 – 49	197	59.9
50 – 100	30	9.1
Years of Operation		
0 – 5	48	14.6
6 – 10	72	21.9
11 – 20	131	39.8
Above 20	78	23.7
Educational Qualification		
HND/B. Sc	132	40.1
M.Sc/Ph.D	197	59.9
Professional Qualification		
Probationer (Awaiting Registration)	150	45.6
Registered Member/ Fellow	179	54.4
Years of experience		
0 - 5 years	60	18.2
6 - 10 years	102	31.0
11 - 20 years	125	38.0
Above 20 years	42	12.8
Location of firm		
Abia	33	10
Anambra	59	18
Ebonyi	46	14
Enugu	69	21
Imo	121	37
Current position		
Director / General Manager	72	21.9
Project manager, supervisor or coordinator	119	36.2
Field engineer	24	7.3
HOD	30	9.1
Construction professional	84	25.5

Source: Field survey (2024)

Table 1 shows that more than half (56.2%) of the firms studied were Quantity surveying firm while the fewest was Engineering firm (12.8%). Similarly, the size of more than half of the firm studied was 5 to 59 employees. Majority of the firm (63.5%) have been in operation for over 10 years. There are more employees with M.Sc/Ph.D (59.9%) and who are registered member/fellow (54.4%). Most of the employees of the firm have between 5 to 20 years of experience (69%). The firm studied were located in Anambra (1.8%), Ebonyi (1.8%), Enugu (17.9%), Imo (32.8%) and other states (45.6%). The current position held by the respondents were Director / General Manager (21.9%), Project manager, supervisor or coordinator (36.2%), field manager (7.3%), HOD (9.1%) and Construction professional (25.5%)

4.2 Component of information management systems operational to construction organizations in South East, Nigeria.

Table 2: Shows response on Components of Information Management System

S/n	**Components of IMS in Use in your firm**	n = 287
1	Microsoft Project / MS Project	263 (91.6)
2	Primavera	132 (46.0)
3	Power Project / PM Systems	191 (66.6)
4	Build soft	84 (29.3)
5	Master bill / WinQS Estimate	132 (46.0)
6	Spreadsheets (e.g., MS Excel)	287(100.0)
7	Presentations (e.g., MS, Power Point)	281 (97.9)
8	Word Processors (e.g., MS Word)	275 (95.8)
9	Microsoft Project Online	197 (68.6)
10	Databases (e.g., MS Access)	156 (54.4)
11	AutoCAD/ArchiCAD	263 (91.6)
12	E-mail and Short MessageServices (SMS)	281 (97.9)
13	Mobile internet	275 (95.8)
14	Video conferencing / Tele conferencing	270 (94.1)
15	Electronic purchasing (E-purchasing)	227 (79.1)
16	Project specific websites (Extranets)	162 (56.4)
17	Site surveillance Technologies (e.g. CCTV etc)	203 (70.7)
18	Electronic tendering (E-tendering)	203 (70.7)
19	Modeling and visualization (e.g., 3D-CAD, 4D-CAD etc)	221 (77.0)
20	Electronic document management systems (EDMS) / Firms private servers	155 (54.0)
21	Integrated software (e.g. Enterprise Resource Planning; ERP) / Web base tools (WPMS)	120 (41.8)

Source: Field survey (2024)

Table 2 shows the different levels of components of information management system operational in the 87% of construction firms that utilize IMS as indicated by the respondents. They components operational in the firms include: MS Project / MS Project, Power Project / PM Systems, Spreadsheets (e.g MS Excel) and Presentations (e.g., MS Power Point). Word Processors (e.g MsWord) , Microsoft Project Online , Databases (e.g MsAccess) , AutoCAD / ArchiCAD, E-mail and Short Message Services (SMS), Mobile internet , Video conferencing / Tele conferencing, Electronic purchasing (E-purchasing), Project specific websites (Extranets) , Site surveillance Technologies (e.g. CCTV etc), Electronic tendering (E-tendering), Modeling and visualization (eg. 3D-CAD, 4D-CAD etc), and Electronic document management systems (EDMS) / Firms private servers.

4.3 Modeling of the relationship between the Utilization of IMS and Firm performance

This section developed a model (CIMS-CFP model) to evaluate whether improving the utilization of information management can influence construction firm performance in South-East, Nigeria. The data underpinning is seen in table 3 and table 4.

Table 3: Performance of construction organizations

S/n	Key Performance indicators and attributes	Very Low n (%)	Very high n (%)	Mean±SD
1	Feedback capabilities between project participants	0 (0.0)	72 (21.9)	3.98±0.75
2	Technology advancement level and technical skill of the project team	0 (0.0)	54 (16.4)	3.89±0.76
3	Consultants' cooperation to Project progress monitoring	0 (0.0)	78 (23.7)	4.05±0.67
4	Consultants' Predictability and commitment to meet cost, time and quality	0 (0.0)	102 (31.0)	4.04±0.83
5	Consultants' commitment to ensure construction work is done according to specifications	0 (0.0)	161 (48.9)	4.31±0.81
6	Consultants' involvement to monitor the project progress	0 (0.0)	131 (39.8)	4.23±0.76
7	Consultants' cooperation to solve problems	0 (0.0)	83 (25.2)	4.09±0.69
8	Control mechanism of the project activities	6 (1.8)	60 (18.2)	3.71±0.95
9	Developing an appropriate organizing structure	6 (1.8)	36 (10.9)	3.60±0.89
10	Motivating skills of the management team and employee	0 (0.0)	72 (21.9)	3.78±0.95
11	Implementing an effective safety, quality assurance program	0 (0.0)	95 (28.9)	3.74±1.05
12	Project team leader's adaptability to changes and working relationship	6 (1.8)	90 (27.4)	3.96±0.89
13	Upgrade in communication system and use of IT	18 (5.5)	72 (21.9)	3.71±1.06
14	Good track record of timely completion of the project	6 (1.8)	90 (27.4)	3.74±1.07
15	Reduced Cost of processing information and construction work	12 (3.6)	66 (20.1)	3.69±1.03
16	Quality of resources (Equipment and Materials) and workmanship	0 (0.0)	90 (27.4)	3.96±0.86
17	Overall management actions, attitude and flexibility to information and innovation	0 (0.0)	60 (18.2)	3.85±0.78
18	Effective Communication system and coordinating among project participants	0 (0.0)	78 (23.7)	3.87±0.86
19	Good Relationship / Cooperation with employees and clients	0 (0.0)	102 (31.0)	3.98±0.91
20	Adopting learning and growth culture in the organization	6 (1.8)	66 (20.1)	3.76±0.92
21	Qualifications of human resources in the company	0 (0.0)	78 (23.7)	3.95±0.78
22	Project management Schedule and Planning performance / efficiency	0 (0.0)	90 (27.4)	3.96±0.86
23	Technological and technical capabilities of the company.	6 (1.8)	66 (20.1)	3.84±0.85
24	An availability of quality control system	0 (0.0)	84 (25.5)	3.85±0.89
25	Capacity and financial stability of the company and market share.	6 (1.8)	54 (16.4)	3.54±0.99
26	Adopting Training and learning to develop capacities and expertise in the organization	6 (1.8)	66 (20.1)	3.62±0.97
27	Higher Profitability ratio /yield to the company.	0 (0.0)	54 (16.4)	3.54±0.95

Source: Field survey (2024)

All the responses in table 3 above show high degree skewness. A high value response and they are arranged in different categories or order of mean value, which are indicated by mean response values greater than the criterion mean of 3 and very low standard deviations indicating low variability of responses. The effective performance indicators fall into the various sub groups of cost group, quality group, environment group, project management group, health and safety group, relationship group, innovation group, qualification group, financial group for measuring performance.

Table 4: Level of utilization of IMS components in south-East

S/N	Components	MIS	Rank	Remarks
1	Video conferencing / Tele conferencing	2.80	10th	Low utilization
2	Mobile internet	3.65	5th	Moderately utilisation
3	E-mail and Short Message Services (SMS)	4.00	1st	Highly used
4	Presentations (e.g., MS Power Point)	3.45	6th	Moderately utilisation
5	Spreadsheets (e.g., MS Excel)	3.90	3rd	Moderately utilisation
6	AutoCAD / ArchiCAD	3.85	4th	Moderately utilisation
7	Word Processors (e.g., MS Word)	3.98	2nd	Moderately utilisation
8	Electronic purchasing (E-purchasing)	2.53	11th	Low utilization
9	Microsoft Project / MS Project	3.01	9th	Moderately utilisation
10	Electronic document management systems (EDMS) / Firms private servers	2.26	12th	Low utilization
11	Modeling and visualization (eg. 3D-CAD, 4D-CAD etc)	3.16	7th	Moderately utilisation
12	Site surveillance Technologies (e.g. CCTV etc)	3.02	8th	Moderately utilisation
13	Databases (e.g MsAccess)	1.71	13th	Very low utilisation
14	Power Project / PM Systems,	1.71	14th	Very low utilisation
15	Electronic tendering (E-tendering)	1.56	15th	Very low utilisation
16	Project specific websites (Extranets)	1.53	16th	Very low utilisation
17	Master bill / WinQS Estimate	1.47	17th	Very low utilisation
18	Microsoft Project Online	1.47	17th	Very low utilisation
19	Integrated software (e.g. Enterprise Resource Planning; ERP) / Web base tools (WPMS)	1.27	18th	Very low utilisation
20	Build soft	1.01	19th	Very low utilisation
21	Primavera	0.74	20th	Very low utilisation

MIS = Mean Item Score
Source: Field Survey (2024)

The results in Table 4 shows four bands of Mean Item Scores (MIS, < 4.0, > 3.0 > 2.0 and > 1.0) respectively. One (1) out of the total information management systems evaluated in the study are in the in top tier (MIS, < 4.0) to emerge as the most important information systems applicable to the construction operations. The MIS for this category of IMS components that is, email and short media messages obtained a mean item score of 4.00 to emerge as the most prevalently or highly used IMS component in the study. The second tier comprised of components with mean item score ranging between 3.01 – 3.98 and eight components that is, 385 are in this category. The second to the 9th most prevalently used IMS components in the study, namely: word processor, spread sheets, AutoCAD, mobile internet, MS PowerPoint, modelling and visualization tools, site surveillance tools and MS projects. The IMS components (2nd – 9th) are moderately used in South-East, Nigeria.

The third band comprises of IMS components with the mean item scores greater than 2.0 (2.25; 2.53; 2.80) and only three or 13% of the components that is electronic document management system, electronic purchasing and video-conferencing are located within this tier and their overall level of utilization is low. The last tier comprises of components with the mean item score greater than 1.00. Ten components are situated in this zone (MIS, 1.01 – 1.71 > 1.00) and the overall level of use of these components is very low. The component with the least level of use is Primavera, build soft software, integrated software such as Enterprise resource Planning and Microsoft project online. In sum the overall level of utilization based on the descriptive statistics show an overall low level of application with an average mean of 2.48 to agree with the results of the previous that very proportion of the sample (13%) engages IMS components in their construction practice.

4.3.1 The Construction Information Management System - Construction Firm Performance (CIMS-CFP) Model

The model is further used to determine hypothesis which states that there is no significant relationship between the current level of information management system utilisation and the performance of construction organisations in South-East, Nigeria. The modelling applied structural equation modelling based on the involvement of multiple dependent and independent variables. The resulting model is termed Construction Information Management System – Construction Firm Performance (CIMS-CFP-model).

Analysis of the structural model: CIMS-CFP-model comprises 44 structural paths in a second-order recursive model, 23 manifest variables (fp1- fp23) measured the barriers and it refers to the dependent variables in the CIMS-CFP-model. The predictor variables are construction information management system components (SCM1-SCM21). The CIMS-CFP-model was iterated four times before selecting the final structural model (Figure 4). Based on the model modification, the validity of the assumptions underpinning the model in the study is extended beyond the theoretical standpoints of the hypothesised model to empirical evidence that is the data underpinning the model.

The overall effects of CIMS on construction firm performance are strongly correlated and the strength of the correlation is high (80%). The examination of the structural paths indicates that the 80% change can stimulate significant improvement in construction firm performance (regression loading, 48% - 79% > 60%; estimates on the arrows) for 100% of the paths in CIMS-CFP-model. Construction information management system produced varying significant direct mitigation ranging between 42% - 71% (estimates on residual estimates e2 - e29) to show that 80% change in information management system is needed to improve construction firm performance up to 71%. A unit improvement in the CIMS will likewise improve construction firm performance 7% -70%.

Feasibility of parameter estimates and appropriateness of standard error: on the appropriateness of the structural model and the overall results of the CIMS-CFP-model, the examination of the parameter estimates portrayed the signs combining positive and negative values and sizes (< 1.00 and < 1.00; Table 5). However, the parameter estimates in the CIMS-CFP-model are feasible with positive values showing a direct relationship in which an increase in one unit of CIMS would induce a corresponding change in barriers respectively.

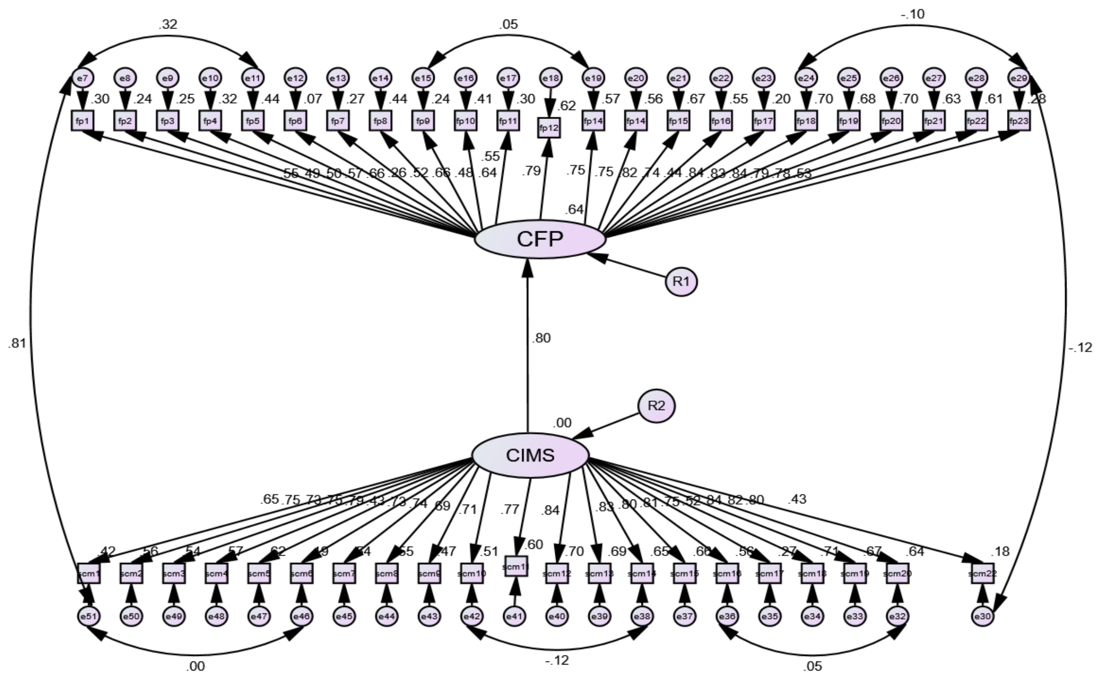

Figure 4: SEM structural model of the influence of construction information management system on construction firm performance **(**CIMS-CFP-model**). Source**: Field survey (2024)

In terms of the appropriateness of the standard error, the significance of the estimates is also adequate with fairly balanced values that are not widely dispersed.

Table 5: Parameters estimates for CIMS-CFP-model

Paths			Estim ate	S. E.	C.R.	P	Lab el
FP2	<-	CF	.831	.05	15.0	**	par_
	--	P		5	60	*	1
FP3	<-	CF	.916	.06	15.3	**	par_
	--	P		0	95	*	2
FP4	<-	CF	1.040	.06	17.3	**	par_
	--	P		0	67	*	3
FP5	<-	CF	1.414	.05	25.7	**	par_
	--	P		5	39	*	4
FP6	<-	CF	.512	.06	8.20	**	par_
	--	P		2	4	*	5
FP7	<-	CF	.883	.05	16.0	**	par_
	--	P		5	20	*	6
FP8	<-	CF	1.187	.05	20.2	**	par_
	--	P		9	25	*	7
FP9	<-	CF	.937	.06	14.9	**	par_
	--	P		3	18	*	8
FP10	<-	CF	1.372	.07	19.6	**	par_
	--	P		0	24	*	9
FP11	<-	CF	1.134	.06	16.7	**	par_
	--	P		8	72	*	10
FP12	<-	CF	1.730	.07	23.8	**	par_
	--	P		3	43	*	11
FP13	<-	CF	1.369	.06	22.9	**	par_
	--	P		0	10	*	12
FP14	<-	CF	1.342	.05	22.8	**	par_
	--	P		9	00	*	13
FP15	<-	CF	1.589	.06	24.8	**	par_
	--	P		4	29	*	14
FP16	<-	CF	1.356	.06	22.5	**	par_
	--	P		0	03	*	15
FP17	<-	CF	.837	.06	13.6	**	par_
	--	P		1	61	*	16
FP18	<-	CF	1.589	.06	25.3	**	par_
	--	P		3	45	*	17

FP19	<---	CFP	1.689	.068	24.970	***	par_18
SCM20	<---	CIMS	2.227	.100	22.172	***	par_23
SCM19	<---	CIMS	2.134	.095	22.518	***	par_24
SCM18	<---	CIMS	2.076	.090	22.959	***	par_25
SCM16	<---	CIMS	1.771	.084	21.026	***	par_27
SCM15	<---	CIMS	2.108	.094	22.401	***	par_28
SCM14	<---	CIMS	2.006	.090	22.186	***	par_29
SCM12	<---	CIMS	2.318	.101	22.931	***	par_31
SCM11	<---	CIMS	1.889	.088	21.521	***	par_32
SCM10	<---	CIMS	1.999	.099	20.171	***	par_33
SCM9	<---	CIMS	1.655	.085	19.514	***	par_34
SCM8	<---	CIMS	1.726	.083	20.847	***	par_35
SCM7	<---	CIMS	1.674	.081	20.609	***	par_36
SCM6	<---	CIMS	1.048	.080	13.048	***	par_37
SCM5	<---	CIMS	1.926	.088	21.875	***	par_38
SCM4	<---	CIMS	1.682	.080	21.123	***	par_39
SCM3	<---	CIMS	1.697	.082	20.599	***	par_40
SCM2	<---	CIMS	1.620	.077	20.979	***	par_41
SCM1	<---	CIMS	1.376	.047	29.333	***	par_42

S.E = standard error, C.R = critical ratio. **Source**: Field survey (2024)

Based on the results in Table 5, the standard error estimates in the CIMS-CFP-model are appropriate (standard error < 1.00), however, the standard errors are averagely determined (standard errors, 31% – 42%) and the inference shows the moderately determined in the model.

Variance and covariance validity: The CR depicts the results of the parameter estimate divided by the standard error and is valid by the critical p-values greater than ± 1.96. A valid CR is greater than 1.96 and the results in Table 6 indicate CR values (8.204 – 29.333 > 1.96) for paths in the structural model to show that the covariance and variance indicators are appropriate by the level of improvement in barriers predicted by human development concerns.

The hypothesis states that there is no significant relationship between the current level of information management system utilisation and the performance of construction organisations in South-East, Nigeria. CIMS-CFP-model (Table 5) is further used to validate Ho_5 using mixed data.

The results in Table 6 indicate that all parameter estimates supporting the rejection of the hypothesis. The null hypothesis for the 44 paths depicting the effect of human development concerns on barriers to house ownership is rejected (p-values 0.0000 or *** < 0.05). The inference confirms CIMS capability to improve barriers to house ownership by the extent of the parameter estimates indicated in Figure 1. When this result is implemented, the implications suggest that improving information management systems is not a stand-alone requirement for scaling construction firm organisations performance as an aspect of the overall measures contributing only 80%.

Table 6: Hypothesis test of the relationship between information management system and construction firm performance

Paths			**Estimate**	**S.E.**	**C.R.**	**P**	**Label**	**Decision**
FP2	<---	CFP	.831	.055	15.060	***	par_1	Reject Ho_5
FP3	<---	CFP	.916	.060	15.395	***	par_2	Reject Ho_5
FP4	<---	CFP	1.040	.060	17.367	***	par_3	Reject Ho_5
FP5	<---	CFP	1.414	.055	25.739	***	par_4	Reject Ho_5
FP6	<---	CFP	.512	.062	8.204	***	par_5	Reject Ho_5
FP7	<---	CFP	.883	.055	16.020	***	par_6	Reject Ho_5
FP8	<---	CFP	1.187	.059	20.225	***	par_7	Reject Ho_5
FP9	<---	CFP	.937	.063	14.918	***	par_8	Reject Ho_5
FP1	<	CF	1.37	.0	19.	*	par	Reje

0	---	P	2	70	624	***	_9	ct Ho_5
FP11	<---	CFP	1.134	.068	16.772	***	par_10	Reject Ho_5
FP12	<---	CFP	1.730	.073	23.843	***	par_11	Reject Ho_5
FP13	<---	CFP	1.369	.060	22.910	***	par_12	Reject Ho_5
FP14	<---	CFP	1.342	.059	22.800	***	par_13	Reject Ho_5
FP15	<---	CFP	1.589	.064	24.829	***	par_14	Reject Ho_5
FP16	<---	CFP	1.356	.060	22.503	***	par_15	Reject Ho_5
FP17	<---	CFP	.837	.061	13.661	***	par_16	Reject Ho_5
SCM20	<---	CIMS	2.227	.100	22.172	***	par_23	Reject Ho_5
SCM15	<---	CIMS	2.108	.094	22.401	***	par_28	Reject Ho_5
SCM14	<---	CIMS	2.006	.090	22.186	***	par_29	Reject Ho_5
SCM13	<---	CIMS	2.023	.089	22.723	***	par_30	Reject Ho_5
SCM12	<---	CIMS	2.318	.101	22.931	***	par_31	Reject Ho_5
SCM11	<---	CIMS	1.889	.088	21.521	***	par_32	Reject Ho_5
SCM10	<---	CIMS	1.999	.099	20.171	***	par_33	Reject Ho_5
SCM9	<---	CIMS	1.655	.085	19.514	***	par_34	Reject Ho_5
SCM8	<---	CIMS	1.726	.083	20.847	***	par_35	Reject Ho_5
SCM7	<---	CIMS	1.674	.081	20.609	***	par_36	Reject Ho_5
SCM6	<---	CIMS	1.048	.080	13.048	***	par_37	Reject Ho_5
SCM5	<---	CIMS	1.926	.088	21.875	***	par_38	Reject Ho_5
SCM4	<---	CIMS	1.682	.080	21.123	***	par_39	Reject Ho_5
SCM3	<---	CIMS	1.697	.082	20.599	***	par_40	Reject Ho_5
SCM2	<---	CIMS	1.620	.077	20.979	***	par_41	Reject Ho_5
SCM1	<---	CIMS	1.376	.047	29.333	***	par_42	Reject Ho_5

S.E = standard error, C.R = critical ratio. **Source**: Field survey (2024).

Measurement of model fits: The results in Table 7 indicate that NFI, CFI, RFI, IFI and TLI (0.939, 0.971, 0.944, 0.976 and 0.944 > 0.90), PNFI (0.592 > 0.50) and RMSEA (0.003 < 0.05) to show that hypothesis underlying the model (CIMS-CFP-model) is supported. Based on the modification of the default model, the deviation between constrained and unconstrained sample covariance test using the Likelihood Ratio test statistics (CMIN) (Chi-Square) further affirms that the hypothesis and model fitness are true and valid (CMIN(χ), 41.780, p(0.00 < 0.05).

Table 7: Internal validity of CIMS-CFP-model

S/N	Index	HDC-Bar Model Score	Thresholds	Remarks
1	NFI	0.966	> 0.900	Appropriate
2	RFI	0.990	> 0.900	Appropriate
3	IFI	0.972	> 0.900	Appropriate
4	TLI	0.996	> 0.900	Appropriate
5	CFI	0.971	> 0.900	Appropriate
6	PNFI	0.508	> 0.500	Appropriate
7	RMSEA	0.001	< 0.005	Appropriate
8	CMIN	0.000	< 0.005	Appropriate

Source: Field survey (2024).

Discussion of Findings

Relationship between Information Management Uses and Firm Performance

The Construction industry has undergone a significant transformation in recent years with the adoption of IMS. These transformations have leveraged overarching benefits, in which knowledge is evenly disseminated across studies. In this study, developing, implementing and utilising a construction information management system (CIMS) could produce compelling overall effects on construction firm performance. The resultant model is termed CIMS-CFP-model and the correlations between CIMS and firm performance are strongly correlated. The strength of the correlation is high (80%). CIMS is objective to predicting 80% changes in construction organisations' performance. The direct impacts of each CIMS and components are likewise significant producing direct varying effects ranging between 48% - 79% each. Indirect change/contribution to the various dimensions of construction firm performances also varies and ranges between 42% - 71% to show that IMSs' utilisation is needed to improve construction firm performance up to 80%.

In support of the findings in this study, IMS has been found to positively influence organisational performance in the construction industry. For instance, [25] found that the adoption of BIM can help to improve project coordination, reduce errors and rework, and enhance communication. [26] found that the adoption of BIM can help to improve project coordination, reduce errors and rework, and enhance communication. [27] also affirmed that the adoption of PMIS can help to improve project management, reduce costs, and enhance communication.

Overall, these studies provide evidence for the positive influence of information management systems on organisational performance in the construction industry. The authors suggest that information management systems can improve decision-making processes, increase efficiency, facilitate communication and collaboration, and enhance the quality and accuracy of information. Organisations in the construction industry can benefit from adopting information management systems to improve their overall performance and gain a competitive advantage in the market. However, these studies support the positive influence of IMS on organisational performance in the construction industry only.

In Nigeria context, prior studies also linked IMS to varying performance contexts of construction organisations. A study by [28] found that information management systems positively impacted the performance of the industry by improving decision-making processes, enhancing communication, and increasing efficiency. The study by [29] in South-East, Nigeria linked IMS to a positive impact on the performance of the industry by improving the accuracy and timeliness of information, enhancing communication, and increasing efficiency and linked IMS to process improvement in construction organisations These studies not only support the key findings dealing with consultant collaboration and focused on project goals, but also affirm that IMS triggers firm performance through process improvement and information quality.

5. CONCLUSION

The study developed CIMS-CFP graphical model using Structural Equation Modelling to predict the influence of utilising Construction Information Management System (CIMS) development and utilisation on construction firm performance. The results indicate that CIMS utilization would improve firm performance by 80%. The overall level of relationship is based on the direct contributions of CIMS ranging between 42% - 71% and the direct contribution of CIMS to respective dimensions of firm performance ranging between 7%-70% respectively. The inference shows that CIMS is objective to stimulating significant positive transformation in construction firm performance. Based on the findings, the study recommends that the current level of utilisation of CIMS in Nigeria construction industry must improve to advance inherent benefits in addition to enabling greater firm performance in construction organisations. Optimizing the full benefits of CIMS utilisation also requires scaling their implementation beyond specialist software reported in this study to advance systems such as building information modeling, project management information systems, enterprise resource planning, construction document management systems, geographic information systems, contract management systems, and safety management systems.

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