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Modelling the Impact of Building Information Modelling (BIM) Implementation Drivers and Awareness on Project Lifecycle

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Abstract: The Architecture, Engineering, Construction and Operations (AECO) industry is generally slow in adopting emerging technologies, and such hesitance invariably restricts performance improvements. A plethora of studies have focused on the barriers, Critical Success Factors (CSFs), lifecycle and drivers independently, but none have explored the impact of BIM drivers and awareness on the project lifecycle. This study empirically explored the impact of BIM drivers and awareness on the project lifecycle using Structural Equation Modelling (SEM). Initially, a conceptual model was developed from an extensive literature review. Thereafter, the model was tested using primary questionnaire data obtained from 90 construction professionals in Lagos, Nigeria. Emergent findings indicate that Building Information Modelling (BIM) drivers have a high impact on BIM awareness at the operation stage of the project lifecycle. The SEM model has an average R^2 value of 23% which is moderate. Consequently, this research contributes to the existing body of knowledge by providing invaluable insight into the impact of BIM drivers on BIM awareness in the project lifecycle. Knowledge acquired will help industry stakeholders and government to develop appropriate policies to increase BIM uptake within contemporary practice.

Keywords: building information modelling; drivers; structural equation modelling; Nigeria; project lifecycle; awareness

1. Introduction

The Architecture, Engineering, Construction and Operations (AECO) industry constitutes a cornerstone of a country's economy and is predicted to account for circa 15% of the World's Gross Domestic Product (GDP) by 2030 [1,2]. Construction outputs create critical infrastructure and buildings that cumulatively constitute the built environment which provides the basis for society and other industries to flourish [3,4]; hence, the economic contribution is perhaps greater than the estimated "direction" contribution to the GDP. Annually, the AECO industry is responsible for nearly 40% of the total energy use, 32% of CO_2 emissions and 25% of the generated waste in Europe [5,6]. Furthermore, in many developing countries, the construction industry has undergone substantial fluctuations to accomplish its local economic objectives [7]. As a result, many developing countries' financial procedures are in the process of improvement [8]. In these countries, construction projects frequently face several time-schedule delays [9–11]. Furthermore, the industry is faced with numerous productivity issues stemming from the lack of adoption of emerging technologies or concepts such as Building Information Modelling (BIM) [12], blockchain [13], Internet of Things (IoT) [14] and Industry 4.0 [15]. As a result, the construction industry in developing countries does not achieve government goals for society and clients, and a need for developing "overall success construction projects" that are resource-efficient has been underlined in the literature [16].

BIM resides at the vanguard of advancements made, and literature on this technology and its applications is ubiquitous and can be combined with the success approach at the preliminary and whole phases of a project [17]. Autodesk [18] defined BIM as "*an intelligent 3D model-based process that gives architecture, engineering, and construction professionals the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure*". BIM contains the inherent latent capacity to improve efficiency in the design, construction and maintenance of buildings [19,20].

BIM continues to undergo radical metamorphosis in response to sector stakeholder calls for technology to address systemic and recurrent issues that doggedly persist, viz. thematically grouped as productivity, cost and time management problems [21]. BIM as a procedure is targeted at the procedure of frequent production and at using the highest effective technology available to increase the improvement of Return on Investment (ROI) via refined and standardized processes [22]. It enables a central hub of data that designers, engineers, Mechanical, Electrical and Plumbing (MEP) contractors, operators and Facility Management (FM) corporations can execute for different buildings of any type and size besides current projects [23]. Consequently, BIM has been considered a critical lifecycle management tool that can have a significant positive effect on a building's lifecycle [24,25].

However, BIM's full potential is arguably yet to be realised despite the many palpable benefits inherent within this software. Many related studies that have sought to disentangle a *Gordian knot* of barriers to BIM adoption have focused on identifying the current state of adoption [26], defining and delineating the barriers (Babatunde, et al. [27]) and identifying the drivers (Olanrewaju, et al. [2], Eadie, et al. [28], Olawumi and Chan [29]) in both developed and developing countries. Consequently, there is also a lack of systematic attempts to examine the drivers for BIM implementation in the construction industry. Whereas previous studies have examined BIM activities and method efficiency in various developed countries, humble effort has been generated to explore the drivers and how BIM implementation can enhance its awareness in Nigerian construction projects. Drivers are important management processes for guaranteeing success and reflect "features where, if successfully executed, their results will assure an organization's competitive performance" [30,31]. For example, Olanrewaju, et al. [2] revealed that key drivers include construction process visualization, improved decision-making process, controlled whole-life costs and environmental data, improved quality and increased sustainability and improved productivity and collaboration, which are the most important drivers for BIM adoption in the Nigerian AECO industry. Similarly, Eadie, et al. [28] identified clash detection, government pressure, competitive pressure, accurate construction sequencing and cost savings through reduced re-work. Rodgers, et al. [32] also identified clash detection, collaboration enhancement and cost saving as the key drivers for BIM adoption in Australia. Anecdotal synthesis of this aforementioned prevailing body of knowledge illustrates similarities in the drivers for BIM adoption. However, the impact(s) of these drivers on the BIM awareness on project lifecycle has received scant academic attention, yet knowledge of this phenomenon is crucial to understanding how to augment BIM implementation in the AECO industry. Consequently, for this empirical investigation, the following research question was posed: What is the impact of BIM drivers' implementation on its awareness in the Project Lifecycle (PL)? As a result, the current work is the first to address this gap by quantitatively investigating the impact of BIM drivers on BIM awareness across the project lifecycle using deterministic techniques to represent networks of constructs to primary data collated and determine relationships between input variables using Structured Equation Modelling (SEM). Associated objectives were to: excoriate the impact of BIM drivers on BIM awareness across the project lifecycle as a basis for the development of appropriate policies and strategies to increase

BIM uptake within the contemporary practice; and engender wider critical debate and discussion amongst industry stakeholders and policy advisors but also stimulate further research and investigation within the academic community. This study can help decision-makers succeed in their construction projects by reducing unnecessary expenditures and improving quality through the usage of BIM. This study is significant for the Nigerian construction sector, which has been slow to implement BIM. As a consequence, the findings from this study might be a game changer in construction projects not only in Nigeria but also in other developing countries where construction projects are carried out in a similar manner and method [33].

2. Awareness of BIM in the AECO Industry

BIM implementation continues to gain exponential momentum among global construction professionals [34]. For example, the National Building Specification (NBS) [35] revealed that there is a high level of BIM awareness in the UK, Canada, Finland and New Zealand. Consequently, BIM awareness and adoption have grown expeditiously from 10% in 2011 to nearly 70% in 2019 [36]. McGraw-Hill [37] revealed the implementation rate of BIM in Australia to be 64% while Rodgers, et al. [32] indicated a 48% level of adoption among Small–Medium Enterprises (SMEs). However, Tookey [38] revealed that there are doubts about the advantage of BIM in New Zealand's construction industry.

In sub-Saharan Nigeria (as an exemplar of a developing country), Anifowose, et al. [39] indicated the adoption level of BIM as 50% while Ogunmakinde and Umeh [40] recorded a 58% level of awareness. Olanrewaju, et al. [26] also reported a high level of BIM awareness at the design stage which concurs with the findings of Onungwa and Uduma-Olugu [41] where client satisfaction and drawing improvement were identified as the major reasons for BIM usage at the design stage. However, Olapade and Ekemode [42] reported that there is very low awareness of BIM implementation for facility management practices in Nigeria. Literature suggests that many Nigerian construction professionals are aware of BIM and its potential benefits. For other developing countries, Gamil and Rahman [43] highlighted that 38% of Yemen's construction practitioners are aware of the benefits of BIM while 8% are already implementing it. Similarly, Ismail, et al. [44] assessed the level of BIM uptake in Asian developing countries including China, Malaysia, India, Indonesia, Thailand, Myanmar, Sri Lanka, Mongolia, Vietnam and Pakistan. The study reported a low level of BIM implementation in the region. Nonetheless, China is at the forefront of BIM adoption due to its hybrid system, i.e., it has attributes of both a developed and developing country. Mehran [45] reported that the use of BIM in the United Arab Emirates (UAE) is gathering momentum while Shibani, et al. [46] indicated a low level of BIM awareness in Lebanon.

Recently, there has been positive feedback regarding BIM awareness in some developing countries such as South Africa [47]. This connotes that much work has been done regarding promoting the use of BIM in developing economies. Conclusively, construction professionals in developing countries are becoming aware of the benefits BIM offers, and the major problem lies in implementing BIM for construction projects. For instance, Olanrewaju, et al. [26] stated that only the Eko Atlantic City project has fully implemented BIM (i.e., from design to operation stage) in Nigeria.

2.1. BIM and Project Lifecycle

Raouf et al. [48] proffered that BIM has transformed traditional construction-project-management practices which in turn impact the project lifecycle. BIM usage varies across this lifecycle which is periodically punctuated by inputs from diverse professionals at various stages of development—defined for brevity as design (e.g., designers and architects), construction (e.g., contractors) and operation stages (e.g., facility managers) [26,49]. The BIM usage at different project lifecycle stages is shown in Table 1 which was adapted from our previous study. The table highlights the different uses of BIM during project execution which are discussed based on building lifecycle stages in Sections 2.1.1–2.1.3.

Table 1. BIM usage and awareness in project lifecycle.

Constructs	Code
Design stage	
Cost Estimation	AW1
Construction Planning	AW2
3D Coordination	AW3
Prefabrication	AW4
Visualization	AW5
Constructability Analysis	AW6
Sequencing	AW7
Construction stage	
Construction Monitoring	AW10
Maintenance Scheduling	AW11
Fabrication	AW12
Operation stage	
Asset Management	AW13
Building System Analysis	AW8
Record Modelling	AW9

Note: Adapted from Olanrewaju, et al. [2].

2.1.1. Design Stage

The design stage often involves a virtual collaboration between the architect/designer, structural engineer and mechanical and electrical services engineer to ensure design clashes are minimised in a federated model [50]. In addition, depending on the country's legalizations, BIM models are implemented using different software (ArchiCAD, Revit or SketchUp, CYPE MEP, DDS-CAD,). These models are imported into simulation software packages (e.g., Ecotect or IES-VE) to assess building features and sustainability. After the successful design, the quantity surveyor is responsible for using BIM tools such as costX, Navisworks or Vico to generate thorough cost analysis and Bills of Quantities. The final designs and cost details are then presented to the client for contractor selection and project commencement. In summary, BIM in the design stage not only enables visualisation of the project and design but also enhances the project by reducing the cost without affecting the quality. Chahrour, et al. [51] expressed that BIM offers cost savings through early clash detection in design before the project execution. It has also been viewed as a tool that facilitates a smart contract-automation process and effective collaboration among team members [52,53]. Cheng, et al. [54] argued that BIM has the potential to enhance the efficiency of facility maintenance management for MEP components (mechanical, electrical and plumbing) in building projects.

2.1.2. Construction Stage

During the construction stage, the "as-designed" BIM model produced is used by the contractor and consultant to ensure appropriate cost and time management and track the project progress; however, changes will be needed to reflect the final "as-built" structure to cater to client variations [49]. Olanrewaju, et al. [26] also highlighted construction monitoring, maintenance scheduling and fabrication as the main uses of BIM during the construction stage. Similarly, Eastman, et al. [55] mentioned monitoring, modelling and fabrication as the major uses of BIM. The 3D models contain essential data related to building projects essential for BIM procedures, far better than usual construction methods [56]. BIM techniques deliver the chance to organize project data, such as building geometry, and construction typology that can be used in creating informed decisions [57,58]. Consequently, BIM represents an effective tool for obtaining an accurate model that reflects the "as-is condition" or "as-built" condition in a project [56]. Currently, key technological advances enabled detailed three-dimensional (3D) models to illustrate the "as-is condition" of buildings projects [59,60]. Three-dimensional laser scanning is a reality-capture technique that aims to collect the greatest and extremely accurate data about "as-built" or "as-is condition" [56].

2.1.3. Operation Stage

The operation stage is characterised by maintenance and facility management operations aimed at improving the building's lifespan. Comparatively, this area attracts less research, and general awareness is low (even in developed countries); however, some advanced applications in the industry are apparent [3]. Within the developing country of Nigeria, Olapade and Ekemode [42] expressed the low level of BIM awareness among facility management professionals. Additionally, Olanrewaju, et al. [26] reported a low level of BIM awareness at the operation stage in the Nigerian construction industry and potential applications that include asset management, building system analysis and record modelling. Elsewhere, Xu, et al. [49] also mentioned that BIM could be used for emergency management, lifecycle management and facility management. In addition, the implementation of the BIM concept in the building industry also belongs to the category of the digital twin approach for enhancement of building maintenance [61]. Digital twin has been the subject of various classic studies for increasing performance and decreasing operating costs in assets, machines, processes and specific applications with different integration and levels [62]. As a result, throughout the BIM implementation process, the design concept is turned into a three-dimensional model and then progressively into architecture for better performance maintenance procedures [61].

2.2. Drivers of BIM

The construction industry is characterized by poor document and information management which negatively impacts the project's lifecycle. Saka and Chan [63] also reported that the industry is notoriously slow to adopt modern digital technologies such as BIM which has stunted industry growth and modernity. In recent years, BIM has grown in popularity as a tool for design and construction in the built environment across the world [34,64]. BIM has developed as a solution, with significant promise for generating, consolidating and maintaining these connected databases, which contain essential information for a facility (or a portfolio of facilities) to assist operations and maintenance [65]. In addition, Nieto-Julián, et al. [66] agreed that BIM can support members of a multi-disciplinary team from the heritage field by providing data interoperability. Furthermore, the study (ibid) revealed four major drivers of BIM adoption in Nigeria, viz.: (1) construction-related; (2) process-digitalization- and economics-related; (3) sustainability- and efficiency-related; and (4) visualization- and productivity-related. Stransky and Dlask [67] suggested that BIM aids decision making during project execution and improves construction productivity. Similarly, Eastman, et al. [55] asserted that BIM improves collaboration among project teams. Studies also highlight the benefit of BIM in cost estimation and management processes [2,68].

BIM has also been considered as a crucial tool in promoting sustainable construction/buildings through the term "Green BIM" which aims to reduce the impact of construction activities on the environment [69,70]. Amarasinghe and Soorige [71] demonstrated the use of BIM for building Lifecycle Assessment (LCA) and made recommendations on how to improve BIM-LCA assessments. The innate visualization capability of BIM is another critical driver for its adoption as it enables the client to virtually preview their proposed structure before construction commences. This empowers the design team with the flexibility to adjust certain building features in line with the client's comments [2,55]. Lin and Hsu [72] adopted BIM to support problem visualization and management using a web-based API. This demonstrates the ability of BIM to visualize problems and work progress at an early stage. Table 2 summarizes the BIM drivers extracted from existing literature reviewed and categorized based on the BIM drivers' groups identified in [2].

Table 2. Drivers of BIM implementation.

Drivers	Code
Construction-related driver	
Construction planning and monitoring	D13
Synchronized design and construction planning	D12
Facilities management record model	D14
Improved decision-making process	D11
Improved productivity and collaboration	D10
Process-digitalization- and economics-related driver	
BIM-enabled estimating capabilities	D2
Controlled whole-life costs and environmental data	D4
Potential economic benefits	D3
Lifecycle data	D8
Sustainability- and efficiency-related driver	
Green building standards incorporation	D6
Increased efficiency and coordination	D9
Improved customer service	D7
Visualization- and productivity-related driver	
Construction process visualization	D1
Improved quality and increased sustainability	D5

Note: Adapted from Olanrewaju, et al. [2].

3. Research Methods

This research adopted positivism analysis to conduct an empirical analysis of primary data collated from a questionnaire survey; such an approach is well established within contemporary construction management literature [73,74]. Positivism was first adopted to analyse extant literature and identify pertinent BIM implementation drivers in BIM awareness across the PL (i.e., model constructs and constructs classification) and build a conceptual model [75–77]. Consequently, Structural Equation Modelling (SEM) was employed to define the relationships between constructs. The overarching epistemological research design is shown in Figure 1, while the conceptual model developed is shown in Figure 2.

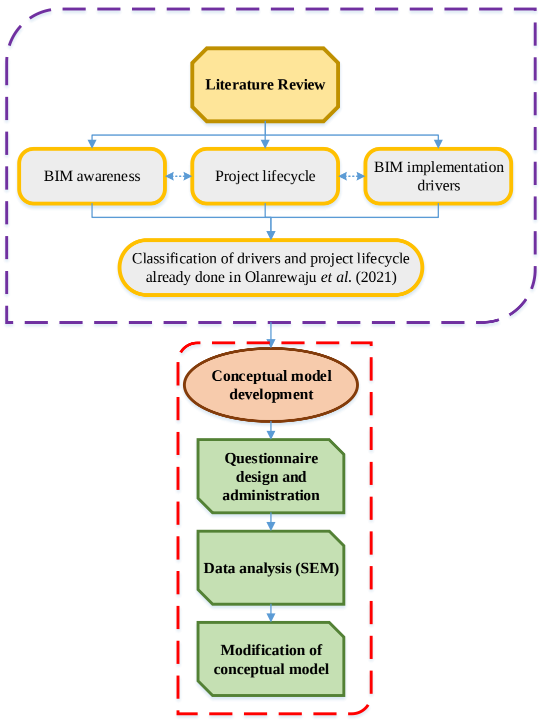

Figure 1. Research design.

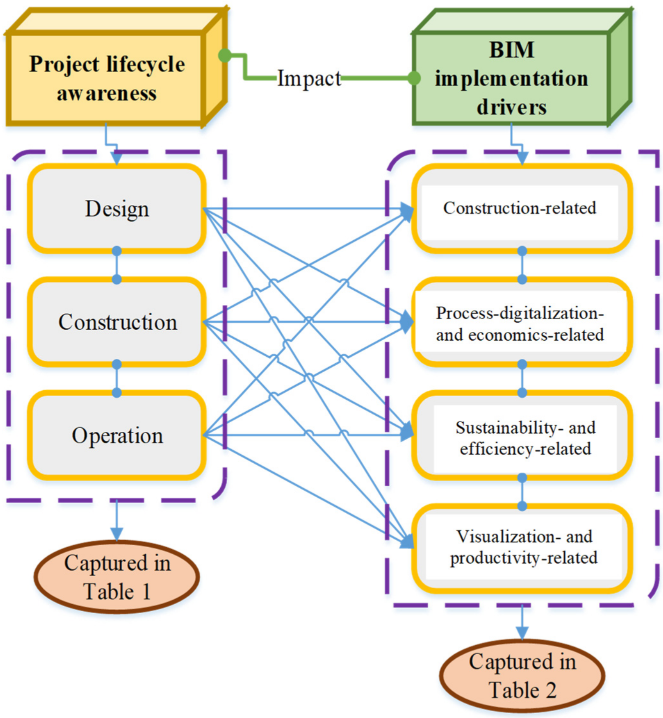

Figure 2. Conceptual model.

3.1. Survey Administration

The identified constructs were used to design a closed-ended 5-point Likert scale with 5 = very high, 4 = high, 3 = average, 2 = low and 1 = very low as used in many earlier studies [78–80]. A closed-ended questionnaire was adopted because of its inherent ability to yield expedient responses from a large survey conducted and low administration costs [81]. The study's scope was restricted to Lagos because it is the commercial hub of Nigeria and, in recent years, has developed remarkable infrastructures such as Eko Atlantic City and Dangote petroleum refinery [26].

The questionnaire was divided into two sections, namely: (1) respondent's demographics; and (2) 5-point Likert scale questions on the constructs (see Tables 1 and 2). A total of one hundred and fifty (150) questionnaires were distributed; ninety (90) were completed and returned—equating to a 60% response rate. This response rate provides reasonable data for analysis [82]. Furthermore, the sample size used is adequate and has been implemented in previous studies on the current state, barriers and drivers of BIM in the Nigerian construction industry [2,26,27,83].

3.2. Data Analysis

3.2.1. Reliability Test

Cronbach's Alpha Reliability Test (CART) was conducted on data collected to determine the internal consistency of the study's constructs in the questionnaire. The Cronbach's alpha coefficients range from 0 to 1 in value [83,84] where 0.90 means high reliability, 0.80 moderate reliability and 0.70 low reliability [85]. CART is calculated by using the following formula in Equation (3) (Cronbach, 1951):

$$\alpha = \frac{n}{n-1}\left(1 - \frac{\sum_i V_i}{V_t}\right) \tag{1}$$

where:

n = the number of items
V_t = the variance of the total scores
V_i = the variance of the item scores

The reliability test for the constructs revealed a Cronbach's alpha coefficient of 0.910 which is considered very reliable.

3.2.2. Respondent Demographics

In terms of the respondents' profession, 24% were quantity surveyors, 20% were builders and civil engineers, 19% were architects, and 17% were estate surveyors. This distribution illustrates that good representation was accrued from the major professionals working within the Nigerian construction industry. For working experience (and in highest to lowest order), 40% of respondents had 5–10 years, 32% had <5 years, 12% had 11–15 years, 10% had 16–20 years, and 6% had 21 years. This connotes the respondents are well experienced to provide informed and insightful information for this study.

3.2.3. Analytical Technique

SEM adopts a confirmatory approach to the analysis of a structural theory based on some conditions. Usually, the theory symbolises "causal processes" that result in the production of multiple variables [86]. It is a powerful tool capable of handling latent variables in multivariate regression analysis [76]. SEM encompasses two critical aspects of the procedure which include: (1) a series of regression equations which implies the study of causal processes; and (2) a diagrammatic representation of structural relations for better theory conceptualisation [86]. SEM was adopted because it has been successfully applied in previous BIM-related studies, viz.: Chen, et al. [87] who sought to identify the impact of information management on BIM maturity; Chang, et al. [88] who explored the impact of BIM implementation on the acceptance of integrated delivery systems; and Okakpu, et al. [89] who explored the influence of environmental factors on BIM adoption for refurbishment projects. The statistical investigation conducted in this study embraced the common-method variance analysis, measurement and structural model evaluation technique via SmartPLS 3.2.7 software which are discussed in the following sub-sections.

3.2.4. Common-Method Variance

Common-method bias (CMB) is the bias generated from the common-methods variance (CMV) and clarifies the error investigation outcomes [90,91]. In many occurrences, data collection may increase the extent of trigger issues such as bias relationships [92,93]. Therefore, it is vital to identify these issues to detect any CMV using a formal systematic one-factor analysis which was conducted as recommended by Harman [94] and Podsakoff, et al. [91]. Factor analysis shows the degree of variance explained by the variable [93].

3.2.5. Measurement Model

The measurement model explains the existing association between the indicators or measurement and their construct [95] and can be addressed via convergent and discriminant validity assessments. Convergent validity explores the level of agreement between two measurements in each construct [96]. In addition, discriminant validity highlights that the concept being assessed for each construct is empirically distinct and proposes any constructs that do not recognize the concept being observed in the SEM [97,98].

3.2.6. Structural Model

The main stage of the proposed model evaluation embraces the use of the structural model [16]. In this study, the structural model was generated via path analysis to evaluate all complicated relationships between constructs at the same time [99]. Consequently, a total of four structural equations for BIM drivers' constructs were considered for the proposed Partial Least Squares Structural Equation Modelling (PLS-SEM) model, demonstrating relationships among the BIM drivers and BIM awareness constructs (Figure 4).

4. Results

4.1. Common-Method Bias

Common-method bias represents a measurement of variance (i.e., variance of error correlated with the measured variables) that influences the validity of a study [91,100]. In this study, a single-factor analysis was conducted to identify the standard method variance [94]. If the overall variance of the factors is <50%, the common-method bias does not influence the collected data [101]. The findings illustrate that the first set of factors indicates 34.63% of the total variance, and consequently, the common-method variance cannot affect the results [101].

4.2. Measurement Model (First-Order Construct)

The SEM depicted in Figure 3 reproduces the above conceptual model for this study. In the previous tables, all the BIM drivers and awareness factors during the project's lifecycle (design, construction and operation) were detailed and classified according to previous studies and EFA analysis. The measurement analysis for the proposed model requires an evaluation of: (1) Cronbach's alpha analysis; (2) internal consistency of composite reliability; (3) Average Variance Extracted (AVE); and (4) discriminant validity [102].

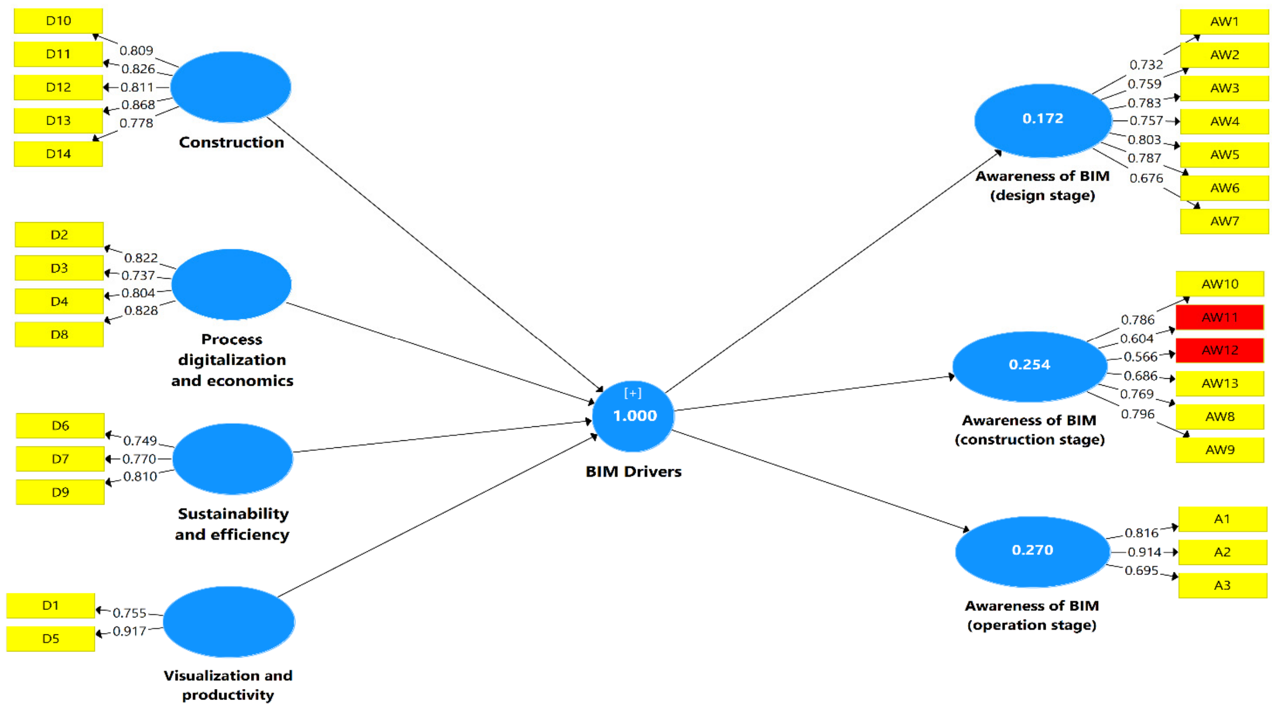

Figure 3. The PLS initial model with outer loading and R^2.

Normally, items with an outer load around 0.40 and 0.65 can only be recommended for omission from the scale if the indicator's removal resulted in a substantial improvement in composite reliability and AVE [102,103]. This is the level at which its construct describes roughly one-half of the item's variance, and the amount at which the variance stated is higher than the error variance. External loads for the original and modified measurement models are shown in Figures 3 and 4.

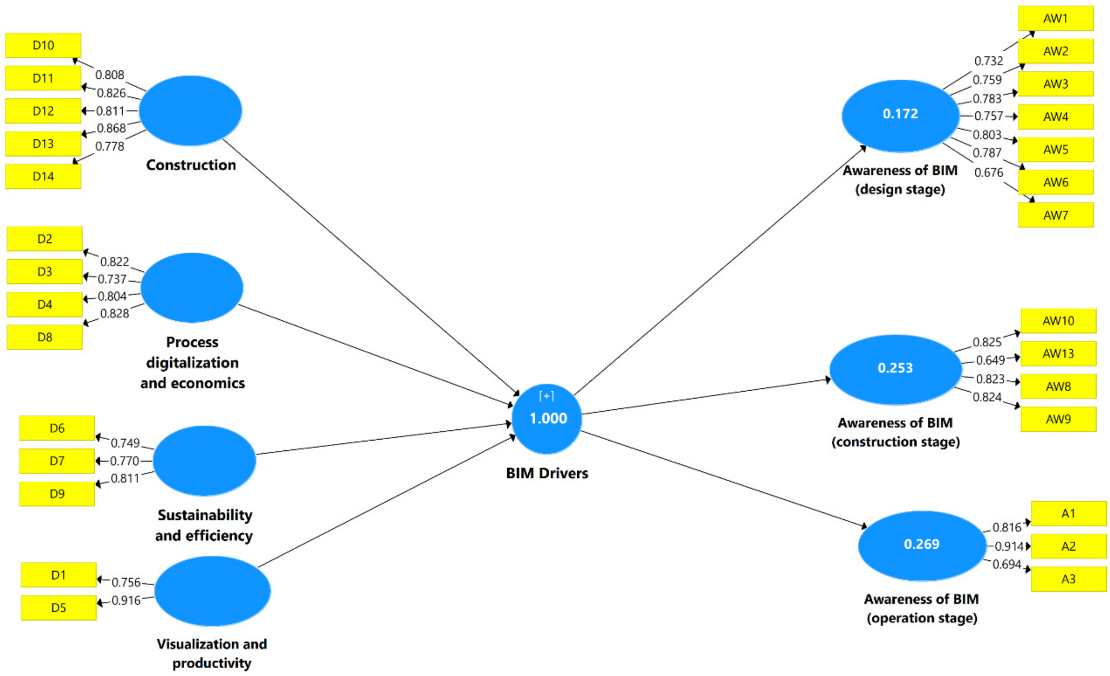

Figure 4. The PLS modified model with outer loading and R^2.

Consequently, all outer loads were accepted with the exception of two items related to "BIM awareness" at the *construction stage* ("AW11" and "AW12"), which were omitted from the initial model resulting in a lower loading factor of <0.6 (see Figure 3 and Table 3). A modified model (see Figure 4) was further calculated once these items were eliminated. Furthermore, the internal consistency of Composite Reliability (*cr*) was assessed due to Cronbach's alpha restrictions, which determine sensitivity concerning the number of items involved [102]. Consequently, these two assessments showed that all constructs reached the Cronbach's alpha and *cr* > 0.60 thresholds and were appropriate [104–106]. The results also show that all constructs passed the AVE test with a value >0.50, which means that all constructs have appropriate convergent values (Table 3) [104].

Table 3. Construct reliability and validity tests.

Constructs	Item	Outer Loading Initial	Outer Loading Modified	Cronbach's Alpha	Composite Reliability	AVE
Construction	D10	0.809	0.808	0.877	0.910	0.670
	D11	0.826	0.826			
	D12	0.811	0.811			
	D13	0.868	0.868			
	D14	0.778	0.778			
Process digitalization and economics	D2	0.822	0.822	0.810	0.876	0.638
	D3	0.737	0.737			
	D4	0.804	0.804			
	D8	0.828	0.828			
Sustainability and efficiency	D6	0.749	0.749	0.674	0.820	0.604
	D7	0.770	0.770			
	D9	0.810	0.811			
Visualization and productivity	D1	0.755	0.756	0.602	0.826	0.705
	D5	0.917	0.916			

Table 3. *Cont.*

Constructs	Item	Outer Loading Initial	Outer Loading Modified	Cronbach's Alpha	Composite Reliability	AVE
Awareness of BIM (design stage)	AW1	0.732	0.732	0.876	0.904	0.574
	AW2	0.759	0.759			
	AW3	0.783	0.783			
	AW4	0.757	0.757			
	AW5	0.803	0.803			
	AW6	0.787	0.787			
	AW7	0.676	0.676			
Awareness of BIM (construction stage)	AW10	0.786	0.825	0.791	0.863	0.615
	AW11	0.604	Deleted *			
	AW12	0.566	Deleted *			
	AW13	0.686	0.649			
	AW8	0.769	0.823			
	AW9	0.796	0.824			
Awareness of BIM (operation stage)	A1	0.816	0.816	0.739	0.852	0.661
	A2	0.914	0.914			
	A3	0.695	0.694			

* Deleted items.

Discriminant validity analysis is important to assess whether each construct has distinctive phenomena that are not captured by other constructs in the proposed model [107]. This study used Fornell and Larcker [108] principles and the cross-loading criterion to measure discriminant validity. Table 4 confirms the discriminant validity of the measurement model according to these principles, which highlighted that all square roots of the AVE, for all constructs, are greater than the correlation among the latent variables [90,109].

Table 4. Correlation of latent variables and discriminant validity (Fornell–Larcker).

Constructs	Awareness of BIM (Construction Stage)	Awareness of BIM (Design Stage)	Awareness of BIM (Operation Stage)	Construction	Process Digitalization and Economics	Sustainability and Efficiency	Visualization and Productivity
Awareness of BIM (construction stage)	**0.784**						
Awareness of BIM (design stage)	0.613	**0.758**					
Awareness of BIM (operation stage)	0.929	0.812	**0.813**				
Construction	0.491	0.406	0.486	**0.819**			
Process digitalization and economics	0.439	0.344	0.477	0.619	**0.799**		
Sustainability and Efficiency	0.401	0.344	0.412	0.664	0.665	**0.777**	
Visualization and Productivity	0.26	0.253	0.266	0.506	0.583	0.567	**0.84**

Notes: Values in bold represent the square root of the AVE.

Nevertheless, many studies have rejected the Fornell and Larcker [108] criterion of characteristic discriminatory validity. Consequently, the cross-loading criterion was also used in this study to assess discriminant validity. This approach confirms that the loading of indicators (items) of their constructs must be greater than the loading of another construct. Figures reported in Table 5 verified the above cross-loading principles as the loading on all indicators of the given construct is greater than the loading on other constructs (by row).

Table 5. Cross-loadings to test the discriminant validity of indicators.

Items	Awareness of BIM (Operation Stage)	Awareness of BIM (Construction Stage)	Awareness of BIM (Design Stage)	Construction	Process Digitalization and Economics	Sustainability and Efficiency	Visualization and Productivity
A1	0.816	0.619	0.998	0.401	0.337	0.343	0.244
A2	0.914	0.98	0.641	0.49	0.438	0.39	0.256
A3	0.694	0.618	0.298	0.263	0.394	0.257	0.132
AW10	0.731	0.825	0.482	0.459	0.385	0.387	0.206
AW13	0.602	0.649	0.264	0.263	0.245	0.235	0.165
AW8	0.763	0.823	0.526	0.383	0.344	0.239	0.195
AW9	0.805	0.824	0.6	0.401	0.378	0.367	0.244
AW1	0.567	0.405	0.732	0.362	0.342	0.231	0.268
AW2	0.509	0.323	0.759	0.288	0.3	0.286	0.315
AW3	0.628	0.506	0.783	0.286	0.215	0.196	0.158
AW4	0.632	0.472	0.757	0.308	0.298	0.271	0.061
AW5	0.669	0.491	0.803	0.243	0.183	0.217	0.174
AW6	0.659	0.511	0.787	0.31	0.256	0.284	0.205
AW7	0.658	0.57	0.676	0.326	0.182	0.319	0.122
D10	0.299	0.299	0.217	0.808	0.577	0.617	0.416
D11	0.458	0.449	0.414	0.826	0.546	0.652	0.481
D12	0.342	0.401	0.286	0.811	0.355	0.525	0.424
D13	0.517	0.478	0.455	0.868	0.519	0.533	0.364
D14	0.364	0.38	0.279	0.778	0.521	0.368	0.383
D2	0.397	0.319	0.317	0.386	0.822	0.422	0.403
D3	0.433	0.409	0.322	0.494	0.737	0.471	0.539
D4	0.356	0.325	0.255	0.589	0.804	0.529	0.445
D8	0.345	0.348	0.215	0.489	0.828	0.679	0.47
D6	0.303	0.274	0.247	0.352	0.455	0.749	0.419
D7	0.415	0.423	0.264	0.485	0.565	0.77	0.419
D9	0.251	0.244	0.287	0.67	0.524	0.811	0.48
D1	0.164	0.15	0.214	0.301	0.351	0.291	0.756
D5	0.266	0.268	0.219	0.514	0.588	0.603	0.916

4.3. Measurement Model (Second-Order Construct)

As the BIM drivers construct was a latent second-order construct, the significant influence of all latent first-order constructs (i.e., construction, process digitalization and economics, sustainability and efficiency and visualization and productivity) were calculated using the bootstrap method. However, the BIM drivers construct was formative, and excessive correlations among latent first-order constructs are typically not anticipated. Additionally, the high correlation between formative items implies collinearity, which is considered problematic [107]. Consequently, the collinearity between the formative latent first-order constructs was explored by analysing the value of the Variable Inflation Factor (VIF). Table 6 shows that all latent first-order constructs have VIF values < 3.5, which indicates that these constructs independently contribute to the BIM drivers construct.

Table 6. Test of second-order models using bootstrapping for formative constructs.

Path	*β*	SE	*T* Values	*p* Values	VIF
Construction → BIM Drivers	0.471	0.039	12.179	<0.001	2.015
Process digitalization and economics → BIM Drivers	0.341	0.032	10.765	<0.001	2.174
Sustainability and efficiency → BIM Drivers	0.224	0.026	8.744	<0.002	2.316
Visualization and productivity → BIM Drivers	0.136	0.025	5.534	<0.003	1.682

The results in Table 6 and Figure 5 show that four first-order subscales for BIM drivers, including construction, process digitalization and economics, sustainability and efficiency and visualization and productivity had a significant standard path coefficient β (outer weight). Table 4 indicates that the maximum outer loading was observed for construction ($\beta = 0.471$, $p < 0.001$), followed by process digitalization and economics ($\beta = 0.341$, $p < 0.001$), sustainability and efficiency ($\beta = 0.224$, $p < 0.001$) and visualization and productivity ($\beta = 0.136$, $p < 0.001$).

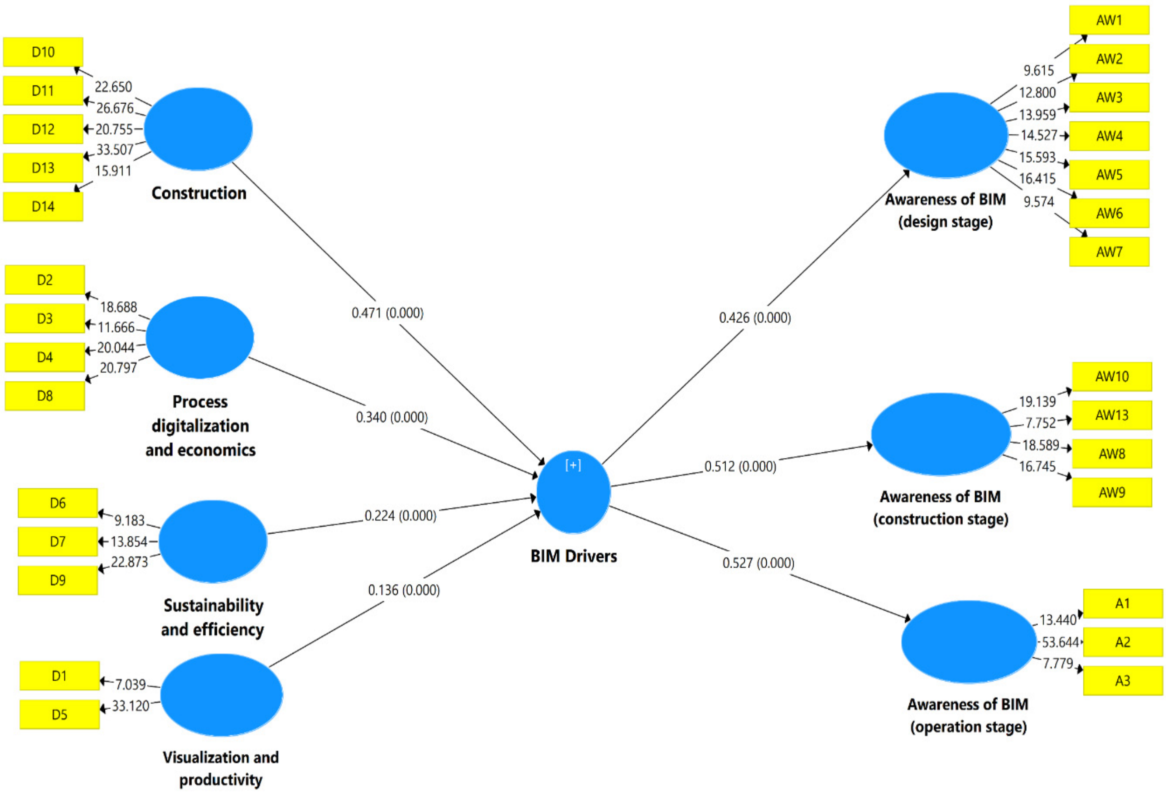

Figure 5. Performing bootstrapping analysis with path coefficients and *p*-value.

4.4. Structural Model (Path Analysis)

Having fitted the measurement model, the structural model examination could now commence. In the structural model, the relationships between variables are rationalised in detail. This analysis displays the relationship between an exogenous construct and endogenous constructs [110]. Structural model evaluation is performed mainly according to the hypothesized parameter evaluations followed by the size, direction and significance of the variables [110].

For the research hypotheses, SEM was utilized. The influence of BIM drivers on the awareness of BIM in the three project lifecycle stages (i.e., design, construction and operation) was examined with PLS-SEM (Figure 5). Consequently, the significance of the model hypothesis, reliability of the data and, thus, the error of the calculated path coefficients set was assessed based on the bootstrapping approach [111]. Figure 5 and

Table 7 illustrate that the impact of BIM drivers on BIM awareness was statistically positive and significant.

Table 7. List of hypotheses and relative paths for the model.

Path	β	SE	*T* Value	*p*-Value
BIM Drivers → Awareness of BIM (construction stage)	0.512	0.071	7.23	<0.001
BIM Drivers → Awareness of BIM (design stage)	0.426	0.095	4.456	<0.001
BIM Drivers → Awareness of BIM (operation stage)	0.527	0.079	6.676	<0.001

4.5. The Explanatory Power of the Structural Model (R^2)

The value of R^2 is the sum of the variation and is demonstrated by the independent construct (BIM drivers) in the dependent constructs. R^2 value improves the predictive capability of the structural model, i.e., the higher the value, the higher the model strength. Usually, an R^2 value of 0.7 and above is considered excellent, and its value ranges between −1 and 1 [112]. Furthermore, Ringle, et al. [113] indicated that values between 0.02 and 0.12 are considered weak, 0.13 and 0.25 are moderate, and values above 0.26 are substantial. In this study, the PLS algorithm concluded that R^2 is similar to the conventional regression and the same rules apply [114]. Table 8 illustrates that the adjusted R^2 for the dependent variable in this model was 0.253 for awareness of BIM in the construction stage, 0.172 for awareness of BIM in the design stage and 0.269 for awareness of BIM in the operation stage, which suggested that the exogenous latent variable (BIM drivers) can averagely explain 23% of BIM awareness on the whole project lifecycle while 77% was a result of other factors not considered in this study. According to Chin [114], the findings mean that the size described by BIM drivers is moderate.

Table 8. Results of the explanatory power of the structural model (R^2).

Endogenous Latent Variable	R Square	R Square Adjusted	Explained Size
Awareness of BIM (construction stage)	0.262	0.253	Moderate
Awareness of BIM (design stage)	0.181	0.172	Moderate
Awareness of BIM (operation stage)	0.277	0.269	Moderate

4.6. Predictive Relevance of the Structural Model

A vital function of a structural model is its capability to evaluate the model's predictive relevance. In this study, the blindfolding protocol was employed to evaluate the cross-validated redundancy measures for each dependent construct. The findings indicate that the Q^2 values (0.15, 0.091 and 0.17) for awareness of BIM in the three project stages (i.e., construction stage, design stage and operation stage) were higher than zero, indicating that the independent construct (BIM drivers) had predictive significance for the dependent constructs (Table 9) [115].

Table 9. Results of predictive relevance (Q^2).

Endogenous Latent Variable	SSO	SSE	Q^2 (=1 − SSE/SSO)
Awareness of BIM (construction stage)	360	305.527	0.151
Awareness of BIM (design stage)	630	572.899	0.091
Awareness of BIM (operation stage)	270	223.763	0.171

5. Discussion

Recent construction enhancement has brought more effective and sustainable approaches, specialized tools and materials [116]. Building direction in the construction industry necessitates significant, long-term growth [117]. Enhancing performance throughout use, on the other hand, is becoming increasingly important. [118]. It is necessary to develop strategies for incorporating the concept of sustainable and performance development [119,120]. Moreover, BIM implementation can carry out an efficient technique of attaining building performance. In this study, SEM revealed the relationship between the constructs (project lifecycle BIM awareness and drivers). All the drivers (construction, process digitalization and economics, sustainability and efficiency and visualization and productivity—in order of impact) were considered significant in relation to the implementation of BIM drivers. This finding illustrates a step-change in the mindset of practitioners in developing countries who acknowledge the latent value of digitising the construction process using BIM as an enabling technology. Such a finding confirms earlier studies such as that by Vass and Gustavsson [121] who asserted that increased digitalization has revolutionized the industry due to the elimination of potential drawbacks and traditional practices gradually becoming redundant. Biancardo, et al. [122] also mentioned that BIM implementation has helped significantly in reducing construction costs and time. BIM has also been viewed as a decision support tool that helps designers in comparing the performance of different designs in terms of energy, emissions and cost [123]. Furthermore, Ibem, et al. [124] agreed that BIM aids effective visualization for client design approval. It must be acknowledged that BIM is not a sole panacea to construction sector ailments and is increasingly being absorbed into the wider concept of Industry 4.0 which represents a broader coalescence of digital technologies [15]. The Internet of Things, artificial intelligence, big-data analytics, sensor-based technologies, etc., are now integrated to provide a suite of sophisticated project management tools that provide greater insight and knowledge of the complex modern projects. This aside, the results do illustrate how the developing country of Nigeria has embraced this digital transition with considerable aplomb and potentially how indigenous contractors could become more internationally competitive.

Another intriguing finding is that BIM awareness at the operation stage of the project lifecycle has a high impact on drivers of BIM adoption. This is accompanied by the construction and design stage. Despite the high impact of BIM awareness at the operation stage on the drivers, studies have shown that there is a poor level of BIM awareness in facility management in Nigeria which is a critical aspect of the operation stage [43]. In this respect, therefore, Nigeria is behind international practice adoption in terms of digitising facilities management to provide much-needed modernity. Ghaffarianhoseini, et al. [123] indicated that BIM supports facility managers to help reduce the lifecycle cost of buildings. Similarly, Wu, et al. [125] indicated that there is a high level of awareness at the design stage while Olanrewaju, et al. [26] revealed that there is a strong correlation between awareness at the design and construction stages and a weak correlation between the design and operation stages. However, the relationship between the construction and operation stages is fairly strong. This connotes that there is a disconnection between the design and operation stages in the level of awareness. Reducing BIM implementation obstacles via the recommended drivers can inspire construction participants to learn more about how BIM can be used. According to Sidani, et al. [126], there is still a need for key industry actors to grasp how to manage BIM techniques, recognising opportunities for further development in accessing, preserving and sharing BIM data. Furthermore, the Internet of Things, artificial intelligence, big-data analytics, sensor-based technologies and other technologies are now integrated to provide a suite of advanced project management devices that enable greater insight and understanding of complex modern projects [127]. These results are in line with the work of Biancardo, et al. [122] who stated that the implementation of BIM has considerably reduced construction costs and time, particularly throughout the building phase. Participants also should consider how BIM use in construction businesses reduces risks. It will explain why the initial high benefits of the employee and enhancing the building environment are so high [128].

Overall, the research illustrates that Nigeria is on course to create a smart built environment within a cyber-physical system in which BIM is an integral part. However, further research is now needed to take a far more holistic view of other digital innovation developments in this respect and how transitional challenges (such as cyber threats (Parn and Edwards [13])) may be overcome to protect critical assets and infrastructure from nefarious hackers and cybercriminals. Such work will help ensure the country's preparedness to embrace future innovative developments and capitalise upon these to reap maximum socio-economic benefits for its citizens.

6. Conclusions

This study used SEM to explore the impact of BIM drivers on usage and awareness in the project lifecycle which is an aspect that has been neglected by previous researchers. It was revealed that BIM drivers have a significant impact on BIM awareness across the project lifecycle. The study is unique because it helps construction researchers and stakeholders determine the impacts of BIM drivers on BIM awareness across the project lifecycle which is essential for BIM uptake across the project lifecycle (design, construction and operation). Particularly, the operation stage was seen to be most impacted by the BIM of the PL which calls for major action to be implemented by stakeholders to increase BIM awareness. In addition, the study is the first to develop a quantified model to measure the impact of BIM drivers on BIM awareness across the project lifecycle which will be useful for policymakers to develop an appropriate framework for BIM adoption in the AECO industry. This framework would be useful for stakeholders, such as client consultants and contractors in adopting BIM in their projects. Furthermore, the proposed framework generated from this study can, to a large extent, support BIM adoption in other developing countries where construction projects are executed in the same way [33]. Nevertheless, this study generates vital managerial implications and empirical contributions to the AECO industry which are given below:

6.1. Conceptual and Empirical Contributions

The suggested model established a necessity for BIM adoption, particularly in the developing-country construction industry. Through the suggested model, this study highlighted the drivers for BIM implementation. These drivers can help overcome the present obstacles to successfully implement BIM in the Nigerian construction industry. As a result of this research, the gap between BIM practice and theory will be narrowed. To the best of our knowledge, no research has been conducted to examine the drivers of BIM implementation in the Nigerian construction sector by determining its influence on BIM awareness at various construction stages. Initially, this study empirically analysed the major BIM drivers that can help in BIM implementation in the construction sector. This discovery lays the groundwork for future study on the drivers of BIM in developing countries, notably in the field of construction management. To that aim, the theoretical elements of this research provide a mathematical framework for identifying the BIM drivers that may be employed successfully in Nigeria and other developing nations. Using the unique PLS-SEM, the four components of the BIM drivers in the Nigerian construction sector were compared. As a result, this study provides a mechanism to assist policymakers who are interns in incorporating BIM impartially. In addition, a number of conceptual and empirical contributions were made by the study as follows:

- The study makes a *conceptual* contribution through the identification and conceptual definition of additional constructs to be added to the conceptual framework such as the impact of BIM implementation drivers on BIM usage and awareness across the project lifecycle.
- The range of construction-based BIM and BIM implementation studies focused primarily on developed countries (UK, USA, Hong Kong and Australia). Consequently, scant research has been conducted in developing countries and the Nigerian construction sector on the adoption of BIM. This creates a solid basis for addressing BIM adoption in improving local construction projects' reliability and filling the above-mentioned gap of knowledge.
- The study's output offers, for the first time, a significant prediction tool (PLS-SEM) to discuss the impact of BIM drivers on BIM usage and awareness in the project

lifecycle in the construction industry. As such, this tool could improve the traditional adoption of BIM in the construction sector, particularly in developing countries. This contribution is *empirical* in nature as it is focused on testing a theoretical linkage between two constructs, namely the BIM implementation drivers and BIM usage and awareness in the project lifecycle, which have not previously been tested.

- Regarding country context, it is evident that there is an increase in the level of BIM awareness in the Nigerian construction industry, and this is expected to rise significantly within the next few years. This empirical study provides evidence that there is a vital and positive impact of BIM drivers on BIM awareness across the project lifecycle. Consequently, this can encourage the Nigerian government and other local organizations to adopt BIM. Such research will improve BIM adoption in this region. Therefore, the study makes *significant contributions* by adding new knowledge in a previously unexplored context.

6.2. Managerial Implications

The following managerial implications that can be used by construction practitioners in understanding the impact of BIM implementation drivers on BIM usage and awareness in the project lifecycle are suggested:

- It provides construction companies with critical drivers that can be leveraged upon for competitiveness and global market survival via BIM incorporation.
- It assists clients, contractors and consultants in evaluating BIM drivers and BIM awareness across the project lifecycle which will facilitate effective decision making during project execution.
- It presents empirical evidence that could be useful to guide Nigerian policymakers and other developing countries in adopting BIM.

6.3. Limitations and Future Research

Whilst this study contributes to knowledge on the impact of BIM drivers on BIM usage and awareness in the project lifecycle, it nevertheless has a number of limitations. First, the study is limited in terms of geographical location. The research instrument (questionnaire) was only administered to construction professionals in Lagos, Nigeria. Future studies should seek to further explore other regions to improve the generalization of the study. In this study, time and resources are limited, and thus it is challenging to carry out a longitudinal analysis that requires data to be obtained at various times as well as chronologically. Consequently, a cross-sectional study examining a particular situation of BIM at a particular time was used. Longitudinal study needs to be conducted in future studies to collect data from several samples to test changes typically in a particular pattern over a long period. Consequently, the casual inferences between BIM implementation drivers and greater BIM usage and awareness in the project lifecycle should be examined. In addition, this study focused on exploring the impact of BIM drivers on BIM usage and awareness in the project lifecycle using Structural Equation Modelling (SEM) with theoretical conceptualization. Future studies could use innovation diffusion theory to explain how, over time, a BIM concept gains momentum and diffuses via a specific stakeholder or organizations in other developing countries. The prediction analysis used in this study was limited to BIM drivers; future studies are recommended to predict the impact of BIM barriers on BIM awareness in the project lifecycle. Lastly, the results from the proposed study may be beneficial to enhance country improvement through adopting BIM, but it is not a promise to prepare the country to accept and capitalize on future creative advancements in order to maximise socioeconomic advantages for its inhabitants. Consequently, the government also plays a significant role to support the use of BIM in construction projects in the country by improving the level of laws and guidelines. The study's findings on BIM implementation requirements and drivers cannot be executed at the business level in emerging companies, and its employees cannot be taught in it without top management guidance.

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Abbreviations

The following abbreviations are used in this manuscript:

AECO	Architecture, Engineering, Construction and Operations
AVE	Average Variance Extracted
CART	Cronbach's Alpha Reliability Test
CMV	Common-Methods Variance
CR	Composite Reliability
CSFs	Critical Success Factors
FM	Facility Management
GDP	Gross Domestic Product
IoT	Internet of Things
LCA	Life Cycle Assessment
MDPI	Multidisciplinary Digital Publishing Institute
MEP	Mechanical, Electrical and Plumbing
PL	Project Lifecycle
PLS-SEM	Partial Least Squares Structural Equation Modelling
RoI	Return on Investment
SEM	Structural Equation Modelling
UAE	United Arab Emirates
VIF	Variable Inflation Factor

References

1. Olanrewaju, O.; Idiake, J.; Oyewobi, L.; Akanmu, W.P. Global economic recession: Causes and effects on Nigeria building construction industry. *J. Surv. Constr.* **2018**, *9*, 9–18.
2. Olanrewaju, O.I.; Babarinde, S.A.; Chileshe, N.; Sandanayake, M. Drivers for implementation of building information modeling (BIM) within the Nigerian construction industry. *J. Financ. Manag. Prop. Constr. Econ. Build.* **2021**. [CrossRef]
3. Edwards, D.J.; Pärn, E.; Love, P.E.; El-Gohary, H. Research note: Machinery, manumission, and economic machinations. *J. Bus. Res.* **2017**, *70*, 391–394. [CrossRef]
4. Owusu-Manu, D.-G.; Edwards, D.J.; Mohammed, A.; Thwala, W.D.; Birch, T. Short run causal relationship between foreign direct investment (FDI) and infrastructure development. *J. Eng. Des. Technol.* **2019**. [CrossRef]
5. Araújo, C.; Almeida, M.; Bragança, L. Analysis of some Portuguese thermal regulation parameters. *Energy Build.* **2013**, *58*, 141–150. [CrossRef]
6. Carvalho, J.P.; Bragança, L.; Mateus, R. Optimising building sustainability assessment using BIM. *Autom. Constr.* **2019**, *102*, 170–182. [CrossRef]
7. Mousa, A. A Business approach for transformation to sustainable construction: An implementation on a developing country. *Resour. Conserv. Recycl.* **2015**, *101*, 9–19. [CrossRef]
8. Fang, Z.; Gao, X.; Sun, C. Do financial development, urbanization and trade affect environmental quality? Evidence from China. *J. Clean. Prod.* **2020**, *259*, 120892. [CrossRef]
9. Kissi, E.; Boateng, E.; Adjei-Kumi, T. Strategies for implementing value management in the construction industry of Ghana. In Proceedings of the DII-2015 Conference on Infrastructure Development and Investment Strategies for Africa, Livingstone, Zambia, 16–18 September 2015; pp. 255–267.

10. Adeyemi, L.A.; Idoko, M. *Developing Local Capacity for Project Management—Key to Social and Business Transformation in Developing Countries*; Project Management Institute: Newtown Square, PA, USA, 2008.
11. Maceika, A.; Bugajev, A.; Šostak, O.R. The Modelling of Roof Installation Projects Using Decision Trees and the AHP Method. *Sustainability* **2020**, *12*, 59. [CrossRef]
12. Acre, F.; Wyckmans, A.J.S. The impact of dwelling renovation on spatial quality: The case of the Arlequin neighbourhood in Grenoble, France. *Smart Sustain. Built Environ.* **2015**. [CrossRef]
13. Parn, E.A.; Edwards, D. Cyber threats confronting the digital built environment: Common data environment vulnerabilities and block chain deterrence. *Eng. Constr. Archit. Manag.* **2019**. [CrossRef]
14. Ghosh, A.; Edwards, D.J.; Hosseini, M.R. Patterns and trends in Internet of Things (IoT) research: Future applications in the construction industry. *Eng. Constr. Archit. Manag.* **2020**. [CrossRef]
15. Newman, C.; Edwards, D.; Martek, I.; Lai, J.; Thwala, W.D.; Rillie, I. Industry 4.0 deployment in the construction industry: A bibliometric literature review and UK-based case study. *Smart Sustain. Built Environ.* **2020**. [CrossRef]
16. Kineber, A.F.; Othman, I.; Oke, A.E.; Chileshe, N.; Buniya, M.K. Impact of Value Management on Building Projects Success: Structural Equation Modeling Approach. *J. Constr. Eng. Manag.* **2021**, *147*, 04021011. [CrossRef]
17. Shirowzhan, S.; Sepasgozar, S.M.; Edwards, D.J.; Li, H.; Wang, C. BIM compatibility and its differentiation with interoperability challenges as an innovation factor. *Autom. Constr.* **2020**, *112*, 103086. [CrossRef]
18. Autodesk. Building Information Modelling (BIM). 2020. Available online: https://www.autodesk.com/solutions/bim (accessed on 10 January 2021).
19. Abubakar, M.; Ibrahim, Y.; Kado, D.; Bala, K. Contractors' Perception of the Factors Affecting Building Information Modelling (BIM) Adoption in the Nigerian Construction Industry. Available online: https://www.researchgate.net/publication/269192661_Contractors\T1\textquoteright_Perception_of_the_Factors_Affecting_Building_Information_Modelling_BIM_Adoption_in_the_Nigerian_Construction_Industry (accessed on 30 January 2021).
20. Pärn, E.A.; Edwards, D.J.; Sing, M.C. The building information modelling trajectory in facilities management: A review. *Autom. Constr.* **2017**, *75*, 45–55. [CrossRef]
21. Oraee, M.; Hosseini, M.R.; Edwards, D.J.; Li, H.; Papadonikolaki, E.; Cao, D. Collaboration barriers in BIM-based construction networks: A conceptual model. *Int. J. Proj. Manag.* **2019**, *37*, 839–854. [CrossRef]
22. Azhar, S. Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. *Leadersh. Manag. Eng.* **2011**, *11*, 241–252. [CrossRef]
23. Bianchini, C.; Inglese, C.; Ippolito, A.; Maiorino, D.; Senatore, L.J. Building Information Modeling (BIM): Great Misunderstanding or Potential Opportunities for the Design Disciplines? In *Handbook of Research on Emerging Technologies for Digital Preservation and Information Modeling*; IGI Global: Hershey, PA, USA, 2017; pp. 67–90.
24. Yan, H.; Demian, P. *Benefits and Barriers of Building Information Modelling*; Tingshua University Press: Beijing, China, 2008.
25. Olanrewaju, O.I.; Chileshe, N.; Babarinde, S.A.; Sandanayake, M. Investigating the barriers to building information modeling (BIM) implementation within the Nigerian construction industry. *Eng. Constr. Archit. Manag.* **2020**, *27*, 2931–2958. [CrossRef]
26. Olanrewaju, O.; Babarinde, S.A.; Salihu, C. Current State of Building Information Modelling in the Nigerian Construction Industry. *J. Sustain. Archit. Civ. Eng. Geod.* **2020**, *27*, 63–77. [CrossRef]
27. Babatunde, S.O.; Perera, S.; Ekundayo, D.; Adeleye, T.E. An investigation into BIM-based detailed cost estimating and drivers to the adoption of BIM in quantity surveying practices. *J. Financ. Manag. Prop. Constr. Econ. Build.* **2019**, *25*, 61–81. [CrossRef]
28. Eadie, R.; Odeyinka, H.; Browne, M.; McKeown, C.; Yohanis, M. An analysis of the drivers for adopting building information modelling. *J. Inf. Technol. Constr.* **2013**, *18*, 338–352.
29. Olawumi, T.O.; Chan, D.W. An empirical survey of the perceived benefits of executing BIM and sustainability practices in the built environment. *Constr. Innov.* **2019**, *19*, 321–342. [CrossRef]
30. Chan, A.P.; Ho, D.C.; Tam, C. Design and build project success factors: Multivariate analysis. *J. Constr. Eng. Manag.* **2001**, *127*, 93–100. [CrossRef]
31. Yu, A.T.; Shen, Q.; Kelly, J.; Lin, G. A value management approach to strategic briefing: An exploratory study. *Archit. Eng. Des. Manag.* **2006**, *2*, 245–259. [CrossRef]
32. Rodgers, C.; Hosseini, M.R.; Chileshe, N.; Rameezdeen, R. Building information modelling (BIM) within the Australian construction related small and medium sized enterprises: Awareness, practices and drivers. In Proceedings of the ARCOM 2015 31st Annual Conference of the Association of Researchers in Construction Management, Lincoln, UK, 7–9 September 2015; pp. 691–700.
33. Aghimien, D.O.; Oke, A.E.; Aigbavboa, C.O. Barriers to the adoption of value management in developing countries. *Eng. Constr. Archit. Manag.* **2018**. [CrossRef]
34. Olugboyega, O.; Edwards, D.J.; Windapo, A.O.; Omopariola, E.D.; Martek, I. Development of a conceptual model for evaluating the success of BIM-based construction projects. *Smart Sustain. Built Environ.* **2020**. [CrossRef]
35. NBS. NBS National BIM Report. 2014. Available online: https://www.thenbs.com/knowledge/nbs-national-bim-report-2014 (accessed on 30 January 2021).
36. NBS. NBS National BIM Report. 2019. Available online: https://www.thenbs.com/knowledge/national-bim-report-2019 (accessed on 30 January 2021).

37. McGraw-Hill. The Business Value of BIM in Australia and New Zealand: How Building Information Modelling Is Transforming the Design and Construction Industry. Available online: https://download.autodesk.com/temp/pdf/mcgraw_hill_business_value_of_bim_anz.pdf (accessed on 30 January 2021).
38. Tookey, J.E. Shaving BIM: Establishing A Framework for Future BIM Research in New Zealand. *Int. J. Constr. Supply Chain. Manag.* **2012**, *2*, 66–79.
39. Anifowose, O.M.; Babarinde, S.A.; Olanrewaju, O.I. Adoption level of building information modelling by selected professionals in Kwara state. *Environ. Technol. Sci. J.* **2018**, *9*, 35–44.
40. Ogunmakinde, O.E.; Umeh, S. Adoption of BIM in the Nigerian Architecture Engineering and Construction (AEC) Industry. Available online: https://www.researchgate.net/publication/328031625_Adoption_of_BIM_in_the_Nigerian_Architecture_Engineering_and_Construction_AEC_Industry (accessed on 30 January 2021).
41. Onungwa, I.O.; Uduma-Olugu, N. Building information modelling and collaboration in the Nigerian construction industry. *J. Constr. Bus. Manag. Prod. Eng. Rev.* **2017**, *1*, 1–10.
42. Olapade, D.T.; Ekemode, B.G. Awareness and utilisation of building information modelling (BIM) for facility management (FM) in a developing economy: Experience from Lagos, Nigeria. *J. Facil. Manag.* **2018**, *16*, 387–395. [CrossRef]
43. Gamil, Y.; Rahman, I.A.R. Awareness and challenges of building information modelling (BIM) implementation in the Yemen construction industry. *J. Eng. Des. Technol.* **2019**, *17*, 1077–1084. [CrossRef]
44. Ismail, N.A.A.; Chiozzi, M.; Drogemuller, R. An Overview of BIM Uptake in Asian Developing Countries. Available online: https://www.researchgate.net/publication/321079523_An_overview_of_BIM_uptake_in_Asian_developing_countries (accessed on 10 January 2021).
45. Mehran, D. Exploring the Adoption of BIM in the UAE Construction Industry for AEC Firms. *Procedia Eng.* **2016**, *145*, 1110–1118. [CrossRef]
46. Shibani, A.; Ghostin, M.; Hassan, D.; Saidani, M.; Agha, A. Exploring the Impact of Implementing Building Information Modelling to Support Sustainable Development in the Lebanese Construction Industry: A Qualitative Approach. *J. Mech. Civ. Eng. Geod.* **2021**, *7*, 33–62.
47. Akinradewo, O.; Oke, A.; Aigbavboa, C.; Molau, M. Assessment of the Level of Awareness of Robotics and Construction Automation in South African. In *Collaboration and Integration in Construction, Engineering, Management and Technology*; Springer: New York, NY, USA, 2021; pp. 129–132.
48. Raouf, A.M.; Al-Ghamdi, S.G. Building information modelling and green buildings: Challenges and opportunities. *Archit. Eng. Des. Manag.* **2019**, *15*, 1–28. [CrossRef]
49. Xu, X.; Ma, L.; Ding, L. A framework for BIM-enabled life-cycle information management of construction project. *Int. J. Adv. Robot. Syst.* **2014**, *11*, 126. [CrossRef]
50. Pärn, E.; Edwards, D.; Sing, M.C. Origins and probabilities of MEP and structural design clashes within a federated BIM model. *Autom. Constr.* **2018**, *85*, 209–219. [CrossRef]
51. Chahrour, R.; Hafeez, M.A.; Ahmad, A.M.; Sulieman, H.I.; Dawood, H.; Rodriguez-Trejo, S.; Kassem, M.; Naji, K.K.; Dawood, N. Cost-benefit analysis of BIM-enabled design clash detection and resolution. *Constr. Manag. Econ.* **2021**, *39*, 55–72. [CrossRef]
52. McNamara, A.J.; Sepasgozar, S.M. Intelligent contract adoption in the construction industry: Concept development. *Autom. Constr.* **2021**, *122*, 103452. [CrossRef]
53. Badi, S.; Ochieng, E.; Nasaj, M.; Papadaki, M. Technological, organisational and environmental determinants of smart contracts adoption: UK construction sector viewpoint. *Constr. Manag. Econ.* **2021**, *39*, 36–54. [CrossRef]
54. Cheng, J.C.; Chen, W.; Chen, K.; Wang, Q. Data-driven predictive maintenance planning framework for MEP components based on BIM and IoT using machine learning algorithms. *Autom. Constr.* **2020**, *112*, 103087. [CrossRef]
55. Eastman, C.M.; Eastman, C.; Teicholz, P.; Sacks, R.; Liston, K. *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors, 2nd ed*; John Wiley & Sons: Hoboken, NJ, USA, 2011.
56. Almukhtar, A.; Saeed, Z.O.; Abanda, H.; Tah, J.H. Reality capture of buildings using 3D laser scanners. *Civ. Eng.* **2021**, *2*, 214–235.
57. Ham, Y.; Golparvar-Fard, M. Mapping actual thermal properties to building elements in gbXML-based BIM for reliable building energy performance modeling. *Autom. Constr.* **2015**, *49*, 214–224. [CrossRef]
58. Sanhudo, L.; Ramos, N.M.; Martins, J.P.; Almeida, R.M.; Barreira, E.; Simões, M.L.; Cardoso, V. A framework for in-situ geometric data acquisition using laser scanning for BIM modelling. *J. Build. Eng.* **2020**, *28*, 101073. [CrossRef]
59. Lagüela, S.; Díaz-Vilariño, L.; Armesto, J.; Arias, P. Non-destructive approach for the generation and thermal characterization of an as-built BIM. *Constr. Build. Mater.* **2014**, *51*, 55–61. [CrossRef]
60. Sanhudo, L.; Ramos, N.M.; Martins, J.P.; Almeida, R.M.; Barreira, E.; Simões, M.L.; Cardoso, V. Building information modeling for energy retrofitting—A review. *Renew. Sustain. Energy Rev.* **2018**, *89*, 249–260. [CrossRef]
61. Sun, L.; Pei, A.; Qi, X.; Cao, S.; Yang, R.; Liu, X. Dynamic Analysis of Digital Twin System Based on Five-Dimensional Model. In Proceedings of the Journal of Physics: Conference Series, Chengdu, China, 13–15 December 2019; p. 072038.
62. Aheleroff, S.; Xu, X.; Zhong, R.Y.; Lu, Y. Digital twin as a service (DTaaS) in industry 4.0: An architecture reference model. *Adv. Eng. Inform.* **2021**, *47*, 101225. [CrossRef]
63. Saka, A.B.; Chan, D.W. A scientometric review and metasynthesis of building information modelling (BIM) research in Africa. *Buildings* **2019**, *9*, 85. [CrossRef]

64. Chan, D.W.; Olawumi, T.O.; Ho, A.M. Perceived benefits of and barriers to Building Information Modelling (BIM) implementation in construction: The case of Hong Kong. *J. Build. Eng.* **2019**, *25*, 100764. [CrossRef]
65. Cavka, H.B.; Staub-French, S.; Poirier, E.A. Developing owner information requirements for BIM-enabled project delivery and asset management. *Autom. Constr.* **2017**, *83*, 169–183. [CrossRef]
66. Nieto-Julián, J.E.; Lara, L.; Moyano, J.J.S. Implementation of a TeamWork-HBIM for the Management and Sustainability of Architectural Heritage. *Sustainability* **2021**, *13*, 2161. [CrossRef]
67. Stransky, M.; Dlask, P. Process of matching work items between bim model and cost estimating software. *Eng. Rural. Dev.* **2018**, *17*, 856–864. [CrossRef]
68. Nagalingam, G.; Jayasena, H.S.; Ranadewa, K. Building information modelling and future quantity surveyor's practice in Sri Lankan construction industry. In Proceedings of the Second World Construction Symposium, Colombo, Sri Lanka, 14–15 June 2013; pp. 81–92.
69. Chileshe, N.; Jayasinghe, R.S.; Rameezdeen, R. Information flow-centric approach for reverse logistics supply chains. *Autom. Constr.* **2019**, *106*, 102858. [CrossRef]
70. Wu, J.; Lepech, M.D. Incorporating multi-physics deterioration analysis in building information modeling for life-cycle management of durability performance. *Autom. Constr.* **2020**, *110*, 103004. [CrossRef]
71. Amarasinghe, I.A.; Soorige, D.; Geekiyanage, D. Comparative study on Life Cycle Assessment of buildings in developed countries and Sri Lanka. *Built Environ. Proj. Asset Manag.* **2021**. [CrossRef]
72. Lin, Y.-C.; Hsu, Y.-T. Enhancing the Visualization of Problems Tracking and Management Integrated BIM Technology for General Contractor in Construction. In *Collaboration and Integration in Construction, Engineering, Management and Technology*; Springer: New York, NY, USA, 2021; pp. 427–432.
73. Aghimien, D.O.; Aigbavboa, C.; Edwards, D.J.; Mahamadu, A.-M.; Olomolaiye, P.; Nash, H.; Onyia, M. A fuzzy synthetic evaluation of the challenges of smart city development in developing countries. *Smart Sustain. Built Environ.* **2020**. [CrossRef]
74. Edwards, D.J.; Rillie, I.; Chileshe, N.; Lai, J.; Hosseini, M.R.; Thwala, W.D. A field survey of hand-arm vibration exposure in the UK utilities sector. *Eng. Constr. Archit. Manag.* **2020**. [CrossRef]
75. Shields, P.M.; Tajalli, H. Intermediate theory: The missing link in successful student scholarship. *J. Public Aff. Educ.* **2006**, *12*, 313–334. [CrossRef]
76. Chileshe, N.; Rameezdeen, R.; Hosseini, M.R.; Martek, I.; Li, H.X.; Panjehbashi-Aghdam, P. Factors driving the implementation of reverse logistics: A quantified model for the construction industry. *Waste Manag.* **2018**, *79*, 48–57. [CrossRef]
77. Christensen, C.M. The ongoing process of building a theory of disruption. *J. Prod. Innov. Manag.* **2006**, *23*, 39–55. [CrossRef]
78. Kineber, A.F.; Othman, I.; Oke, A.E.; Chileshe, N.; Alsolami, B. Critical Value Management Activities in Building Projects: A Case of Egypt. *Buildings* **2020**, *10*, 239. [CrossRef]
79. Kineber, A.F.; Othman, I.; Oke, A.E.; Chileshe, N.; Buniya, M.K. Identifying and Assessing Sustainable Value Management Implementation Activities in Developing Countries:The Case of Egypt. *Sustainability* **2020**, *12*, 9143. [CrossRef]
80. Oke, A.E.; Kineber, A.F.; Albukhari, I.; Othman, I.; Kingsley, C. Assessment of Cloud Computing Success Factors for Sustainable Construction Industry: The Case of Nigeria. *Buildings* **2021**, *11*, 36. [CrossRef]
81. Gilham, B. *Developing a Questionnaire*, 2nd ed.; Bloomsbury: London, UK, 2015; ISBN 978-0-826409631-7.
82. Collins, H. *Creative Research: The Theory and Practice of Research for the Creative Industries*; Bloomsbury: London, UK, 2018.
83. Babatunde, S.O.; Ekundayo, D.; Adekunle, A.O.; Bello, W. Comparative analysis of drivers to BIM adoption among AEC firms in developing countries: A case of Nigeria. *J. Eng. Des. Technol.* **2020**. [CrossRef]
84. Santos, J.R. Cronbach's alpha: A tool for assessing the reliability of scales. *J. Ext.* **1999**, *37*, 1–5.
85. Buniya, M.K.; Othman, I.; Durdyev, S.; Sunindijo, R.Y.; Ismail, S.; Kineber, A.F. Safety Program Elements in the Construction Industry: The Case of Iraq. *Int. J. Environ. Res. Public Health* **2021**, *18*, 411. [CrossRef]
86. Adedokun, O.A.; Ibironke, O.T.; Olanipekun, A.O. Vulnerability of motivation schemes in enhancing site workers productivity for construction industry's sustainability in Nigeria. *Int. J. Sustain. Constr. Eng. Technol.* **2013**, *4*, 21–30.
87. Byrne, B.M.; Group, F. Structural equation modeling with AMOS: Basic concepts, applications, and programming (multivariate applications series). *N. Y. Taylor Fr. Group* **2010**, *396*, 7384.
88. Chen, Y.; Dib, H.; Cox, R.F.; Shaurette, M.; Vorvoreanu, M. Structural equation model of building information modeling maturity. *J. Constr. Eng. Manag. Prod. Eng. Rev.* **2016**, *142*, 04016032. [CrossRef]
89. Chang, C.-Y.; Pan, W.; Howard, R. Impact of building information modeling implementation on the acceptance of integrated delivery systems: Structural equation modeling analysis. *J. Constr. Eng. Manag. Prod. Eng. Rev.* **2017**, *143*, 04017044. [CrossRef]
90. Okakpu, A.; GhaffarianHoseini, A.; Tookey, J.; Haar, J.; Ghaffarianhoseini, A. Exploring the environmental influence on BIM adoption for refurbishment project using structural equation modelling. *Archit. Eng. Des. Manag.* **2020**, *16*, 41–57. [CrossRef]
91. Kineber, A.F.; Othman, I.; Oke, A.E.; Chileshe, N.; Zayed, T. Exploring the value management critical success factors for sustainable residential building—A structural equation modelling approach. *J. Clean. Prod.* **2021**, 126115. [CrossRef]
92. Podsakoff, P.M.; MacKenzie, S.B.; Lee, J.-Y.; Podsakoff, N.P. Common method biases in behavioral research: A critical review of the literature and recommended remedies. *J. Appl. Psychol.* **2003**, *88*, 879. [CrossRef]
93. Williams, L.J.; Cote, J.A.; Buckley, M.R. Lack of method variance in self-reported affect and perceptions at work: Reality or artifact? *J. Appl. Psychol.* **1989**, *74*, 462. [CrossRef]

94. Strandholm, K.; Kumar, K.; Subramanian, R. Examining the interrelationships among perceived environmental change, strategic response, managerial characteristics, and organizational performance. *J. Bus. Res.* **2004**, *57*, 58–68. [CrossRef]
95. Harman, H.H. *Modern Factor Analysis*; University of Chicago press: Chicago, IL, USA, 1967.
96. Al-Ashmori, Y.Y.; Othman, I.; Rahmawati, Y.; Amran, Y.M.; Sabah, S.A.; Rafindadi, A.D.u.; Mikić, M. BIM benefits and its influence on the BIM implementation in Malaysia. *Ain Shams Eng. J.* **2020**, *11*, 1013–1019. [CrossRef]
97. Hulland, J. Use of partial least squares (PLS) in strategic management research: A review of four recent studies. *Strateg. Manag. J.* **1999**, *20*, 195–204. [CrossRef]
98. Hair, J.F.; Anderson, R.E.; Babin, B.J.; Black, W.C. *Multivariate Data Analysis: A Global Perspective*; Pearson: Upper Saddle River, NJ, USA, 2010; Volume 7.
99. Al-Mekhlafi, A.-B.A.; Isha, A.S.N.; Chileshe, N.; Abdulrab, M.; Saeed, A.A.H.; Kineber, A.F. Modelling the Relationship between the Nature of Work Factors and Driving Performance Mediating by Role of Fatigue. *Int. J. Environ. Res. Public Health* **2021**, *18*, 6752. [CrossRef]
100. Tabachnick, B.G.; Fidell, L.S.; Ullman, J.B. *Using Multivariate Statistics*; Pearson: Boston, MA, USA, 2007; Volume 5.
101. MacKenzie, S.B.; Podsakoff, P.M. Common method bias in marketing: Causes, mechanisms, and procedural remedies. *J. Retail.* **2012**, *88*, 542–555. [CrossRef]
102. Podsakoff, P.M.; Organ, D.W. Self-reports in organizational research: Problems and prospects. *J. Manag.* **1986**, *12*, 531–544. [CrossRef]
103. Hair, J.F., Jr.; Matthews, L.M.; Matthews, R.L.; Sarstedt, M. PLS-SEM or CB-SEM: Updated guidelines on which method to use. *Int. J. Multivar. Data Anal.* **2017**, *1*, 107–123. [CrossRef]
104. Henseler, J.; Ringle, C.M.; Sinkovics, R.R. The use of partial least squares path modeling in international marketing. In *New Challenges to International Marketing*; Emerald Group Publishing Limited: Bingley, UK, 2009.
105. Wong, K.K.-K. Partial least squares structural equation modeling (PLS-SEM) techniques using SmartPLS. *Mark. Bull.* **2013**, *24*, 1–32.
106. Bagozzi, R.P.; Yi, Y. Specification, evaluation, and interpretation of structural equation models. *J. Acad. Mark. Sci.* **2012**, *40*, 8–34. [CrossRef]
107. Perry, R.H.; Charlotte, B.; Isabella, M.; Bob, C. *SPSS Explained*; Routledge: London, UK, 2004.
108. Hair, J.F.; Ringle, C.M.; Sarstedt, M. Partial least squares structural equation modeling: Rigorous applications, better results and higher acceptance. *Long Range Plan.* **2013**, *46*, 1–12. [CrossRef]
109. Fornell, C.; Larcker, D.F. Evaluating structural equation models with unobservable variables and measurement error. *J. Mark. Res.* **1981**, *18*, 39–50. [CrossRef]
110. Hair, J.F.; Black, W.C.; Babin, B.J.; Anderson, R.E.; Tatham, R.L. Multivariate Data Analysis. In *Humans: Critique and Reformulation*, 6th ed.; Pearson Prentice Hall: Hoboken, NJ, USA, 2006; Volume 87, pp. 49–74.
111. Chin, W.W. The partial least squares approach to structural equation modelling. *Mod. Methods Bus. Res.* **1998**, *295*, 295–336.
112. Olanrewaju, O.I.; Oyewobi, L.O.; Idiake, J.E.; Alumbugu, P.; Babarinde, S.A.; Oke, A.E. Nexus of economic recession and building construction cost in Nigeria. *J. Niger. Inst. Quant. Surv.* **2019**. [CrossRef]
113. Ringle, C.; Da Silva, D.; Bido, D.; Ringle, C. Structural Equation Modeling with the SmartPLS. Available online: https://www.researchgate.net/publication/281448905_STRUCTURAL_EQUATION_MODELING_WITH_THE_SMARTPLS (accessed on 30 January 2021).
114. Chin, W.W. Commentary: Issues and opinion on structural equation modeling. *JSTOR* **1998**, *22*, vii–xvi.
115. Hair, J.F.; Ringle, C.M.; Sarstedt, M. PLS-SEM: Indeed a silver bullet. *J. Mark. Theory Pract.* **2011**, *19*, 139–152. [CrossRef]
116. Švajlenka, J.; Kozlovská, M. Perception of user criteria in the context of sustainability of modern methods of construction based on wood. *Sustainability* **2018**, *10*, 116. [CrossRef]
117. Švajlenka, J.; Kozlovská, M.; Pošiváková, T. Analysis of selected building constructions used in industrial construction in terms of sustainability benefits. *Sustainability* **2018**, *10*, 4394. [CrossRef]
118. Švajlenka, J.; Kozlovská, M. Evaluation of the efficiency and sustainability of timber-based construction. *J. Clean. Prod.* **2020**, *259*, 120835. [CrossRef]
119. Spychalska-Wojtkiewicz, M. The Relation between Sustainable Development Trends and Customer Value Management. *Sustainability* **2020**, *12*, 5496. [CrossRef]
120. Al-Atesh, E.; Rahmawati, Y.; Zawawi, N.A.W.A. Sustainability Criteria for Green Building Material Selection in the Malaysian Construction Industry. Available online: https://www.researchgate.net/publication/348159484_Sustainability_Criteria_for_Green_Building_Material_Selection_in_the_Malaysian_Construction_Industry (accessed on 1 January 2021).
121. Vass, S.; Gustavsson, T.K. Challenges when implementing BIM for industry change. *Constr. Manag. Econ.* **2017**, *35*, 597–610. [CrossRef]
122. Biancardo, S.A.; Viscione, N.; Oreto, C.; Veropalumbo, R.; Abbondati, F. BIM approach for modeling airports terminal expansion. *Infrastructures* **2020**, *5*, 41. [CrossRef]
123. Ghaffarianhoseini, A.; Tookey, J.; Ghaffarianhoseini, A.; Naismith, N.; Azhar, S.; Efimova, O.; Raahemifar, K. Building Information Modelling (BIM) uptake: Clear benefits, understanding its implementation, risks and challenges. *Renew. Sustain. Energy Rev.* **2017**, *75*, 1046–1053. [CrossRef]

124. Ibem, E.; Uwakonye, U.; Akpoiroro, G.; Somtochukwu, M.; Oke, C. Building information modeling (BIM) adoption in architectural firms in Lagos, Nigeria. *Int. J. Civ. Eng. Technol.* **2018**, *9*, 902–915.
125. Wu, S.; Wood, G.; Ginige, K.; Jong, S.W. A technical review of BIM based cost estimating in UK quantity surveying practice, standards and tools. *J. Inf. Technol. Constr.* **2014**, *19*, 534–562.
126. Sidani, A.; Dinis, F.M.; Duarte, J.; Sanhudo, L.; Calvetti, D.; Baptista, J.S.; Martins, J.P.; Soeiro, A. Recent Tools and Techniques of BIM-Based Augmented Reality: A Systematic Review. *J. Build. Eng.* **2021**, 102500. [CrossRef]
127. Olanrewaju, A.F.K.O.I.; Chileshe, N.; Edwards, D.J. Analysis of the role of Building Information Modelling (BIM) Implementation drivers and awareness on Project Lifecycle. *Sustainability* **2021**, submitted.
128. Delgado, J.M.D.; Oyedele, L.; Ajayi, A.; Akanbi, L.; Akinade, O.; Bilal, M.; Owolabi, H.J.J.o.B.E. Robotics and automated systems in construction: Understanding industry-specific challenges for adoption. *J. Build. Eng.* **2019**, *26*, 100868. [CrossRef]