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LATENT FACTORS MANIFESTING SUSTAINABLE CONSTRUCTION UNDERSTANDING

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ABSTRACT

There is a strong premonition that a future successful sustainable construction implementation pivots partly upon a manifestation of sustainable construction understanding among the professionals in the industry. This research stands to advocate that a distinct manifestation of sustainable construction concept by AEC professionals reflects the knowledge kept, which mirrors the understanding thus provides a plausible starting point for future successful implementation of sustainable construction practices. Using Nigeria AEC industry's current effort in sustainable construction as the backdrop, this research aimed to determine latent factors that characterise sustainable construction understanding among professionals in the AEC industry. Research data was gathered via a survey carried out on 580 construction professionals. Data were analysed by way of EFA and CFA (using PLS-SEM). Findings from the structural model developed showed seven latent factors which includes awareness, political, passive culture, knowledge, demand, financial and attitude. The latent factors derived from this research provide a context-specific understanding of sustainable construction concept by AEC professionals in its indigenous setting as a basis for future implementation of sustainable construction practices.

Key words: Sustainable development, Sustainable construction, Sustainable construction practices, Nigerian construction industry, Structural equation modelling.

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1. INTRODUCTION

Consideration of sustainable construction has been at the centre stage due to the escalating energy and water consumption, menacing air pollution, and the volume of greenhouse gas emissions. Together, these effects make the promotion of sustainable construction practices in the construction sector inevitable (Berardi, 2013). The construction sector, on the one hand, has the potential in the reduction of energy consumed and the amount of air pollution produced (Ghaffarianhoseini et al., 2013) by adopting sustainable construction practices.

Sustainable construction and green construction understanding are every so often applied interchangeably (Potbhare et al., 2009) as both refer to a chance to act efficiently in an environmentally friendly way. Sustainable construction researches abound in the literature at a varying degree in the context of different countries though with least understood words (Lafarge Holcim Foundation, 2017). These in a way echoes the need to implement sustainable construction practices as mentioned in Du Plessis, (2002), Häkkinen & Belloni (2011) and Kibert (2007).

Sustainable construction products like green buildings, zero energy buildings sprang up in numerous countries (Kibert, 2007), which were achieved as a result of employing novel products, services, and practices at the same time. Sustainable construction, according to Durdyev et al. (2018), while citing Du Plessis (2007) was defined as an 'integrative and holistic approach offering harmony between the pillars (environment, economic and social) of sustainability'. The reduction in the environmental quality and resources efficiency constitute the initial consideration of the sustainable construction concepts. However, there was a disregard for the aspects of the economy and society. Available studies were done mostly by employing qualitative methods to examine on challenges, prospects elements and professional perspectives on sustainable construction practices in developing countries including Nigeria (Aghimien, Adegbembo, et al., 2018; Dania, 2016; Dania et al., 2014; Chrisna Du Plessis, 2007; Kwakye, 2010; Mensah et al., 2015).

Nigeria's quest for development will remain deficient without input from the construction sector. The world over, the construction industry is one of the ever-growing sectors following its contribution to macroeconomic growth which includes infrastructures such as transportation, communication, housing, water supply and sanitation. The construction industry in Nigeria is responsible for contributing up to 50% to the domestic fixed capital formation, and about 6.83% of the Gross Domestic Product (GDP) in the second quarter of 2020 (National Bureau of Statistics, 2020). The Nigerian construction industry also employs about 20% of the working population (Olanipekun & Saka, 2019). Like many other developing countries, Nigeria now is more aware of the urgency to take practical steps that will improve the performance of the construction industry (Ofori, 2012). With environmental and resource optimization becoming the focus, concerted efforts to reduce unsustainable practices by implementing several measures towards sustainable development are touted, as one of the key elements to improve the performance of the industry.

However, the adoption and implementation of sustainable construction in Nigeria is still at its infancy. Akinshipe et al. (2019) reported that there is an absence of relevant sustainability codes to guide construction activities in Nigeria, which caused its implementation to remain unclear. Various authors (Abolore, 2012; Aghimien et al., 2019; Baron & Donath, 2016) have shown that sustainable construction understanding in Nigeria is characterised by several issues that need to be addressed. Concerted efforts need to be put in place to overcome the issues in order to implement sustainable construction in the Nigerian construction industry. Vandierendonck et al. (2010) stated that characteristics and situations that can hamper actions or obstruct progress towards achieving specific aims, in this case implementing the sustainable construction practices have to be identified. Mensah et al. (2015) and Opoku et al. (2017) further

asserted that an apparent paucity in characterizing what sustainable construction stands has an undesirable effect on the implementation of sustainable construction practices.

While the environmental and resources degradation which accentuates the concept of sustainable construction seem to be understood, the understanding of the concept, for future implementation by professionals in the AEC industry somehow appears to be inconsistent. An idiosyncrasy with the AEC industry's effort to promulgate the concept and implementation was the cause, reciprocating the specific context and the knowledge of the professionals operating in its indigenous setting. There was a strong premonition that a future successful sustainable construction implementation pivots partly upon a manifestation of sustainable construction understanding among the professionals in the industry (Dania et al., 2013). This research stands to advocate that a distinct manifestation of sustainable construction concept by AEC professionals reflects the knowledge kept, which mirrors the understanding thus provides a plausible starting point for future successful implementation of sustainable construction practices.

Using Nigeria AEC industry's current effort in sustainable construction as the backdrop, this research aims to determine latent factors that characterise sustainable construction understanding among professionals in the AEC industry. Two objectives were outlined: (1) to determine latent factors that manifest sustainable construction understanding, and (2) to develop latent factors structural model that manifest a sustainable construction understanding among professionals in the AEC industry. The following section presents the outcome from the literature review carried out, which focuses to identify the broad factors that manifest sustainable construction understanding among professionals in the AEC industry.

2. RESEARCH METHODOLOGY

The research employed a cross-sectional design that employed a survey instrument as the method for data collection. Hair et al. (2010) showed that using a survey makes the collection of comprehensive data from a considerable population possible in an efficient way. For this research, there are thirty-five variables whose assessment will help in achieving the objective of the research. The 35 variables will form the questionnaire instrument used in determining the latent factors manifesting sustainable construction understanding among construction professionals in the AEC industry.

The questionnaire is divided to contain (1) Demographic information of the respondents (2) Factors that characterise sustainable construction understanding. The research considered registered construction professionals located in the Federal Capital Territory, Abuja. The sampling frame for the research consisted of names of all registered construction professionals obtained from the websites of the regulatory bodies. A pilot study has been carried out to test the reliability of the instrument using a selected number of registered professional construction professionals. Fifty sets of the survey questionnaires were distributed among the selected group by way of stratified random sampling to ascertain the Cronbach Alpha values of all items listed in the questionnaire. If the Cronbach Alpha value is more than 0.70, the item/construct is accepted as reliable (Nunnally, 1978). Hair et al. (2019), consider 0.60 to below 0.70 as reasonable and adequate for use in the research.

Table 1 Reliability statistics

Cronbach's Alpha	N of Items
.912	35

For this research, Cronbach's alpha is 0.912 (Table 1), which is above the recommended threshold of 0.7. Therefore, the research instrument has attained good reliability, and it is suitable for data collection.

Table 2 Normality Test

Factors	Profession	Shapiro-Wilk		
		Statistic	df	Sig.
MeanUnderstand	Architect	0.988	77	0.713
	Builder	0.983	90	0.311
	Civil Engineer	0.979	102	0.099
	Quantity Surveyor	0.965	21	0.618

aLilliefors Significance Correction

Before data was analysed, normality test, which is an essential assumption in a multivariate investigation (Hair et al., 2017; Hair et al., 2019) was carried out first. The test is to ascertain the normality of the data gathered from the survey. From the result of the normality test carried out, The test results showed that the p-value for all the pre-test and post-test is higher than 0.05. Therefore, it can be concluded that the data comes from the normal distribution.

Responses received were coded, and SPSS version 25 and SmartPLS 3 was employed to analyse the data. The method of data analysis employed in this research is the Exploratory factor analysis and a confirmatory factor analysis using structural equation being a second-generation technique used in multivariate analysis of latent constructs (Taiwo & Misnan, 2020).

3. DATA ANALYSIS

3.1. Respondents Demographic Distribution

The participants in this research were 290 respondents; the distribution of the respondent's demographic information is presented in Table 3.

Table 3 Demographic distribution

Demographic Variables	Categories	Frequency	Per cent
Profession	Architecture	77	26.6
	Building	90	31.0
	Structural Engineering	102	35.2
	Quantity Surveying	21	7.2
	Total	290	100.0
Construction work experience	Up to 5 years	91	31.4
	6 – 10 years	129	44.5
	11 – 15 years	36	12.4
	16 – 20 years	34	11.7
	Total	290	100.0
Highest Qualification	Bachelors / HND	93	32.1
	Masters	146	50.3
	PhD	45	15.5
	others	6	2.1
	Total	290	100.0
Practice Sector	Private Practice	212	73.1
	Public sector	78	26.9
	Total	290	100.0
Sustainable construction experience	Yes	270	63.1
	No	3	3
	Total	290	100.0

The distribution of the respondents by their profession, as presented in Table 3, revealed that 77 (26.6%) of the respondents were Architect, 90 (31%) were Builders, 102 (35.2 %) were Civil Engineers, and 21 (7.2%) were Quantity Surveyor. This distribution shows that the respondents from different groups were fairly represented. The working experience of participants for this research shows that 31.4% had up to 5 years of working experience, with 44.5 per cent having up to 10 years of work experience. Those with up to 15 % were 12.4 per cent, while those with up to 20 years were about 11.7 % of the total numbers. Among these professionals, 73.1% work in the private sector while 26.9 % work in the public sector.

4. RESULTS AND DISCUSSION

The results of this research, as explained in the preceding section of data analysis, are obtained using Exploratory Factor Analysis (EFA), and the conceptual paths were tested using SEM based on the PLS technique. The responses of the participants coded were used to conduct the exploratory factor analysis to identify the factors that characterise sustainable construction understanding in Nigeria. The factor analysis was conducted in two stages to eliminate items that are not loading correctly.

4.1. Exploratory Factor Analysis (EFA)

Exploratory factor analysis (EFA) was carried out from data obtained from 290 respondents. The EFA saw the deletion of items with a poor loading; the same procedure was repeated in three stages. The factorability of the 30 remaining items out of the initial 35 was examined. The criteria for the factorability of a correlation recommended in Hooper (2012) is used. Firstly, all the 30 items correlate at more than 0.3 with at least one other item, suggesting reasonable factorability. Secondly, as presented in Table 6, the new round of the factor analysis shows the Kaiser-Meyer-Olkin (KMO) measure of overall sampling adequacy is equal to 0.611, well above the recommended value of 0.5. Bartlett's test of sphericity is significant with the p-value of < 0.05 (Hair et al., 2012).

Table 4 KMO and Bartletts Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy. .611

Bartlett's Test of Sphericity	Approx. Chi-Square	11709.261
	df	435
	Sig.	.000
	Approx. Chi-Square	11709.261

Thirdly, the communality for each item is set to be above 0.4 (Leimeister, 2010) to confirm that each item shares some common variance with other items. With the satisfaction of these conditions, the extraction method of principal component analysis as examined to determine the factors identified in the analysis. The EFA results presented are the factor loadings, eigenvalues, and percentage (%) of variance explained are presented. The results are presented in Tables 5 and 6.

The results of the eigenvalues and percentage of variance explained by the components are shown in Table 5—the result show 7 – components with eigenvalues greater than 1. The seven components cumulatively explained 74.714% variance in the factor structure. Thus, with the results of Eigenvalues, and the variance explained, the EFA presented seven factors in the data structure that explained the larger percentages of the variance in the model. With the identification of 7 components that provides enough information to understand the factor structure. The factor loadings for each item in the components, the number of items for each

factor (component), and the range for the factor loadings for the items in each factor were examined, as presented in Table 8.

Table 5 Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	%	Cumulative %	Total	%	Cumulative %
1	.003	16.675	16.675	5.003	16.675	16.675
2	.190	13.965	30.641	4.190	13.965	30.641
3	.565	11.883	42.523	3.565	11.883	42.523
4	.889	9.630	52.153	2.889	9.630	52.153
5	.518	8.393	60.546	2.518	8.393	60.546
6	.247	7.491	68.037	2.247	7.491	68.037
7	.003	6.677	74.714	2.003	6.677	74.714
8	998	3.328	78.042			
9	881	2.938	80.980			
10	789	2.631	83.611			
11	706	2.352	85.963			
12	650	2.166	88.129			
13	553	1.843	89.972			
14	517	1.723	91.694			
15	488	1.628	93.322			
16	434	1.447	94.770			
17	345	1.151	95.921			
18	290	.965	96.886			
19	271	.902	97.787			
20	253	.843	98.630			
21	135	.451	99.081			
22	06	.354	99.435			
23	064	.212	99.647			
24	040	.134	99.781			
2	033	.109	99.889			
26	014	.046	99.935			
27	012	.040	99.975			
28	005	.015	99.991			
29	003	.009	99.999			
30	000	.001	100.000			

Extraction Method: Principal Component Analysis.

Table 6 Rotated Component Matrix[a]

Items/Factor	1	2	3	4	5	6	7
Govt. Leadership			.891				
Clear Policy			.835				
Local regulations			.781				
Resource conservation			.787				
Indoor air requirement			.895				
Irrespective cost					.831		
Value for money					.715		
Financial incentives					.799		
Cost of Project delivery					.852		
Enough knowledge						.666	
Sufficient experience						.677	
Reliable information						.673	
Adequate training						.669	
Adequate Research						.672	
Resistant to change							.771
Adequate coordination							.827

Foreign technology							.636
Resist innovation							.716
Reluctance				.964			
Academic exercise				.980			
Professional practice				.979			
Enough awareness	.976						
Successful models	.985						
Similar countries	.986						
Areas of deficit	.965						
Comfortable	.976						
Growing interest		.976					
Clients willing		.964					
Level of demand		.989					
Availability of supply		.960					
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.							
a. Rotation converged in 5 iterations.							

Table 6 shows the Exploratory Factor Analysis Result using Varimax with Kaiser Normalization. The rotated component matrix indicated the loadings and number of items valid for each component/factor. The process produced seven Factors in order of their strength in the factor structure.

- Awareness
- Demand
- Political
- Attitude
- Financial
- Knowledge
- Passive culture

The seven factors identified will be used to construct the structural model for latent factors manifesting sustainable construction. The principles of Partial Least Square Structural Equation Modelling will be applied to ascertain the strength of influence of each factor on sustainable construction understanding.

4.2. Confirmatory Factor Analysis (PLS-SEM)

The measurement model of the factors that characterise sustainable construction understanding is assessed in an initial measurement model where factors that did not meet the required threshold were deleted. The modified measurement model in Figure 1 shows items factor loading (at least 0.7 showed satisfactory indicator reliability), composite reliability (CR), and average variance extracted (AVE). Seven (7) items identified as the key factors that characterise sustainable construction understanding in Nigeria.

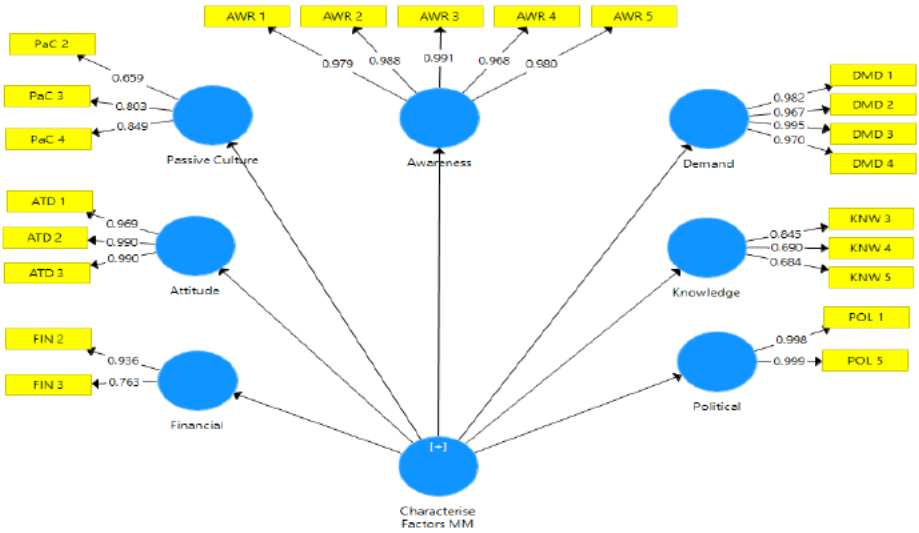

Figure 1. Modified Measurement Model of Factors that characterise SC understanding

Table 7 Measurement Model of factors that characterise SC understanding

S/N	Factors	Item	Factor Loadings	CR	AVE
1.	Attitude	ATD 1	0.969	0.989	0.966
		ATD 2	0.990		
		ATD 3	0.990		
2.	Awareness	AWR 1	0.979	0.992	0.963
		AWR 2	0.988		
		AWR 3	0.991		
		AWR 4	0.968		
		AWR 5	0.980		
3.	Demand	DMD 1	0.982	0.989	0.958
		DMD 2	0.967		
		DMD 3	0.995		
		DMD 4	0.970		
4.	Financial	FIN 2	0.936	0.842	0.729
		FIN 3	0.763		
5.	Knowledge	KNW 3	0.845	0.786	0.553
		KNW 4	0.690		
		KNW 5	0.684		
6.	Political	POL 1	0.998	0.816	0.600
		POL 5	0.999		
7.	Passive Culture	PaC 2	0.659	0.999	0.997
		PaC 3 PaC 4	0.803 0.849		

Based on the result presented in table 7, the 21 items measuring the sub-construct (seven factors) showed factor loadings of 0.7 and above. The measurement indicators showed satisfactory loading. Similarly, the seven factors achieved satisfactory reliability with the composite reliability (CR) of more than 0.7, an indication that the CR for the model is above the recommended minimum value of 0.7. Equally, the convergent validity measured through investigating the AVE value; in cases where constructs have an AVE value equal to or greater than 0.5, convergent validity is acceptable. The result shows that all the seven factors that characterise sustainable construction understanding in Nigeria have AVE ranging from 0.5. The

result shows that the model had satisfactory convergent validity and composite reliability. Thus, this result confirmed that Political, Financial, Knowledge, Passive Culture, Attitude, Awareness, Demand are the factors that characterise sustainable construction understanding in Nigeria.

5. CONCLUSIONS

Based on the findings presented in this research, it is, therefore, concluded that there is inadequate understanding of sustainable construction practices among construction professionals in Nigeria's AEC industry. The result implies that, for there to be an improvement in sustainable construction understanding, then there must be a change from viewing sustainable construction as an academic exercise is necessary. Also, proper enlightening of construction industry participants is needed to understand the inherent benefits of implementing sustainable construction properly. Therefore, for successful implementation of sustainable construction practices in Nigeria's AEC industry, more attention should be given towards increasing the awareness with the support of the political class. It will play a massive role in changing the passive culture of construction professionals to live up to the anticipated surge in demand. The increase in financial incentives and knowledge will have a profound effect on the attitude of construction professionals in Nigeria's AEC industry towards sustainable construction practices. The findings of this research showed that all the suggested hypotheses were supported. Sustainable construction understanding is affected by all the seven constructs, i.e., awareness, political, passive culture, demand, Finance, knowledge and attitude related factors.

This research presents several contributions in terms of implementing sustainable construction in Nigeria's AEC industry. Findings of this research provide insights into construction professionals understanding of latent factors manifesting sustainable construction in Nigeria. These understanding underscore the status of sustainable construction practices implementation in the AEC industry. In practice, the findings provide an insight for the government in providing guidelines to promote implementing sustainable construction practices; hence, invest their efforts and allocate resources more efficiently. Thus, precise and valid regulatory framework, adequate education in combination with appreciable financial incentives will ultimately lead to effective implementation of sustainable construction practice initiatives; hence, attainment of sustainable development and efficient utilisation of natural resources (energy, water and materials).

The aim of this research was achieved successfully; however, despite the success demonstrated, the conclusions should be treated with caution because it suffers the following limitations. Firstly, this research is biased towards the understanding of AEC industry professionals in Nigeria; therefore, the socio-economic and legislative environment is that of Nigeria. The realities should be noted before further application in similar developing countries. More so, this research is limited by the relatively small responses received, which requires further quantification and the validation of the SEM based on a larger sample. For successful implementation of sustainable construction practice understanding of latent factors manifesting sustainable construction implementation from a wider AEC industry stakeholders (i.e. Clients, contractors, project managers, suppliers) should be carried out. There is a need for a Green Building Council for Nigeria (GBCN). The establishment of the council will help drive adoption and implementation of sustainable construction practices.

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