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Exploring the Cyber Technology Critical Success Factors for Sustainable Building Projects: A Stationary Analysis Approach

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Abstract: We sought to identify and examine the critical success factors (CSFs) necessary for incorporating cyber technology into residential building projects to augment operational performance and sustainability. An iterative two-stage approach was adopted to explore the phenomena under investigation. General CSFs for cyber technology were first identified from the extant literature, and subsequently explored using primary questionnaire survey data accrued from professionals within the Nigerian building industry. The survey results illustrated that the availability of sensors, good communication networks, mobile devices, and device layers and the creation of workable virtual modes are the main critical success factors for adopting cyber technology. Moreover, Gini's mean difference measure of dispersion showed that the success factor in stationary cyber technology adoption is government support. The study's findings guide building industry stakeholders to embrace cyber technology to improve cost and sustainability performance in the Nigerian building industry. Due to the originality of the findings of this study, a strong basis is provided for critically evaluating and analyzing the many vital aspects of cyber technology success.

Keywords: cyber technology; sustainability; sustainable development; building projects; project success

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1. Introduction

The availability and state of residential buildings are essential indicators of the health and well-being of a country's populace [1]. Globally, residential buildings use approximately 40% of power and also generate one-third of the global anthropogenic greenhouse gas emissions (GHG) [2]. Nevertheless, the volume of global residential property remains insufficient to meet demand [3]. Migration to city centers engenders rapid, sprawling and often unregulated urbanization (via slum settlement). This issue is further exacerbated by a housing shortfall that impedes low-income earners' access to affordable housing [4]. By the year 2030, an estimated 3 billion people will have a need for housing that is both suitable and cheap [5]. Moreover, building in many developing countries has retained traditional methods which produce excessive environmental pollution, consume vast natural energy resources, create safety issues, and engender low productivity rates [6]. Furthermore, the substandard quality of housing in developing countries necessitates that residential buildings are upgraded in order to improve residents' quality of life [7]. Governments have therefore prioritized quality and affordable housing through the design of several residential policies [1]. However, there remains considerable controversy regarding the affordability of residential buildings for low-income earners [3]. Approximately 30% of building costs are lost to errors, design variations, inefficiencies, poor communication, and concomitant schedule delays [8]. Without proper communication of changes made in real time, cost or time overruns may occur [9]. Moreover, variations made on site should be updated in the as-built model for the purpose of lifecycle management. Hence, design model updates in real time are necessary to optimize project managers' decision making [10]. At present, as-built models are predominantly updated manually after building, and are prone to human errors or omissions [11].

Ubiquitous extant literature advocates the need for constructing "sustainable buildings" that are resource-efficient and environmentally friendly. Wolstenholme et al. [12] campaigned for the adoption of efficient and environmentally friendly building processes as a means of bringing about a revolution in the building sector. However, building professionals often struggle to measure the environmental effects of buildings during construction [13]. Virtual models can offer significant sustainable benefits such as the documentation of as-built information, team collaboration, and visual progress of the project. However, the use of virtual models such as computer-aided design (CAD) models and building information models (BIM) remains largely limited to the pre-building phase [14], although larger facility management organizations in developed countries are integrating BIM during the operational phase of a building's life cycle. This is because virtual models can assist in the maintenance management of buildings via improved knowledge handling and management of building facilities and assets within [15].

Several studies (cf. Chin et al. [16,17], Sørensen [18]) have used a variety of data collection technologies including radio frequency, laser scanners, identifying tags, and digital cameras in an effort to connect virtual models and actual structures. However, the current methods do not provide communication in both directions between the virtual models and the physical building. It is essential to have communication in both directions in order to improve the facility's feedback and level of control. Providing appropriate feedback on design or building alterations in real time may be accomplished via the use of bi-directional coordination between virtual models and the actual building. The integration of virtual and physical platforms in such a manner that any changes made to one are immediately reflected in the other is what we mean when we talk about bi-directional coordination [19]. This tight integration and coordination between the virtual model and the physical building is commonly known as a cyber–physical systems approach. Cyber–physical systems bridge the cyber (intelligence, communication, and information) and physical worlds through the use of networked sensors. [20]. This technique enables significant advances to be made in the monitoring of building progress, management of the building process, as-built documentation, and sustainable building practices. Even in the building business, new cyber technologies that fall under the umbrella term "Industry 4.0", such as artificial intelligence, big data, Internet of Things, and cloud computing, have shown that they may successfully contribute to industrial intelligence [21]. These cyber technologies coalesce to enhance design optimization, resource management, energy savings, risk monitoring, emissions reduction, performance evaluation, and overall project delivery [22]. However, in developing countries, these technologies are only partially adopted in specific areas of the building industry, with only a few macroscopic studies on their wider integration.

Hence, the following research questions were set for this study: (1) What are the requirements for the implementation of cyber technology in developing countries' building industry? (2) Is the need to examine these requirements by determining the critical success factors (CSFs) for cyber technology? According to Rockart [23] CSFs are factors that improve the organizational competitiveness and success of a phenomenon's implementation. CSFs also enhance active customer support and participation through stakeholder engagement [24].

Consequently, this study addresses a notable gap in the prevailing body of knowledge on the adoption of cyber technology in Nigeria by answering the following questions: (1) What are the critical success factors for implementing cyber technology in the Nigerian building industry? (2) Which factor is the stationary success factor of cyber technology in Nigeria? Answers to these questions will generate new knowledge on the critical success factors for implementing cyber technology in the Nigerian building industry [24]. Rockart [23] recognizes CSFs as "areas where, if satisfactory, the results will ensure the organization's competitive success." Likewise, Chan et al. [25] and Yu et al. [26] posit that CSFs might be viewed as essential management preparation and action sectors for success [27]. In this paper, after an overview of the current state of the art is a discussion of the methodology that was ultimately chosen for this research. Following that, a discussion of the suggested conclusions of this work is conducted with reference to the prior research. In the conclusion, we provide the most important results and make suggestions for the future.

2. Cyber Technology Critical Success Factors

Sensor-based networks monitor different characteristics (e.g., temperature, the movement of occupants or energy consumption (cf. Shen et al., 2008)) of the developed facility or the building process itself [28]. These networks may also provide building workers access to other control options (for example, information captured in the radio frequency identification tag (RFID)) dependent upon the senor's specification and design. Additionally, devices are available that comprise the client devices (e.g., personal digital assistant (PDA) or smart phones), through which the end user (for example, the building crew on site) may interact with the system [28,29]. This network has a dual purpose because it grants information access that was discovered by the layer below it (the sensing layer), and it also makes it possible for the user to submit information themselves (through the user interface) [30]. Furthermore, the availability of the communication layer is a component that is quite significant in this equation. This layer of the protocol stack encompasses the Internet as well as other wireless communication networks. Some examples of these networks are wireless personal area networks (WPANs), wide area networks (WANs), and local area networks (LANs) [28]. These communication networks connect mobile devices and other pieces of technology, enabling building workers on site to cooperate and share information with colleagues in the design office. Data gathered through mobile devices can also be sent to a database in the contents and application layer [28,31]. The communication network is one of the most significant technologies for improving bi-directional coordination between virtual models and physical buildings since it allows mobile and stationary devices to communicate and share information [32–34]. The Internet, wireless local area networks (WLAN, more commonly known as Wi-Fi), and wireless personal area networks (WPAN), which comprise of ultra-wide band, Zigbee, and Bluetooth, are all examples of communication tools that are currently being utilized in the building industry [28,35]. Bluetooth enables data to be transferred or exchanged wirelessly between equipment on site, as well as between site and remote offices, which in turn promotes project collaboration over geographically dispersed areas. Within the parameters of this study, the information or data acquired at the building site may be transmitted to the virtual model situated in the remote office via communication networks and vice versa [28]. A number of CSFs are used to decide the type of communication network that is required, as indicated in Table 1. This may include the cost, the quantity of data that must be transmitted in a given length of time, the network architecture, and the amount of battery life that must be conserved.

Table 1. CSFs of cyber technology in the building industry.

Code	CSFs	References
D1	Availability of sensors	[36–42]
D2	Availability of good communication networks	
D3	Availability of mobile devices	
D4	Availability of device layers	
D5	Creation of workable virtual modes	
D6	Availability of a working communication layer	
D7	Availability of sensing layers	
D8	Government support	
D9	Globalization	
D10	Flexibility	
D11	Market advantage	
D12	Customer satisfaction	
D13	Employment development	
D14	Its safety and security	
D15	Its fraud resistance	
D16	Accuracy	
D17	Life quality improvement	
D18	Project time regulations	

3. Research Methodology

The epistemological approach adopted was based on a mixed philosophical construct consisting of both interpretivism and postpositivism. Specifically, a two-stage process adopted used pertinent literature (as a secondary data source) to determine CSFs for measurement, and primary questionnaire survey data were gathered on these identified CSFs and analyzed to determine these factors. The questionnaire contained three sections. Section one collated the demographic profile of respondents; section two gathered quantitative interval data on a 5-point Likert scale to measure the CSFs of cyber technology (Table 1), where 5 = extremely high, 4 = high, 3 = average, 2 = small, and 1 = no or very small, as frequently used in previous studies [43–47]; and section three gathered qualitative open-ended data on questions that sought further information on the essential CSFs identified. To ensure robust ethical compliance, all participants were assured that all data would be kept strictly confidential, no personal details would be divulged nor disseminated, and data collected would be retained on a secure server and destroyed upon completion of this investigation. It is vital to note that a critical review analysis has been carried out in order to identify the research gap that was indicated before. This analysis was undertaken for the purpose of conducting an in-depth and critical study of the gathered literature. These assessments were helpful in exposing both the gaps in the research as well as the prospects for the use of cyber technology. This analysis makes it possible to map out and expand one's knowledge in a particular area of research by illuminating the connections between the most prominent publications, scholars, organizations, subjects, and other facets of the subject.

Three thematic groups of professionals were identified and contacted, including contractors, consultants, and clients [48]. These professionals were further sub-classified by profession/occupation as Quantity Surveyors, Builders, Architects, and Engineers. As for ethical consideration, approval for the study was not required in accordance with local/national legislation. Entry prequalification criteria were based on the knowledge and understanding of the participants of the phenomena under investigation. A convenience sampling technique was used in the research to ensure that there is an equal chance of every member being selected. Moreover, a methodological purpose analysis was used to determine the sample size [43,49]. The questionnaire was administered to 119 people using a postal survey and 98 completed questionnaires were retrieved, constituting an 82% response rate. This high level of return is considered appropriate for a study of this nature [47,50,51]. Figure 1 illustrates the research framework of this study, adopted from El-Kholy and Akal [52].

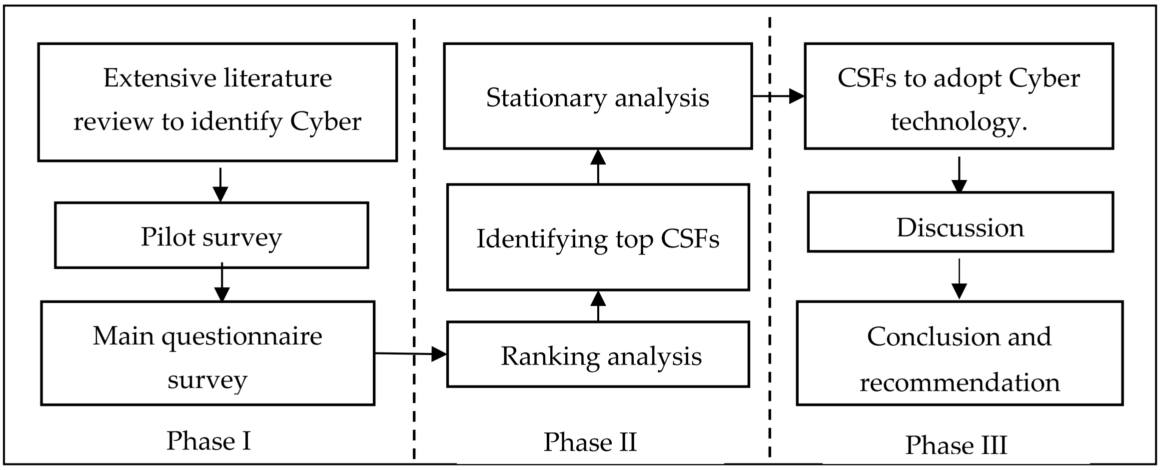

Figure 1. Research framework.

3.1. Relative Importance Index (RII)

For Likert scale data analysis, mean scores and the Relative Importance Index (RII) were used. RII is a statistical approach used to rank different variables [53]. It is also a frequently used method for evaluating variables [54–56]. Previous studies assessed the frequency and intensity of responses using Equation (1) [57,58]:

$$RII = \frac{\sum w}{A \times N} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5 \times N} \quad (1)$$

where W is each participant's weighting, A is the maximum weight, and N is the total number of participants. Table 2 provides statistical means, standard deviations, and RII scores based on these parameters. After rating the elements, the consultants, contractors, and owners compare their relative importance.

Table 2. Demographic background.

Profession of Practice	Percentages
Architect	26%
Quantity Surveyor	30%
Builder	18%
Engineer	26%
Number of practice years	
Below 10	37%
11–20	50%
Above 20	13%
Educational qualification	
HND	15%
B.Sc/B.Tech	46%
M.Sc/M.Tech	27%
Ph.D.	12%
Number of projects participated in	
1–5	10%
6–10	17%
11–15	32%
16–20	22%
Above 20	19%

Table 2. *Cont.*

Profession of Practice	Percentages
Type of organization	
Consulting	35%
Contracting	29%
Government Agency	36%

3.2. Stationary Analysis (Gini's Mean)

The technique used by El-Kholy (2021) is followed in the present research, and Gini's Mean Difference Measure of Dispersion and the Weighted Geometric Mean are used to determine the amount of variation in the data. The following is a list of the stages that comprise this method. (a) First is figuring out the standard deviation of the RII figures by using Gini's mean difference as a measure of dispersion, as outlined in Equation (2) [59]:

$$G.M = \frac{G}{M} \tag{2}$$

where $G.M$ is Gini's mean difference measure of dispersion, G is the summation of the differences in the value of all possible pairs of variables, and M is the total number of differences, where N is the number of variables:

$$M = \frac{N(N-1)}{2} \tag{3}$$

Then, we develop a weight for each RII number based on the calculated Gini mean difference measure of dispersion through the application of Equation (4) [52]:

$$Wi = G.M \times \frac{\text{RIIi}}{\text{RII1}} \tag{4}$$

where Wi is the weight that is assigned to each RII number, RII is the relative index number that is assigned to any cause, and RII1 is the highest relative index number that is assigned to specify the weighted geometric mean (G:M. (w)) of the RII numbers in order to represent the stationary central value and fit on the RII calibration in order to reflect the stationary success factors for adopting cyber technology (see Equation (5)) [52]:

$$G : M.\ (w) = Antilog\frac{\sum \text{w.logRII}}{\sum \text{w}} \tag{5}$$

where $\sum$w is the sum of the weights assigned to the RII numbers.

4. Results

4.1. Demographic Background

Table 2 shows the professions of the respondents to the study. About 26% are architects, 30% are quantity surveyors, 18% builders, and 26% are engineers. The key professions in the building industry are well represented among the respondents, hence providing credible sources of information for the study. In addition, half (50%) of the respondents have been in their profession in the building industry for 11 to 20 years and 37% of them have experience of less than 10 years. Only about 13% have more than 20 years of experience. This indicates that the respondents possess the requisite knowledge in the building process. Furthermore, B.Sc./B.Tech degree holders make up 46% and HND holders represent 15%. M.Sc./M.Tech holders constitute 27% while those with a Ph.D. represent 12% of the respondents. This shows that all the respondents are educationally sound in the building industry, and are thus relevant for the research purpose. Table 2 also indicates the number of building projects undertaken/participated in by the respondents. About 32% of the respondents have participated in 11–15 projects, 22% in 16–20 projects, and 19% in more than 20 projects.

Only 17% and 10% have participated in 6–10 and 1–5 projects, respectively. This reveals that the professionals are experienced in the building industry; hence, they are familiar with the use of technology in the industry. Regarding the type of organization where the respondents work, 35% of them work in consulting firms, 36% in government agencies, and 29% in contracting firms. This indicates that the professionals practice in sectors relevant to the building industry.

4.2. Consistency of the Collected Data

The Cronbach's alpha coefficient was 0.711, which is >0.70, a designated limit value [60]. Consequently, the data obtained from the questionnaires satisfied the internal consistency and were considered reliable and valid to carry out the analysis.

4.3. Relative Importance Index (RII)

We identified 18 CSFs (from extant literature reviewed) necessary to implement cyber technology. Data obtained from the survey were entered into SPSS software and analyzed using the RII method. The value of the RII range is between 0 and 1, with 0 not inclusive. The higher the RII value, the more the criteria are deemed important and vice versa. Chen et al. [61] argues that the transformation matrix is an evaluation of RII, complete with the appropriate level of significance and the level of importance that was generated from RII; this argument may be read as follows.

High (H)	0.8 < RII < 1.0
High-Medium (H-M)	0.6 < RII < 0.8
Medium (M)	0.4 < RII < 0.6
Medium-Low (M-L)	0.2 < RII < 0.4
Low (L)	0.0 < RII < 0.2

According to the respondents, the most significant CSF for cyber technology adoption is the availability of good communication networks, with an RII of 0.85 (Table 3). This is followed by the availability of sensing layers, accuracy, availability of sensors, and life quality improvement, with RIIs of 0.80, 0.77, 0.73, and 0.67, respectively (Figure 2).

Table 3. Drivers for adopting cyber technology during building.

S/N	Drivers for Adoption	R.II	Level of Importance	Rank
1	Availability of good communication networks	0.85	H	1
2	Availability of sensing layers	0.80	H	2
3	Accuracy	0.77	H-M	3
4	Availability of sensors	0.73	H-M	4
5	Life quality improvement	0.67	H-M	5
6	Availability of a working communication layer	0.65	H-M	6
7	Government support	0.61	H-M	7
8	Availability of mobile devices	0.54	M	8
9	Availability of device layers	0.46	M	9
10	Customer satisfaction	0.39	M-L	10
11	Its safety and security	0.35	M-L	11
12	Market advantage	0.32	M-L	12
13	Employment development	0.27	M-L	13
14	Creation of workable virtual modes	0.24	M-L	14
15	Its fraud resistance	0.22	M-L	15
16	Project time regulations	0.20	M-L	16
17	Flexibility	0.13	L	17
18	Globalization	0.11	L	18

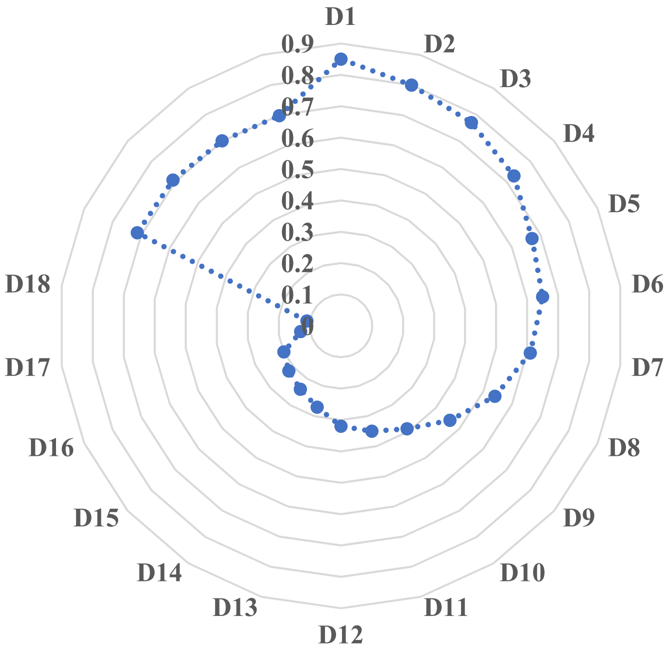

Figure 2. RII for cyber technology success factors.

Other significant drivers of cyber technology adoption in the order of significance are the availability of a working communication layer, government support, availability of mobile devices, availability of device layers, customer satisfaction, safety and security, market advantage, employment development, creation of workable virtual modes, and fraud resistance. Flexibility (0.13) and globalization (0.11) are not considered as significant drivers for the adoption of cyber technology in the study area.

4.4. Stationary Cyber Technology Success Factors

It is possible to calculate Gini's coefficient of mean difference for these values by making use of the RII scores that are provided for each CSF in Table 3. Gini's coefficient of mean difference (G.M) is found by first finding the total of the differences in the scores of all possible pairs of variables (G). This is so that Gini's coefficient may be computed. Table 3 displays the results of the computations performed to determine the differences between all possible pairings of RII values. The total number of differences (M) comes to 153, whereas the sum of the differences in the scores of all of the conceivable combinations of variables, denoted by "G", is 44.27. (Table 4). Gini's coefficient of mean difference (G.M) is 0.289 when Equation (2) is used to calculate it. In addition, as shown in Table 4, w.Log RII = −0.77 and w.Log RII = 2.828; accordingly, the weighted geometric mean G.M (w) is 0.532. According to Table 5, this score on the RII calibration is equivalent to the RII numbers D8 and D9. As a result, the use of cyber technology in the Nigerian building sector is judged according to this success element, which is regarded the stationary criterion.

Table 4. Differences between all possible pairs of RII numbers.

Rank	Criterion	RII	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Sum
1	D1	0.85	0.74																	0.74
2	D2	0.8	0.72	0.69																1.41
3	D3	0.77	0.65	0.67	0.66															1.98
4	D4	0.73	0.63	0.60	0.64	0.62														2.49
5	D5	0.67	0.61	0.58	0.57	0.60	0.560													2.92
6	D6	0.65	0.58	0.56	0.55	0.53	0.540	0.540												3.30
7	D7	0.61	0.53	0.53	0.53	0.51	0.470	0.520	0.500											3.59
8	D8	0.53	0.50	0.48	0.50	0.49	0.450	0.450	0.480	0.430										3.78
9	D9	0.46	0.46	0.45	0.45	0.46	0.430	0.430	0.410	0.410	0.350									3.85
10	D10	0.39	0.39	0.41	0.42	0.41	0.400	0.410	0.390	0.340	0.330	0.280								3.78
11	D11	0.35	0.31	0.34	0.38	0.38	0.350	0.380	0.370	0.320	0.260	0.260	0.240							3.59
12	D12	0.32	0.24	0.26	0.31	0.34	0.320	0.330	0.340	0.300	0.240	0.190	0.220	0.210						3.30
13	D13	0.27	0.20	0.19	0.23	0.27	0.280	0.300	0.290	0.270	0.220	0.170	0.150	0.190	0.160					2.92
14	D14	0.24	0.18	0.15	0.16	0.19	0.210	0.260	0.260	0.220	0.190	0.150	0.130	0.120	0.140	0.130				2.49
15	D15	0.22	0.12	0.13	0.12	0.12	0.130	0.190	0.220	0.190	0.140	0.120	0.110	0.100	0.070	0.110	0.110			1.98
16	D16	0.2	0.08	0.07	0.10	0.08	0.060	0.110	0.150	0.150	0.110	0.070	0.080	0.080	0.050	0.040	0.090	0.090		1.41
17	D17	0.13	0.05	0.03	0.04	0.06	0.020	0.040	0.070	0.080	0.070	0.040	0.030	0.050	0.030	0.020	0.020	0.070	0.020	0.74
18	D18	0.11	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
Sum			6.99	6.14	5.66	5.06	4.220	3.960	3.480	2.710	1.910	1.280	0.960	0.750	0.450	0.300	0.220	0.160	0.020	44.27

Table 5. Calculations of the weighted geometric mean.

Criterion	RII	Wi	Log RII	Wi. Log RII
D1	0.85	0.2893	−0.071	−0.0204
D2	0.8	0.2723	−0.097	−0.0264
D3	0.77	0.2621	−0.114	−0.0298
D4	0.73	0.2485	−0.137	−0.0340
D5	0.67	0.2281	−0.174	−0.0397
D6	0.65	0.2213	−0.187	−0.0414
D7	0.61	0.2076	−0.215	−0.0446
D8	0.54	0.1838	−0.268	−0.0492
D9	0.46	0.1566	−0.337	−0.0528
D10	0.39	0.1328	−0.409	−0.0543
D11	0.35	0.1191	−0.456	−0.0543
D12	0.32	0.1089	−0.495	−0.0539
D13	0.27	0.0919	−0.569	−0.0523
D14	0.24	0.0817	−0.62	−0.0506
D15	0.22	0.0749	−0.658	−0.0492
D16	0.2	0.0681	−0.699	−0.0476
D17	0.13	0.0443	−0.886	−0.0392
D18	0.11	0.0374	−0.959	−0.0359
Sum		2.8288		−0.7755

5. Discussion

Despite the strong reliance on cyber technology by building industries in developed countries, its presence remains modest in developing nations. Akin to other developing countries, Nigeria has faced challenges and contradictions in the standard of building of residential properties. Although it is expected that new technologies will have a significant impact in the industry, the implications and potential benefits of cyber technology remain difficult to assess. Moreover, its effects on different stakeholders, vital components of the supply chain, and the different stages of the lifecycle of building projects are not fully understood [62]. This emphasizes the need for cyber technology adoption so that these challenges of the availability of good communication networks and other concerns raised in the findings of this study can be alleviated. Practitioners' recognition of the critical role cyber technology in enhancing project delivery will influence top management decisions to accept cyber technology as a major aspect of their projects. Successful adoption of cyber technology is often predicated on the requirement of the CSFs affecting the adoption of cyber technology and a good degree of understanding of cyber technology from various stakeholders. This study illustrates the stationary and critical factors for the adoption of cyber technology which can enhance the sustainability of residential building projects. Building companies that embrace cyber technology have the ability to reduce costs and save time while also improving product quality without having to sacrifice any of the functionalities of their projects.

5.1. Critical Success Factors for Adopting Cyber Security

5.1.1. Availability of Sensors

Wireless sensors are commonly employed for information sharing, functioning as a bridge between traditional and new methods of building [63]. These sensors are used to collect data on the facilities, processes, and resources that are under development at any given time. In addition to this, the sensors are used to monitor the current status of buildings and other types of infrastructure for the whole of their useful lives [64]. These include laser scanners, UWB, cameras, and RFID. With these sensors, relevant information for the specific cyber application can be assessed. They facilitate two-way coordination by serving as a medium for connecting the physical component to their corresponding virtual representation.

5.1.2. Availability of Good Communication Networks

Because it enables the transfer and sharing of information between sensors, mobile devices, and fixed devices, the communication network is one of the crucial technologies for improving the two-way directional coordination between the virtual model and the physical building. This is because the network allows for the transfer of information between sensors [33,65]. Internet, wireless local area network (WLAN) (Wi-Fi), and wireless personal area network (WPAN) are some examples of communication tools that are used in the building sector (comprising UWB, Zigbee, and Bluetooth). These communication networks allow data to be sent wirelessly between equipment on the building site as well as between the building site and the office, which results in improved cooperation among members of the project team. The range, cost, data transfer rate, network architecture, and battery life of a device are all factors that should be considered while selecting a communication network [66].

5.1.3. Availability of Mobile Devices

Mobile devices are portable computer devices that include a display screen. These devices allow users to access and embed information that is necessary for coordinating operations between the site and the office. It has been discovered that these gadgets are helpful in the building business for monitoring the progression of work [67]. Members of the building crew may use these devices to remotely access virtual models, update variants, communicate questions to the design team about particular components, and receive immediate responses [67]. Instructions on how to install a building component can also be embedded on these devices. There are mobile devices available that come equipped with barcode scanners, and these may be used to read the information that is encoded in the tags.

5.1.4. Availability of Device Layers

The device layers include client devices (such as personal digital assistants (PDAs), tablets, personal computers (PCs), iPads, and smart phones) that allow end users to engage with the system. This layer not only allows access to the data that has been detected but also makes it possible for information to be entered through the user interface.

5.2. Creation of Workable Virtual Modes

The data collected during a project's lifespan may be visualized and embedded into virtual models, which serve as a platform for this purpose. Facility information models are digital representations of a building that have the capacity to retain data that may be accessed at any point in the facilities' life cycle. Software programs such as Autodesk Revit, Navisworks, and Bentley architecture are some examples of the kind of programs that may be used to construct these models. These models are able to act as a platform for watching and monitoring the progress of building operations since they include a virtual depiction of the real components [42]. The information that can be retrieved by wireless sensors, such as the status of tagged components, may be displayed in virtual models and saved in the virtual component that corresponds to it. The virtual components may be queried by members of the project to retrieve previously saved information or to upload new information [68]. For instance, designers are able to include information on design assessments into the virtual systems, which can then be transferred to tags on the physical components and viewed on the site, and vice versa [36]. Virtual models also serve as a platform for remotely controlling physical systems, such as lighting electrical components during the operation and maintenance phase.

5.3. The Stationary Success Factors for Adopting Cyber Security

Governmental Support

Governmental support is important for successful project execution. Ramkumar et al. [69] noted that communication networks allow data obtained from mobile devices to be transferred via the Internet to the database. Support of the government at all levels can also promote the use of technology in the building industry (Shen et al. [15]).

6. Conclusions

In many nations, cyber technology is regarded as a helpful instrument for maximizing the return on investment of monetary resources, furthering organizational goals, and ensuring long-term viability. Contrarily, the adoption of cyber technology in developing economies is limited. In Nigeria, as is the case in other developing nations, there are inconsistencies and irregularities in the quality of housing, particularly large-scale projects. As a result, the use of cyber technology is strongly suggested to improve the situation. This study modeled the CSFs of cyber technology using RII analysis. Previous studies identified critical success factors (CSFs) for cyber technology. These CSFs were then contextually investigated using a questionnaire survey conducted within the Nigerian building sector. According to the findings, the most important critical success factors for implementing cyber technology are the availability of sensors, the availability of reliable communication networks, the availability of mobile devices, the availability of device layers, and the creation of workable virtual modes. Moreover, Gini's mean difference measure of dispersion showed that government support and globalization are the stable variables that contribute to the success of cyber technologies in Nigeria. The study will serve as a guide for stakeholders to reduce costs and enhance sustainability in the Nigerian building industry.

7. Managerial Implications

The rearrangement of CSFs can be beneficial for creating a "road-map" that stakeholders, such as project owners and contractors, can utilize to more successfully implement cyber technology in their projects. Additionally, this reorganization may serve as a benchmark for developing a practical framework for the smooth transition of building actors through the stages of cyber technology. The "road-map" would help Nigerians achieve their goals of establishing a strong, competitive economy and ranking among the top 30 nations in the world [70]. Additionally, the study's findings on the important success elements for cyber technology can encourage the use of cyber technology in other developing countries where building projects are undertaken in a similar manner [71]. This is especially relevant in developing nations because they encounter more obstacles, such as having to spend a lot of money to address environmental difficulties [72]. Cyber technology can therefore give these nations the chance to incorporate sustainability into the planning stages of building projects [73,74]. The following specific ways in which this study makes a substantial contribution, with important implications for the building sector, are:

- It provides a database of cyber technology standards and the characteristics that are related to them so that their competitiveness and ability to survive in the global market through the integration of cyber technology can be determined.
- It assists owners, consultants, and contractors in evaluating and choosing cyber technology implementation to enhance the planning, effectiveness, and uniformity of building projects.
- It presents a scientific demonstration that might assist Nigeria and other developing nations in implementing cyber technology.
- The majority of developed countries (the U.K., the U.S., Hong Kong, and Australia), as well as other nations such as Malaysia, China, and Saudi Arabia, have focused on cyber technology research and related it to the building industry. In contrast, there is little research on applying cyber technology in the Nigerian building sector and even less in poor nations. This study has been successful in establishing a link between Nigeria's building industry and cyber technologies. This offers a solid framework for talking about how using cyber technology may improve the dependability of local building projects and close the knowledge gap.
- The research findings in this paper may help Nigerian building projects adopt cyber technology. Our research can help people understand why cyber technology is used, including how to reduce wasteful spending and allocate funds appropriately for each project. Thus, by creating and putting into practice the planned strategies, all interested parties may concentrate on the project's goal in terms of cost, time, and efficiency. Ultimately, a project's ability to achieve a high level of sustainability benefits.
- The study's findings also offer a benchmark or guideline for mitigating the issues that can arise during project execution. These include project completion, cost overruns, and vague specifications. Additionally, this research gives business owners or employers advice on how to use cyber technology to improve the success of their projects.

8. Theoretical Implications

Although the concept of sustainable development is not new [61], it appears to be more important than ever for a number of businesses [75]. The recommended prioritized analysis stipulates a need for the adoption of cyber technology, particularly in the area of environmentally friendly homebuilding. Through the proposed investigation, this study determined the CSFs for the adoption of cyber technology. These CSFs are helpful in removing the obstacles that currently prevent the successful application of cyber technology in the Nigerian building sector. As a result, this study will help close the gap between cyber technology theory and practice. To the best of our knowledge, no study has been conducted to examine the CSFs of cyber technology implementation in the Nigerian building sector. This study's initial step was to empirically identify the key CSFs of cyber technology that can facilitate the adoption of cyber technology in the building sector. This work lays the foundation for future research on the CSFs of cyber technology in developing nations, especially for researchers in the field of building management. For this purpose, the mathematical basis provided by the theoretical components of this analysis provides a means of defining the CSFs of cyber technology that can be successfully applied in Nigeria and other developing nations.

9. Limitations and Future Research

Even though this study makes substantial contributions to both the academic community and practice, certain limitations provide an opportunity for further research. Data retrieved from 98 respondents were adopted for data analysis. If we had a greater number of people in our sample, we could have seen another substantial impact. In addition, the three categories of respondents (clients, contractors, and consultants) are all considered to be part of the same homogeneous group for the sake of this research. The interaction between the different user groups in the sector will be investigated further in future research. The study was limited to the roles of cyber technology factors exclusively on the issue of the sustainability of the construction process. Further studies can consider other areas of sustainability of the construction process/business from the perspective of socio-economic factors, demographic trends, the transition from rural to urban areas, and new construction technologies, among others.

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