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Drivers for the Implementation of Circular Economy in the Nigerian AECO Industry: A Structural Equation Modelling Approach

Abstract

Purpose: This study aims to investigate the drivers influencing the implementation of circular economy principles in the Nigerian architecture, engineering, construction, and operation (AECO) industry across diverse regions of Nigeria.

Design/Methodology/approach: A quantitative research approach was adopted, using a structured questionnaire distributed to AECO professionals across four selected regions (North Central, North West, South-South, South West) in Nigeria. The data were analysed using Kruskal-Wallis test and structural equation modelling (SEM).

Originality: This study contributes to the nascent field of circular economy implementation in the Nigerian AECO industry. It offers a unique perspective by exploring variations in stakeholder opinions, providing insights into the nuanced understanding of circular economy drivers.

Findings: The study findings show a robust consensus of opinions among the respondents across regions and professions. The SEM analysis establishes the significant influence of the hypothesised drivers, regulatory and institutional, supply chain collaboration, technological advancements, organisational support, and business strategies on the successful implementation of circular economy principles in the Nigerian AECO industry.

Practical implications: The findings imply that stakeholders can adopt a unified approach to promote circular economy principles in the AECO industry. By recognising the common understanding of circular economy drivers, collaborative efforts can be streamlined to advance sustainability, resource efficiency, and circularity in the industry.

Research limitations: The study is limited to specific regions and professions within Nigeria. Further limitation is the quantitative orientation of this study which collects data using only questionnaire.

Keywords: Circular Economy, Developing Countries, Drivers, Sustainable Development, AECO Industry, Government Policies

Introduction

The Architecture, Engineering, Construction and Operation (AECO) industry is recognised as a cornerstone of economic growth and development. It also wields a significant environmental footprint marked by excessive resource consumption and waste generation (Ajayi & Oyedele, 2018). The AECO industry has historically been characterised by its linear consumption patterns, accounting for 40% of the global energy consumption and greenhouse gas emissions (UNEP, 2021). Additionally, the industry contributes significantly to global waste generation, with approximately one-third generated from construction and demolition waste (Menegaki & Damigos, 2018). The circular economy provides a transformative strategy to reduce these environmental impacts, aligning with the UN Sustainable Development Goals (Urain *et al*., 2022).

The global pursuit of sustainability has led to the emergence of the circular economy principles, which presents an alternative to the linear "take-make-dispose" economic model (Pomponi & Moncaster, 2017). The AECO industry's traditional linear production and consumption patterns are increasingly acknowledged as unsustainable, prompting a global shift towards a circular economy paradigm (Munaro *et al*., 2020). Circular economy principles emphasise the regeneration of resources, reduction of waste, and maximisation of value retention throughout the product lifecycle (Ellen MacArthur Foundation, 2015). As industries globally seek to address the pressing challenges of resource scarcity, environmental degradation, and climate change, the AECO industry stands out as a critical focus area due to its substantial resource consumption and waste generation (Liu *et al*., 2021).

In the AECO industry, implementing circular economy principles offers multifaceted benefits, ranging from reduced resource depletion to curbing greenhouse gas emissions and minimising waste (Gonz'alez *et al*., 2021). Given the benefits, several countries are promoting the implementation of a circular economy in the construction industry, including Denmark, Japan, Hong Kong, the United Kingdom, Australia, Germany, and Switzerland (García-Quevedo *et al*., 2020; Kirchherr *et al*., 2018).

The development of circular economy principles in the AECO industry is motivated by resource scarcity (Ghisellini *et al*., 2016), waste reduction imperatives (Tura *et al*., 2019), regulation and policies (Munaro *et al*., 2020), cost savings through material reuse (Ghisellini *et al*., 2018), climate change mitigation (Wuni & Shen, 2022), social responsibility (Oyinlola *et al*., 2018), technological innovation and stakeholder demand (Giorgi *et al*., 2022), and alignment with the Sustainable Development Goals.

Developing countries, which often exhibit rapid urbanisation and industrialisation confront unique challenges and opportunities in their pursuit of circularity (Bello *et al*., 2023a; Oluleye *et al*., 2022). The construction industry in these economies, characterised by exponential growth and substantial infrastructure demands, is central to the discourse on circularity (Torgautov *et al*., 2021). While these nations contribute significantly to global resource consumption, they face heightened vulnerabilities due to limited resource availability and waste management infrastructure (Bello *et al*., 2023b).

Nigeria, a major African economy and a rapidly urbanising economy exemplifies the complexities of implementing circular economy practices in a developing country. The Nigerian AECO industry has experienced remarkable growth due to population expansion, urban migration, and infrastructural demands (Aboginije *et al*., 2021). However, this growth

has been accompanied by inefficient resource use, inadequate waste management, and environmental degradation (Ojo *et al*., 2021). The Nigerian government has recognised the need for sustainable development and circular economy implementation, as evidenced by the Nigeria Circular Economy Working Group (NCEWG). The NCEWG framework promotes sustainable production and consumption patterns within the AECO industry.

However, the knowledge of circular economy principles is limited among the professionals in developing countries which contributes to the slower transitioning and implementation of this sustainable and efficient approach. Moreso, while studies on circular economy implementation in developed countries are apparent (Giorgi *et al*., 2022), there is a paucity of research that examines the factors that influence the implementation of circular economy in Africa built environment industry (Mhlanga *et al*., 2022). Idris & Bello (2023) further substantiated the prevalence of limited knowledge of circular economy among the Nigerian AECO professionals. These challenges necessitate the need to examine the drivers that could influence circular economy implementation in Nigeria.

Aslam *et al*. (2020), Paiho *et al*. (2020) and Mahpour (2018) demonstrated how government can drive and support the circular economy implementation while Hina *et al*. (2022) shows how technological application can drive the implementation of circular economy. Similarly, factors such as adequate research and development and financial system have been noted to drive the implementation of circular economy (Wuni, 2023; Adabre *et al*., 2022; Agyemang *et al*., 2019; Hart *et al*., 2018; Adams *et al*., 2017).

This study aims to bridge these gaps by employing a Structural Equation Modelling (SEM) approach to elucidate the impact and relationship between key drivers of circular economy implementation in the Nigerian AECO industry. As a robust statistical technique, SEM

enables the assessment of direct and indirect relationships among various factors thereby providing clarity on the complex interplay of variables (Hair *et al*., 2019). The study introduction provides an overview of the study, while subsequent sections provide insights into the principles and drivers of circular economy, adopted methodological approach, presentation and discussion of results and conclusion of the study.

Review of Related Literature

This chapter provides an exploration of the principles and drivers underpinning the circular economy. The chapter underscores how the implementation of CE principles can lead to environmental protection, economic development, and the creation of new business opportunities. The diverse range of drivers is presented in Table 1, showing a comprehensive overview of the multifaceted factors that contribute to the successful implementation of CE practices in the construction industry.

Principles of Circular Economy

Circular economy principles have gained significant attention in recent years as a sustainable approach to resource management and environmental conservation. The principles of a circular economy are centred around minimizing waste and maximizing the value of resources by promoting reuse, recycling, and regeneration. The CE concepts are summarised in the 10 Rs, which are as follows: R0 Refuse, R1 Rethink, R2 Reduce, R3 Reuse, R4 Repair, R5 Refurbish, R6 Remanufacture, R7 Repurpose, R8 Recover, and R9 Recycle (Peiro *et al*., 2020; Vermeulen *et al*., 2019).

According to Geissdoerfer *et al*. (2017), the core principles of a circular economy include designing out waste and pollution, keeping products and materials in use, and regenerating natural systems. This holistic approach emphasizes the importance of product design that enables easy disassembly and recycling, reducing the environmental impact of production processes. The work of Stahel (2016) highlights the significance of extending the lifespan of products through repair, refurbishment, and remanufacturing, thereby reducing the need for continuous extraction of raw materials. Furthermore, the principles of a circular economy

advocate for the use of renewable energy sources and the adoption of sustainable production practices to minimize the environmental footprint of industrial processes (Urain *et al*., 2022).

By implementing these principles, companies can transition from the traditional linear model of "take, make, dispose" to a more sustainable and regenerative approach. This shift not only reduces the strain on natural resources but also promotes energy efficiency and fosters the development of a more resilient and environmentally friendly economy. As argued by Bocken *et al*. (2016), the adoption of circular economy principles can lead to increased resource productivity, cost savings through reduced material inputs, and the creation of new business opportunities based on the development of innovative and sustainable products and services. Additionally, a circular economy can contribute to the mitigation of climate change by minimizing greenhouse gas emissions and reducing the overall environmental impact of industrial activities (Urain *et al*., 2022). To conclude, the principles of the circular economy offer a comprehensive framework for achieving sustainable development goals while fostering economic growth and environmental stewardship.

Drivers of Circular Economy Implementation in the AECO Industry

In achieving a sustainable future, implementing circular economy practices is paramount, and regulatory and institutional drivers stand at the forefront of propelling this transformation. A comprehensive literature review shows that the availability of government-level action, circular vision, and well-defined goals is pivotal in setting the stage for circular economy implementation. Aslam *et al*. (2020), Bilal *et al*. (2020), and Wuni (2023) emphasize that when governments take the lead by establishing clear circular economy objectives and strategies, it acts as a powerful impetus for businesses, industries, and communities to align their operations and behaviours with circular principles. Paiho et

al. (2020) and Mahpour (2018) underscore the significant impact of increasingly stringent landfill regulations and taxes on fostering circularity.

As elucidated in the work of Urbinati *et al*. (2021), Burke *et al*. (2021), and Kazancoglu et al. (2018) collaborative culture within the supply chain network stands out as a core driver which encourages knowledge exchange, innovation, and the establishment of sustainable practices across the supply chain, paving the way for circularity.

Wuni (2023), Hina et al. (2022), and Aslam et al. (2020) emphasis on availability of adequate technology to drive the rapid and successful implementation of circular economy in the AECO industry. Moreso, adequate technological solutions streamline the monitoring and management of circular processes, promoting transparency and traceability (Giorgi *et al*., 2022). Critical organizational related drivers such research and development, design for circular business model good organizational structure has been reported by extant of literature such as (Wuni, 2023; Konietzko *et al*., 2020; Nogueira *et al*., 2020).

Effective business strategies are pivotal in adopting circular economy principles, aligning economic goals with sustainable practices. A good business strategy serves as a fundamental driver (Tura *et al*., 2019; Hina *et al*., 2022; Bilal *et al*., 2020). This approach involves understanding and responding to market demands for environmentally responsible products and services, which fosters sustainability and positions businesses favourably in today's eco-conscious consumer landscape. The environmental drivers underscore efficient resource management, reduced environmental footprints, and energy savings, as highlighted by (Wuni, 2023; Giorgi *et al*., 2022). While social related drivers emphasize the creation of employment opportunities, public health concerns, and cultural change, as discussed by (Tura *et al*., 2019; Patwa *et al*., 2020). Economic related drivers stress the development of

new businesses, long-term revenue generation, and the maximization of the data economy (John *et al*., 2023; Giorgi *et al*., 2022). The summary of the categorised drivers is presented in Table 1.

Table 1: Drivers for the Implementation of Circular Economy

Code	Category	Drivers	References
RIDR1	Regulatory and Institutional	Availability of government level action circular vision and goals	Aslam *et al*. (2020)
RIDR2		Increasing landfill regulations and taxes	Bilal *et al*. (2020)
RIDR3		Penalties for non-compliance	Wuni (2023)
RIDR4		Tax increment on the usage of raw materials	Paiho *et al*., 2020
RIDR5		Increased CE requirement in public procurement	Mahpour (2018)
RIDR6		Reward for CE requirements compliance	Ghisellini *et al*. (2018)
RIDR7		Availability of effective legal and regulatory framework	Witjes & Lozano (2016)
SCDR1	Supply chain	A collaborative culture within the supply chain network	Urbinati *et al*. (2021)
SCDR2		Market demand for circular materials, products and services	Burke *et al*. (2021)
SCDR3		Long-term relationships, collaboration and partnerships with supply	Kazancoglu *et al*. (2018)
SCDR4		Market-based incentives for circular construction supply chain	Tura *et al*. (2019)
SCDR5		Trust environment and information sharing between stakeholders	Wuni 2023
SCDR6		Development of reverse logistics infrastructure and network	Agyemang *et al*. (2019)
SCDR7		Supply chain integration	Hina *et al*. (2022)
SCDR8		Supportive circular supply chain culture	Sousa-Zomer *et al*. (2018) Bilal *et al*. (2020)
TDR1	Technological	Availability of effective technological infrastructure and equipment	Wuni (2023)
TDR2		Incentive Design for adaptability and disassembly using design tools	Hina *et al*. (2022)
TDR3		Technological innovations to enable closed loops in material flows	Aslam *et al*. (2020)
TDR4		Availability of tools for the assessment of building circularity	Chang & Hsieh (2019)
TDR5		Availability of technical solutions	Hart *et al*. (2020)
TDR6		Efficient information system to track materials in recycling SCD Supply chain drivers	Giorgi *et al*. (2022) Wuni (2023)
TDR7		Availability of effective and reliable ICT solutions	Ghisellini *et al*. (2018)
ODR1	Organizational	Research and development	Hart *et al*. (2018)
ODR2		Design for circular business models	Wuni (2023)
ODR3		Top management support	Adams *et al*. (2017)
ODR4		Good leadership	Kirchherr *et al*. (2018)
ODR5		Good organisational infrastructure	Konietzko *et al*. (2020)
ODR6		Alignment of CE with organizational vision, goals and strategies	Nogueira *et al*. (2020)
ODR7		Collaboration between organizational departments	Govindan & Hasanagic (2018)
BDR1	Business	Good market strategy	Hina *et al*. (2022)
BDR2		Green financial innovation	Wuni (2023)
BDR3		Stability in business operations	Bilal *et al*. (2020); Adabre *et al*. (2022)
BDR4		Minimizing business reliance on virgin raw materials	Tura *et al*. (2019)
BDR5		Promotion of service-oriented business models	Wuni (2023)
BDR6		New revenue generation path	Tura *et al*. (2019)
BDR7		Cost reduction and savings	Wuni (2023)
BDR8		Clear business case and benefits of CE	Wuni (2023)
EVD1	Environmental	Efficient resource and management	Wuni (2023)
EVD2		Reduce environmental footprint of organizations	Giorgi *et al*. (2022)

EVD3		Waste reduction	Bilal *et al.* (2020)
EVD4		Environmental protection	Smol *et al.* (2021)
EVD5		Energy savings	Ghisellini *et al.* (2018)
SO1		Creation of employments	Tura *et al.* (2019)
SO2		Public health and wellness concerns	Wuni (2023)
SO3	Social	Global pressure	Tura *et al.* (2019)
SO4		Awareness of CE	Patwa *et al.* (2020)
SO5		Cultural change among stakeholders	Wuni (2023)
ECO1		Development of new business	John *et al.* (2023)
ECO2		Increase long-term revenue generation	Wuni (2023)
ECO3	Economic	Material Circularity Marketplace	Giorgi *et al.* (2022)
ECO4		Recycling Incentive Programs	Smol *et al.* (2021)
ECO5		Maximize Data Economy	Ilić & Nikolić (2016); Ghisellini *et al.* (2018)
		Source: Authors compilation	

Research Methodology

In conducting this research, a quantitative approach was adopted to systematically examine and quantify the relationships and drivers pertinent to implementing circular economy principles among selected AECO professionals in Nigeria. This technique allows for the precise measurement and analysis of attitudes, perceptions, and factors influencing the circular economy adoption in this specific context (Saunder *et al*., 2016).

The study's target population consists of selected AECO professionals namely Architects, Builders, Civil engineers, and Quantity Surveyors, operating in selected regions across Nigeria, namely the North Central, North West, South-South, and South West regions. These regions were chosen to ensure geographical diversity and representation of the Nigerian context, which is crucial for obtaining a comprehensive understanding of circular economy implementation in Nigerian AECO industry. The professional's categories were selected based on their leading roles and direct involvements in AECO activities in the Nigerian AECO activities. The other two regions (North East and South East) were excluded from the study due to the high insecurity rate, which has hampered the economic developments in the regions.

A snowball sampling technique was adopted to collect data from the population. This technique was chosen for its effectiveness in reaching professionals in a specific field and for generating a sample that reflects the diversity of the population (Bryman, 2016). The initial questionnaire was pilot tested to ensure wider respondents will not have difficulties in filling the questionnaire and also to exclude drivers that might be similar or have same meaning. Participants consented to participate in the study while their confidentiality and privacy are protected as research ethics demands. The questionnaire was distributed virtually

using Google Forms. At the end of the survey, total of 208 valid responses were received and subsequently considered for the study. This sample size was considered adequate based on related studies in Nigeria that has used similar sample size (Idris & Bello, 2023; Olanrewaju *et al*., 2022).

Data collection was facilitated through a well-structured questionnaire. The questionnaire was designed to elicit responses related to the perceptions, attitudes, and practices of AECO professionals regarding circular economy principles. Questionnaire survey was adopted because it is cost effective and easy to reach wider respondents to participate in the study. Respondents were asked to rate their responses using a five-point Likert scale, a common approach for assessing levels of agreement or disagreement (Dawson, 2013). Subsequently, the data was subjected to a rigorous analytical process. To identify potential variations in responses across different regions and professions, the Kruskal-Wallis test, a non-parametric statistical test, was employed. The non-parametric approach was chosen due to the ordinal nature of the collected data, ensuring the validity of the analysis within the context of the study. This test helps compare multiple groups and determine whether observed differences are statistically significant (Field, 2013).

Additionally, Smart PLS-SEM (Partial Least Squares-Structural Equation Modelling) version 4 was employed to delve deeper into the complex relationships and dependencies within the dataset. SEM is a robust and comprehensive statistical technique that allows for a more intricate analysis of the structural relationships between variables (Hair *et al*., 2019).

By employing these rigorous quantitative research methods, this study aimed to provide a detailed, data-driven analysis of the circular economy adoption among AECO professionals in Nigeria.

This study further develops eight hypotheses and a conceptual framework shown in Figure1:

i. H_1- Business drivers significantly influence the implementation of circular economy principles in Nigeria AECO industry

ii. H_2- Economic drivers significantly influence the implementation of circular economy principles in Nigeria AECO industry.

iii. H_3-Environmental drivers significantly influence the implementation of circular economy principles in Nigeria AECO industry.

iv. H_4-Organizational drivers significantly influence the implementation of circular economy principles in Nigeria AECO industry.

v. H_5-. Regulatory and institutional drivers significantly influence the implementation of circular economy principles in Nigeria AECO industry.

vi. H_6- Social drivers significantly influence the implementation of circular economy principles in Nigeria AECO industry.

vii. H_7- Supply chain drivers significantly influence the implementation of circular economy principles in Nigeria AECO industry.

viii. H_8- Technological drivers significantly influence the implementation of circular economy principles in Nigeria AECO industry
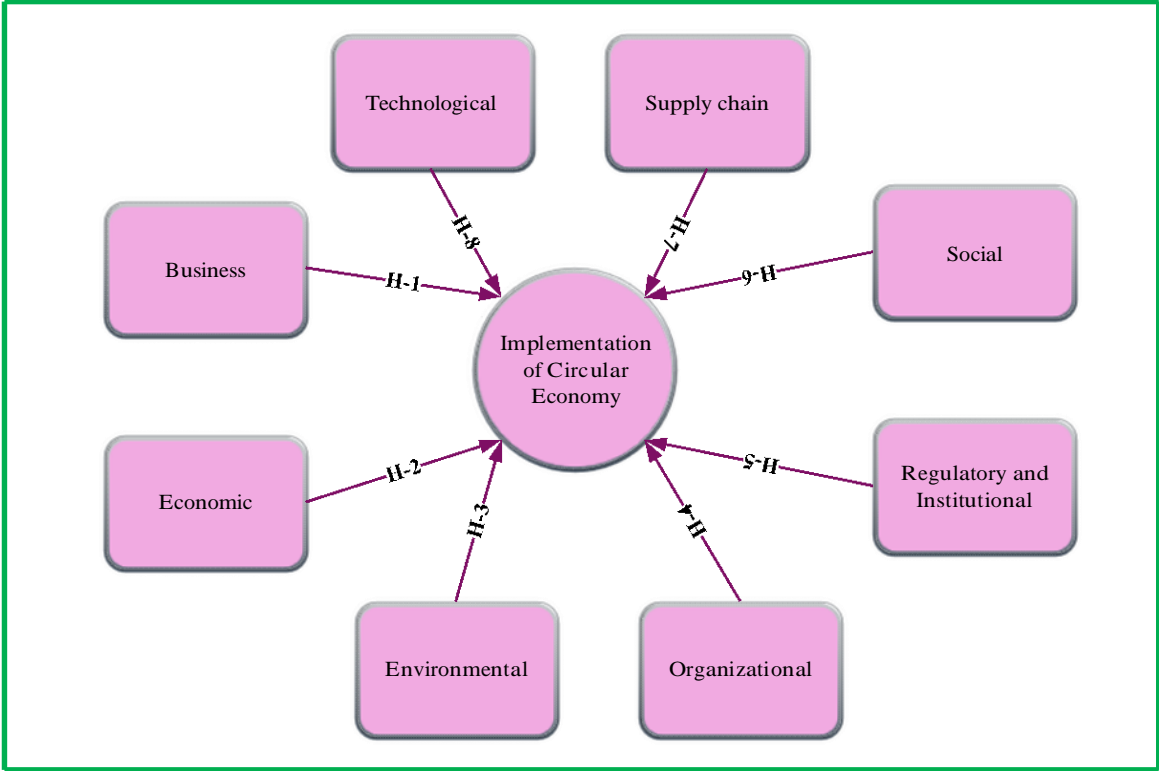
Figure 1: Conceptual Framework (Authors Concept)

Results

Respondents Information

The result provides an overview of the characteristics of the respondents (208) in the study representing AECO professionals in the Nigerian AECO industry. Engineers dominate the professional distribution, comprising 45.19% of the sample, highlighting their significant role in implementing circular economy principles. Architects, Builders, and Quantity surveyors account for 16.35%, 25%, and 13.46%, respectively, contributing adequately to the profession diversity. The majority hold Bachelor's degrees (63.46%) as their highest academic qualification, 30.29% hold Master's degrees, and 6.25% hold Doctorate degrees. Respondents with 11-20 years of working experience accounts for (46.15%), 0-5 years (14.9%), 6-10 years (30.29%), and 20 years above (8.65%). The regional distribution reveals the South West as the most represented region (42.79%), followed by the North Central (29.33%), North West (15.38%), and South-South (12.5%). Notably, most professionals work in small firms (10-49 employees) (70.19%), emphasising the significance of smaller enterprises in the AECO industry, medium firms (50-249 employees) (20.67%), and large firms (250 employees above) (9.13%). Respondents were asked about the nature of construction works they engaged into between Civil works such as roads and bridges, Building constructions or combination of both. 42.79% engaged in combination of Civil and Building works, while 34.61% and 22.60% only works on Building works and Civil works respectively.

Measurement Model

A measurement model is a fundamental component of SEM used to assess the relationships between observed indicators (variables) and their underlying latent constructs. According to

Hair *et al*. (2006), the validity of the measurement model is assessed based on its ability to demonstrate both convergent and discriminant validity.

Convergent validity is a critical aspect of measurement validation in SEM and assesses whether different indicators measuring the same latent construct converge (Hulland 1999). High convergent validity indicates that multiple indicators effectively capture the same underlying concept. Convergent validity is examined using Cronbach alpha (α), composite reliability (ρc), and average variance extracted (AVE) Fornell & Larcker (1981).

Table 2 comprehensively assesses convergent validity for each identified cluster within the study. The high alpha (> 0.70) coefficients indicate strong internal consistency within each construct, while the substantial composite reliability values emphasise the reliability of the measurement model. Furthermore, the AVE values, all surpassing the 0.5 threshold, established that a substantial portion of the variance in the indicators is attributed to their respective constructs.

Multicollinearity was assessed using the Variance Inflation Factor (VIF) test. The VIF values for each construct were all below the acceptable threshold of 3.3, as recommended by Kock (2015). This suggests that common method bias is not present in the data. Consequently, the findings in Table 2 substantiate the absence of multicollinearity issues in the data. These robust measures collectively affirm the convergent validity of the measurement instruments for each essential domain, providing a solid foundation for subsequent structural analyses within the study.

Table 2: Convergent Validity

Components	α	ρc	AVE	VIF
Business	0.921	0.936	0.648	3.004
Economic	0.860	0.910	0.771	1.889
Environmental	0.851	0.910	0.770	3.075
Organizational	0.885	0.918	0.693	2.593
Regulatory and Institutional	0.783	0.824	0.547	1.392
Social	0.917	0.938	0.792	1.835
Supply chain	0.989	0.936	0.833	1.375
Technological	0.814	0.915	0.843	1.929

Notes; α = Cronbach's alpha; ρc = Composite reliability; AVE = Average variance extracted. VIF = Variance Inflation Factor. Source: Author data analysis

Figure 2 and 3 show the initial and final loading measurements. According to the Hair Jr et al. (2017) a load value of 0.700 is considered adequate. However, if the study is exploratory then a value of 0.4 higher is adequate (Hulland, 1999). Hence, this study set minimum benchmark of 0.6 load factor. Figure 2 shows 52 initial loaded items, while 34 items were later determined to have a load factor above 0.6 after loading three times as shown in Figure 3.
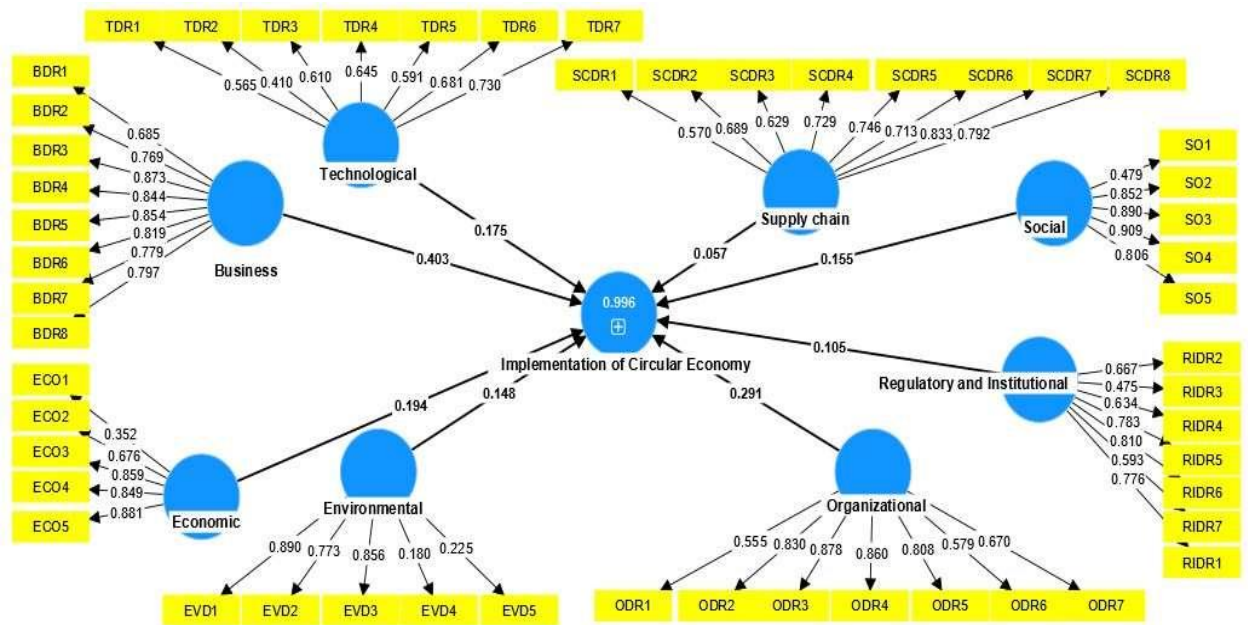

Figure 2: Initial Loading (Authors data analysis)

Discriminant validity aims to confirm that the measurement instruments effectively capture unique and separate concepts. To establish discriminant validity, examining the correlations (Fornell-Larcker) between constructs and ensuring that they are lower than the square root of the AVE for each construct is pertinent. When correlations are lower than the AVEs, it indicates that the constructs are distinct and do not measure the same underlying concept, reinforcing the validity of the measurement model.
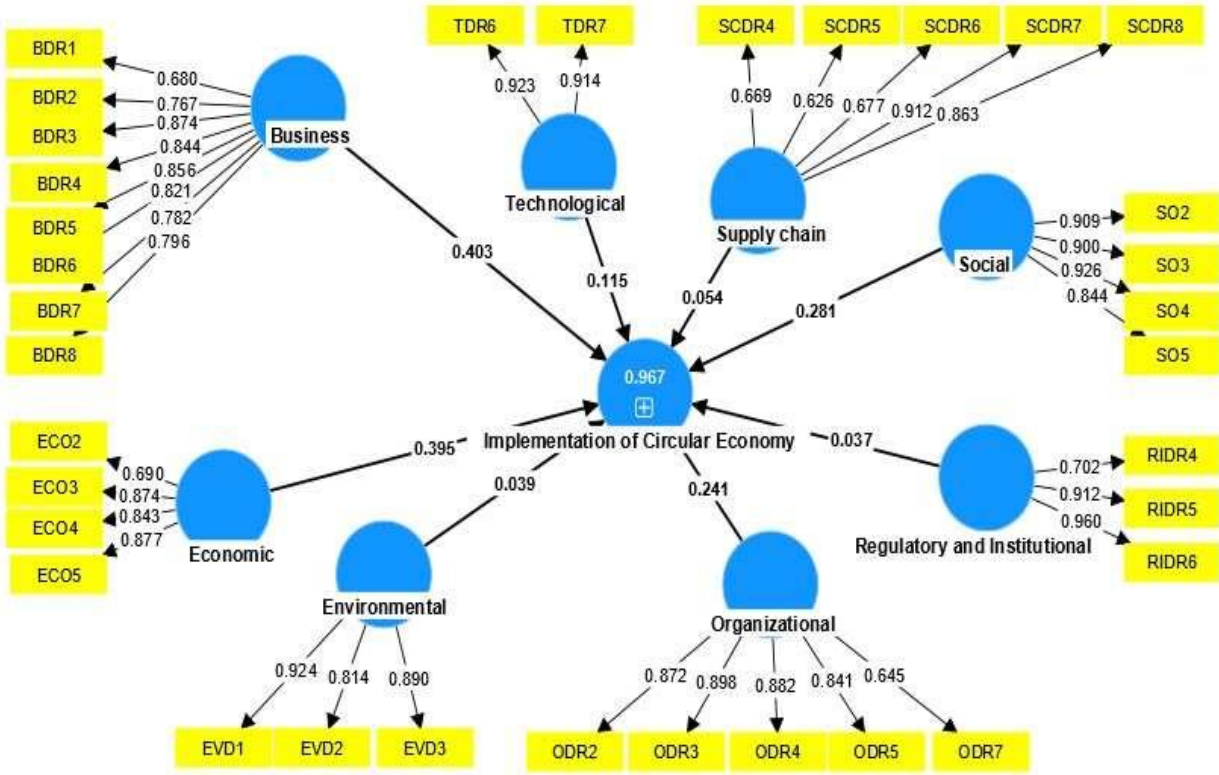
Figure 3: Final Loading (Source: Authors data analysis)

The discriminant validity in this study was evaluated using the Hetrotrait-Monotrait ratio (HTMT) and the Fornell-Larcker criterion. Table 3 shows the results of the Fornell-Larcker criterion, which examines the relationship between the square root of AVE and the correlation between constructs. The correlation results indicate that the square root of AVE surpasses the inter-construct correlation for all the constructs. According to Kock (2015) if the square root of the AVE is greater

than the correlation then the model discriminant validity is adequate. Table 3 also summarises the HTMT analysis, which reveals that all the constructs have correlations that fall below the recommended threshold of 0.900, as suggested by Gold *et al*. (2001) and Henseler *et al*. (2015).

Table 3: Heterotrait-Monotrait ratio and Fornell-Larcker criterion (HTMT)

Heterotrait-Monotrait ratio (HTMT)								
Category	Business	Economic	Environmental	Organizational	Regulatory and Institutional	Social	Supply chain	Technological
Business								
Economic	0.724							
Environmental	0.708	0.807						
Organizational	0.758	0.882	0.741					
Regulatory and Institutional	0.742	0.644	0.719	0.715				
Social	0.797	0.708	0.699	0.897	0.819			
Supply chain	0.866	0.835	0.649	0.804	0.849	0.803		
Technological	0.888	0.893	0.532	0.778	0.772	0.744	0.892	
Fornell-Larcker criterion								
Category	Business	Economic	Environmental	Organizational	Regulatory and Institutional	Social	Supply chain	Technological
Business	0.805							
Economic	0.866	0.878						
Environmental	0.814	0.964	0.878					
Organizational	0.795	0.799	0.768	0.833				
Regulatory and Institutional	0.711	0.912	0.811	0.816	0.740			
Social	0.819	0.944	0.847	0.757	0.813	0.890		
Supply chain	0.846	0.831	0.716	0.808	0.879	0.833	1.000	
Technological	0.799	0.709	0.854	0.767	0.818	0.861	0.902	0.918
Source: Authors data analysis								

Path Analysis (Bootstrapping) and Cross-Validated Predictive Ability Test (CVPAT)

Path bootstrapping is a resampling technique commonly used in SEM to assess the significance and robustness of path coefficients in a model (Hair *et al*., 2021; Kline, 2023). Examining path bootstrapping, the statistical significance of path coefficients, calculating confidence intervals, and assessing the model stability and reliability can be determined, enabling adequate hypotheses

testing. In examining the validity of the hypotheses, the Bootstrapping technique was applied by randomly resampling the original dataset to create 5,000 new samples at a 95% confidence interval (CI), a commonly used maximum number of random samples. The standardised path coefficients (β) and p-values are shown in Table 4, indicating that all the hypotheses are significant.

Predictive evaluation is crucial as it enables researchers to determine whether their proposed model can outperform a naive baseline, a core predictive validity component (Sharma *et al*., 2019; Shmueli and Koppius, 2011).

Prediction-oriented tools for PLS-SEM have been introduced to aid in these assessments, including PLS$_{predict}$ (Shmueli *et al*., 2016) and CVPAT$_{compareoverall}$ (Liengaard *et al*., 2021). Before conducting a CVPAT analysis, it is essential to note that both alternative models meet the necessary measurement and structural evaluation criteria (Hair *et al*., 2019). The evaluation of these models indicates that they meet the required benchmark (Hair *et al*., 2022). For the models to possess predictive validity, their average loss must be significantly lower (higher predictive accuracy) than the benchmark of naïve indicator averages. If this is not the case, the models should be discarded (Shmueli *et al*., 2019). Table 4 shows strong predictive validity (Average loss difference = -0.382, t = 19.194, p = 0.000).

Table 4: Bootstrapping and Cross-Validated Predictive Ability Test

Path	β	SD	t	p	CI	
					2.50%	97.50%
H1-Business -> Implementation of Circular Economy	0.403	0.042	12.659	0.000*	0.412	0.576
H2-Economic -> Implementation of Circular Economy	0.395	0.058	8.193	0.033*	0.115	0.519
H3-Environmental -> Implementation of Circular Economy	0.039	0.036	6.064	0.000*	0.122	0.565
H4-Organizational -> Implementation of Circular Economy	0.241	0.033	9.215	0.000*	0.211	0.742
H5-Regulatory and Institutional -> Implementation of Circular Economy	0.037	0.078	6.223	0.002*	0.242	0.629
H6-Social -> Implementation of Circular Economy	0.281	0.076	9.433	0.016*	0.113	0.531
H7-Supply chain -> Implementation of Circular Economy	0.054	0.058	7.32	0.039*	0.118	0.401

H8-Technological -> Implementation of Circular Economy	0.115	0.021	4.987	0.008*	0.182	0.684

Cross-Validated Predictive Ability Test (CVPAT)			
		t	p
Implementation of Circular Economy	-0.382	19.194	0.000*
Overall	-0.382	19.194	0.000*

Notes: β = Original Sample, SD = Standard Deviation, t = T Statistics, p = P Values, CI = Confidence Interval. Source: Authors data analysis

The study's results indicate 7 of the 8 hypotheses are significant. Firstly, the relationship between business factors and the implementation of the circular economy is strongly established (β = 0.403, t = 12.659, p = 0.000). Similarly, economic drivers significantly contribute to circular economy implementation (β = 0.395, t = 8.193, p = 0.033). Additionally, the organizational factors also have a substantial impact on the implementation of circular economy principles (β = 0.241, t = 9.215, p = 0.000). Furthermore, the environmental drivers show a moderate yet statistically significant influence on circular economy implementation (β = 0.039, t = 6.064, p = 0.000). Similarly, regulatory and institutional factors (β = 0.037, t = 6.223, p = 0.002), social factors (β = 0.281, t = 9.433, p = 0.050), supply chain factors (β = 0.054, t = 7.32, p = 0.039), and technological factors (β = 0.115, t = 4.987, p = 0.067) all exhibit significant contributions to the implementation of circular economy principles.

Kruskal Wallis (Analysis of Variance)

The Kruskal-Wallis test results indicate no statistically significant (p > 0.05) variations in opinions across different regions and professions within the Nigerian AECO industry circular economy hypothesised drivers. This result provides a broad consensus among participants on the significance of these drivers, with no notable distinctions based on geographic regions or professional backgrounds. While some variations may exist, they did

not reach statistical significance, implying a shared understanding of the relevance of these drivers in promoting circular economy principles. These results underscore the potential for a unified approach to circular economy in the Nigerian AECO industry, facilitating collaborative efforts among professionals and policymakers to advance sustainability and resource efficiency.

Discussion of Results

This study critically examines the drivers towards implementation of circular economy in the Nigerian AECO industry through the application of SEM to examine the impact and relationship between the drivers. The outcome of this study is consistent with prior researches (Aslam *et al*., 2020; Bilal *et al*., 2020; Wuni, 2023; Paiho *et al*., 2020; Mahpour, 2018; Ghisellini *et al*., 2018; Witjes & Lozano, 2016), which has highlighted the importance of government-level actions, regulations, penalties, and incentives in promoting circular economy initiatives. This factor underscores the significance of supportive policies, legal frameworks, and governmental initiatives in fostering sustainability and circularity within the AECO industry. These drivers can influence business practices, encourage resource efficiency, and drive the transition toward circular business models in AECO, aligning with global sustainability goals.

Similarly, the importance of collaborative supply chain practices, market demand for circular materials, and the development of reverse logistics networks in advancing circularity was stretched in various studies (Urbinati *et al*., 2021; Burke *et al*., 2021; Kazancoglu *et al*., 2018; Tura *et al*., 2019). Collaborative cultures, market-based incentives, and efficient information sharing within the supply chain can enhance resource efficiency and promote circular business models in AECO. This finding has practical implications for supply chain

managers, AECO professionals, and policymakers, emphasising the need for collaborative supply chain practices to drive sustainability and circularity in the AECO industry, contributing to environmental and economic benefits.

Wuni (2023) and Hina *et al*. (2022) accentuate the significance of technological innovation, adequate information systems, and technical solutions in increasing circularity. Adequate technological infrastructure and innovative solutions can enhance resource efficiency, promote sustainable materials management, and enable the transition toward circular business models. In other studies, research and development, leadership support, and cross-departmental collaboration in promoting circularity were demonstrated to promote organizational effort to implement circular economy (Konietzko *et al*., 2020; Nogueira et al., 2020). Organisational culture, leadership commitment, and alignment with circular goals and strategies can foster a conducive environment for circularity and sustainable practices.

This findings of (Hina *et al*., 2022; Bilal *et al*., 2020; Adabre *et al*., 2022;) emphasised on the importance of market-oriented strategies, financial innovations, and cost-saving initiatives in advancing circularity which is in consistency with this study. Effective market strategies, financial innovation, and transparent business cases can drive the adoption of circular business models and practices.

The drivers of environmental implementation are critical for promoting sustainable practices. Studies by Wuni (2023), Giorgi *et al*. (2022), Bilal *et al*. (2020), and Smol *et al*. (2021) underscore the importance of these drivers in minimizing the ecological impact of industrial operations and fostering sustainable resource management. Similarly, the social drivers, such as job creation (Tura *et al*., 2019), public health concerns (Wuni, 2023), global pressure (Tura *et al*., 2019), awareness of circular economy (Patwa *et al*., 2020), and cultural

change among stakeholders (Wuni, 2023), are essential drivers for facilitating community engagement and fostering a more sustainable and inclusive society. Moreover, the economic focus, such as the development of new business models (John *et al*., 2023; Wuni, 2023; Giorgi *et al*., 2022; Smol *et al*., 2021; Ilić & Nikolić, 2016; Ghisellini et al., 2018), increasing long-term revenue generation, promoting material circularity marketplaces, initiating recycling incentive programs, and maximizing the data economy, are crucial for enhancing economic resilience and promoting sustainable growth. These dimensions collectively emphasize the necessity of integrating these drivers to establish a robust framework for implementing circular economy principles in the Nigeria AECO industry.

Conclusion

This study delved into the multifaceted landscape of circular economy implementation in the Nigerian AECO industry. Through rigorous quantitative research and SEM, the impact of 8 key drivers was investigated: Business, Economic, Environmental, Organizational, Regulatory and Institutional, Social, Supply Chain, and Technological. The findings of this study have illuminated the profound influence of these drivers on the successful implementation of circular economy principles in the Nigerian AECO industry. These insights hold significant implications for various stakeholders, including policymakers, industry practitioners, and researchers. Consequently, the study further established that professionals have similar opinions on the drivers for implementing a circular economy irrespective of their profession or region of operation. This implies that development of strategies or interventions might be universally applicable or accepted across different groups, simplifying the implementation process. This research has comprehensively espoused the interplay between various circular economy drivers and their influence on the Nigerian AECO industry.

Implications for the Study

The implications derived from this study encompass practical, theoretical, and managerial aspects, offering valuable guidance for various stakeholders in the Nigerian AECO industry. From a practical perspective, the study highlights the urgent need for policymakers to proactively shape and enforce regulatory frameworks that foster circular economy principles. This includes revisiting existing regulations to align them more effectively with circularity goals and providing incentives for sustainable construction practices. The elucidation of these drivers can provide the stakeholders with the requisite information to

implement circular economy in the Nigerian AECO industry. Further, it can provide guidance to policy-makers in making informed decisions in the implementation of this novel approach.

This practical collaboration can accelerate the adoption of circular material flows and enhance resource efficiency in the industry. Theoretically, this study contributes to understanding circular economy implementation in the Nigerian AECO industry and enriches the literature by validating the impact of the various drivers. It paves the way for future research to explore the mechanisms behind policy implementation, assess the long-term sustainability implications of circular practices, and examine the interactions and potential trade-offs among drivers.

Managerially, the insights generated can encourage AECO professionals and policymakers to strategically integrate circular economy principles into their decision-making processes, ensuring a more sustainable and environmentally responsible construction industry in Nigeria. The implication of this study can be extended to other developing and least developing economies.

Limitations

This study limitations include the exclusive use of a quantitative approach and the limited sample size. These can be effectively addressed in future research by incorporating qualitative methods to gain a more comprehensive understanding of these factors. Additionally, increasing the sample size and diversifying the demographic characteristics of respondents can enhance the generalizability of the findings.

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