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Evaluating the Influence of Green Innovation Competencies on Sustainable Construction Practices in Nigeria Using PLS-SEM

Soji, S. M. [1]; **Abdullahi, U.** [2]; **Usman, N. D.** [3]; **Anum, I.** [4]; & **Alara, S. A.** [5]

[1]Department of Building, Nigerian Army University, Biu, Nigeria. [2-4]Department of Building, Modibbo Adama University, Yola, Nigeria. [5]Department of Quantity Surveying, Federal Polytechnic Mubi, Nigeria

Corresponding Author: soj0089@gmail.com

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Abstract

The construction industry is a major contributor to global greenhouse gas emissions and resource depletion, underscoring the urgent need for sustainable practices. Hence, this study investigates the influence of Green Innovation Competencies (GICs), categorized into economic, social, environmental, and technical dimensions on Sustainable Construction Practices (SCPs) in Nigeria. Data were collected through an online survey from 263 randomly selected registered construction professionals, including Architects, Builders, Civil engineers, Estate surveyors, Town planners, and Quantity surveyors. Using Partial Least Squares Structural Equation Modelling (PLS-SEM), the study assessed measurement reliability, validity, and the structural model fit. Results revealed that economic, social, and technical competencies significantly and positively influenced SCPs, while environmental competencies exhibited a limited direct effect. This limited effect may be attributed to weak regulatory enforcement, low adoption of environmental policies, and cultural barriers that hinder the translation of environmental awareness into tangible sustainable construction practices. The model explained 35.6% of the variance in sustainable construction practices attributable to green innovation competencies, indicating a moderate predictive strength of the model. Despite this, the study highlights the critical need for enhanced policy frameworks, targeted professional training, and stronger regulatory enforcement to promote the widespread adoption of green innovation in the Nigerian construction sector.

Keywords: Competency Development**,** Green Innovation, Green Skills, Sustainable Construction Indicators, Sustainable Construction Practices.

Introduction

The construction industry plays an essential role in economic growth and development but it is also a significant contributor to environmental degradation, resource depletion, and greenhouse gas emissions (Hossain *et al.,* 2020; Munaro *et al.,* 2020). In response, sustainable construction practices (SCPs) have emerged as one of the strategies in minimizing the industry's environmental footprint while promoting economic and social benefits. Frempong *et al.* (2021) and Windapo *et al.* (2021) posited that SCPs encompass various measures, including energy-efficient designs, waste reduction strategies, and the use of environmentally friendly materials. However, the successful implementation of these practices depends largely on the competencies of professionals within the industry, particularly in the area of green technology. Green innovation competencies (GICs) refer to the knowledge, skills, and attitudes required to develop and implement innovative approaches in the quest of ensuring an environmentally friendly solutions in construction (Zhong *et al.,* 2022; Cai & Dai, 2021). According to Adedeji *et al.* (2021), these competencies enable construction professionals to integrate sustainability principles into project design, execution, and management. Research suggests that technical expertise, economic knowledge, environmental awareness, and social engagement are critical factors in fostering green innovation in construction (Sachs *et al.,* 2019). However, there remains a gap in understanding how these competencies, such as energy efficiency, waste management, resource optimisation, and preservation of natural resources directly influence indicators of sustainable construction practices (Waziri, 2016).

Amoah and Oduro – Kwarteng (2019) noted that firms with strong green competencies are more likely to adopt sustainable technologies and processes, leading to improved project outcomes. Similarly, Aram *et al.* (2019) highlighted that the development of green innovation capabilities enhanced environmental performance and cost efficiency in construction projects. Despite these findings, there is still a need to explore the specific competencies that have the most significant impacts on sustainable construction indicators, particularly in developing economies like Nigeria (Usman *et al.,* 2021; Windapo *et al.,* 2021). Furthermore, studies by Bhatia (2021) and Aram *et al.* (2019) have shown that the relationship between green innovation competencies and sustainable construction practices is influenced by various challenges, including regulatory barriers, financial constraints, and lack of technical expertise. Hossain *et al.* (2020), stated that to address these challenges a multi-stakeholder approach that includes government policies, industry standards, and academic contributions to training and capacity building is required. Scholars have

emphasized the importance of integrating sustainability education into construction curricula to equip professionals with the necessary skills for green innovation (Munaro *et al.,* 2020; Fang *et al.,* 2018). This highlights the need for continuous professional development programs focused on green construction practices (Yu *et al.,* 2020; Fredrick, 2019; Yusuf *et al.,* 2017). Given the increasing urgency of climate change and resource conservation, understanding how green innovation competencies drive sustainable construction has become increasingly important for policy formulation and industry transformation (Windapo *et al.,* 2021). However, empirical evidence on how specific competencies correlate with sustainable construction indicators remains limited, especially in the context of emerging economies. Bridging this gap will provide valuable understanding for relevant stakeholders to promote sustainability in the construction sector. Therefore, this study aimed to examine the influence of green innovation competencies on the indicators of sustainable construction practices, focusing on key dimensions such as environmental, social, economic, and technical competencies. The analysis of the relationship between these competencies and sustainability indicators guided the study in providing pathways to enhance green innovation competencies for promoting best practices in emerging economies.

Research Hypotheses

For this study, four (4) hypotheses were postulated. These hypotheses were formulated in order to test the influence and relationships between dependent and independent variables of the study. Figure 1 shows the hypothesized relationship between the independent variables and the dependent variable.

H_1: Social green innovation competencies have significant positive effect on the adoption of sustainable construction practices in Nigeria.

H_2: Economic green innovation competencies positively influence sustainable construction practices in Nigeria.

H_3: Environmental green innovation competencies significantly impact sustainable construction practices in Nigeria.

H_4: Technical green innovation competencies positively affect the implementation of sustainable construction practices in Nigeria.

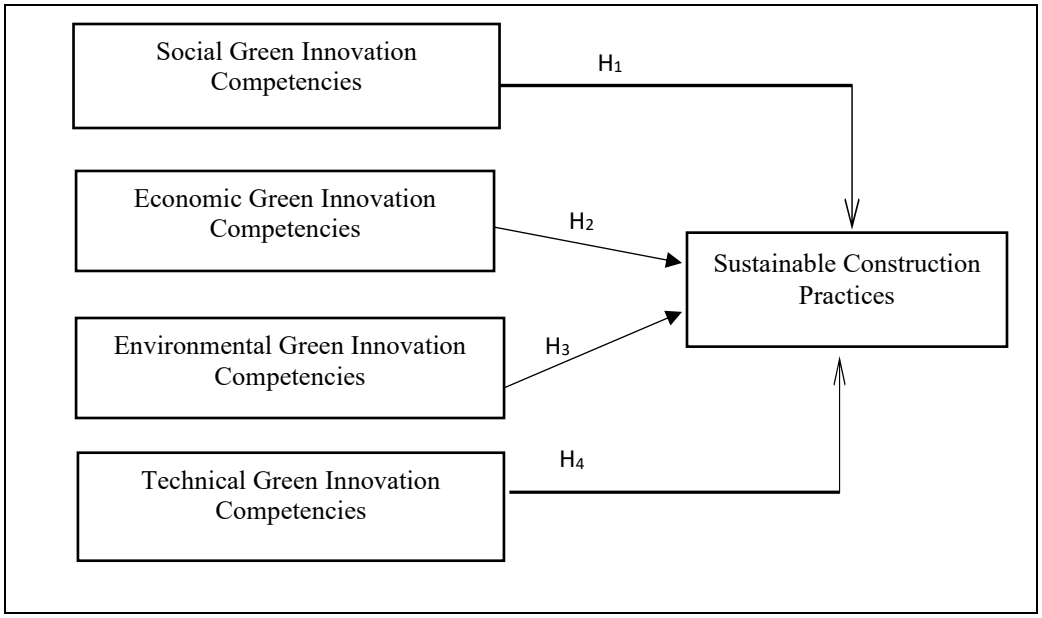


Figure 1. Research assessment model

Materials and Methods

This study examined the relationship between Green Innovation competencies (GICs) and Sustainable Construction indicators in the Nigerian construction industry using a structured research approach, including literature review, data collection, and analysis. Responses were received from 263 construction professionals through an electronic questionnaire survey. The use of 263 respondents was informed by statistical justification using Power analysis for PLS-SEM (Partial Least Squares Structural Equation Modelling), which recommended a minimum of 103 respondents for adequate model testing at 95% confidence and 80% power. The construction professionals that responded randomly comprised of 48 Architects, 45 Builders, 52 Civil Engineers, 40 Estate managers, 42 Town planners, and 36 Quantity surveyors practicing in Nigeria. A 5-point Likert scale was used to assess the importance of 26 identified core competencies constructs of GIC from a Delphi Survey which was later used to develop the questionnaire. Data analysis involved Confirmatory Factor Analysis (CFA) for reliability and validity checks, and Partial Least Square Structural Equation Modelling (PLS-SEM) to determine the influence of each construct on Sustainable Construction indicators. The PLS-SEM an extension of standardised regression modelling was used to determine causal relationships between variables in this study. The PLS-SEM was chosen because it aligns with guidelines by Marcoulides and Saunders (2006), as well as the "10-times rule" by Hair *et al*. (2011). The analysis was conducted using Smart PLS 3.0 software. The PLS-SEM usually involves a two-stage evaluation process, the first stage assesses measurement model (outer model measurement) while the second stage evaluates the structural model (inner model measurement).

Results and Discussion

Assessment of Measurement Model (Outer model)

The conceptual framework of this study contains five main constructs. Four of the five constructs are dimensions of the independent variable (green innovation competencies) each formatively linked to the dependent variable (sustainable construction practices). The recommended practice for assessing a latent variable model involved the assessment of both the dependent and independent constructs to establish construct validity (Hair *et al.,* 2014). Construct validity shows the extent to which the respective indictors represent their underlying latent variables. In addition, to establish construct validity, the indicators in the measurement model have to meet up the requirement for convergent and discriminant validity. Convergent validity measures the extent to which indicators of the same concept are correlated while discriminant validity measures the degree of uniqueness of a construct in relation to other constructs (Hair *et al.,* 2011). Thus, the measurement model evaluation involves assessing the outer weights and collinearity issue in the model in order to establish construct validity (Hair *et al.,* 2014). Table 1 shows the weights of the constructs.

Table 1. Formative Model Assessment

Constructs	Weight	t-value
Economic Green Innovation Competencies	0.882	15.906
Environmental Green Innovation Competencies	0.871	14.341
Social Green Innovation Competencies	0.850	12.823
Sustainable Construction Practices	0.836	13.870
Technical Green Innovation Competencies	0.877	15.115

Table 1 shows that the weights are all significant thus meeting the threshold as recommended in (Hair *et al.,* 2014). The constructs were also assessed for multi-collinearity. The essence of multi-collinearity assessment in PLS-SEM analysis is to ensure that the estimation between the exogenous constructs and the endogenous construct are unbiased (Hair *et al.,* 2014). Multicollinearity diagnosis in PLS-SEM involves the examination of variance inflation factor (VIF) across each construct of the model in order to detect the constructs that are highly correlated. Hair *et al.* (2011) suggested that a tolerance value of 0.20 or lower and a VIF value of 5 and higher are indication for potential problem of multi-collinearity.

Multicollinearity Test

Table 2 shows the result of the collinearity statistics (VIF) of the constructs in the overall research model. Multicollinearity, occurs when independent variables in a regression model are highly correlated, these can distort coefficient estimates and inflate standard errors. The Variance Inflation Factor (VIF) is a standard metric to assess multicollinearity, with values above 10 indicating serious issues and values between 1 and 5 deemed acceptable (Hair *et al.,* 2014). Across all the constructs, the VIF values were well within acceptable limits, confirming

minimal multicollinearity. For instance, Economic Green Innovation competencies had VIF values ranging from 1.869 to 2.544, while Environmental Green Innovation competencies ranged from 1.350 to 2.975. The results indicate that these constructs are sufficiently distinct, enabling reliable analysis. Similarly, Social and Technical Green Innovation competencies, as well as Sustainable Construction Practices, showed VIF values below the critical threshold of 10. The lowest VIF values were observed for Sustainable Construction Practices, ranging from 1.336 to 2.001, further confirming their conceptual distinctiveness. Generally, the findings suggest that multicollinearity is not a significant concern in the dataset, ensuring the reliability of the regression model. These results align with the guidelines provided by Hair *et al.* (2014), supporting the validity and interpretability of the structural model.

Table 2. Multicollinearity Results

	VIF		VIF		VIF		VIF		VIF
CE1	2.435	EN1	2.541	ID1	1.791	CS2	1.894	TE1	1.784
CE2	2.544	EN2	2.961	ID10	1.579	CS3	1.873	TE2	2.540
CE3	2.497	EN3	2.975	ID2	2.001	CS4	1.851	TE3	2.259
CE4	1.869	EN4	2.695	ID3	1.786	CS5	2.783	TE4	2.378
CE5	2.307	EN5	1.543	ID4	1.766	CS6	1.768	TE5	2.348
CE6	2.117	EN6	1.350	ID5	1.336	CS7	2.939	TE6	1.765
		EN7	1.636	ID6	1.846	CS1	2.728		
				ID7	1.800				
				ID8	1.846				
				ID9	1.686				

Where: VIF – Variance Inflation Factor
CE – Economic Green Innovation Competency
EN – Environmental Green Innovation Competency
ID - Sustainable Construction Practices
CS – Social Green Innovation Competency
TE – Technical Green Innovation Competency

Reliability and Validity of the Measurement Model

The measurement model was further tested for reliability and validity of the indicators using the composite reliability and the average variance extracted. The recommendation for assessing convergent validity involves meeting the criteria for indicator reliability by examining the indicator loadings, composite reliability, and the average variance extracted (AVE) and comparing the values with the recommended thresholds. For a construct to achieve convergent validity, the literature recommended the values of 0.7 and above for both indicator loading and composite reliability and 0.5 and above for AVE (Hair *et al.*, 2014). On the other hand, discriminant validity is assessed by examining the cross loadings, the Fornell-Larcker criterion and the Heterotrait-Monotrait (HTMT) ratio of correlations (Henseler *et al.,* 2015;

Hair *et al*., 2014). Figure 2 shows the measurement model indicating the factor loadings of the various indicators on the respective latent constructs in the research model.

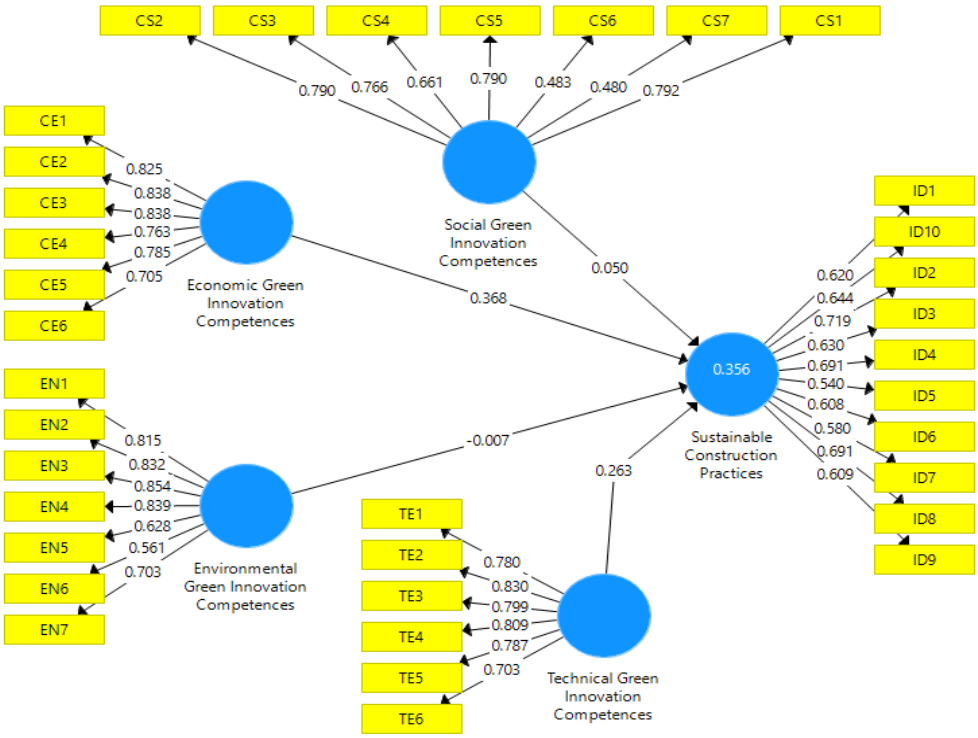


Figure 2. Direct Measurement Model (Measurement Model)

Convergent Validity

The loadings of the respective indicators on their respective constructs of the research model are presented in Table 3.

Table 3. Factor Loading of Constructs

Economic Green Inno. Comp.		Environmental Green Inno. Comp		Sustainable construction practices		Social Green Inno. Comp		Technical Green Inno. Comp	
CE1	0.825	EN1	0.815	ID1	0.720	CS2	0.790	TE1	0.780
CE2	0.838	EN2	0.832	ID10	0.744	CS3	0.766	TE2	0.830
CE3	0.838	EN3	0.854	ID2	0.719	CS4	0.791	TE3	0.799
CE4	0.763	EN4	0.839	ID3	0.730	CS5	0.709	TE4	0.809
CE5	0.785	EN5	0.728	ID4	0.791	CS6	0.783	TE5	0.787
CE6	0.705	EN6	0.761	ID5	0.740	CS7	0.780	TE6	0.703
		EN7	0.705	ID6	0.708	CS1	0.792		
				ID7	0.780				
				ID8	0.791				
				ID9	0.709				

As shown in the Table, all the loadings meet the recommended 0.7 threshold. The lowest loading is 0.703 associated with the Technical green innovation competencies constructs while the highest loading is 0.854 associated with the Environmental green innovation competencies construct. This shows that the indicators of each construct were highly correlated with their respective construct thus indicative of good convergent validity. To further verify the convergent validity of the measurement model, additional analysis to determine the composite reliability and the AVEs of the latent constructs was conducted. Table 4 shows the composite reliability and the AVEs of the constructs in the research model. As indicated by the result, the composite reliability values, which measures the extent to which the indicators depict the latent construct, all reported values higher than the recommended minimum threshold of 0.7. Similarly, the reported AVEs showed that all values meet the minimum threshold of 0.5 (Hensler *et al.*, 2015). Therefore, the requirements for convergent validity were achieved.

Table 4. Reliability and Validity of Measurement Model

Constructs	Composite Reliability	Average Extracted Variance AVE
Economic Green Innovation Competencies	0.911	0.630
Environmental Green Innovation Competencies	0.889	0.571
Social Green Innovation Competencies	0.862	0.581
Sustainable construction practices	0.844	0.504
Technical Green Innovation Competencies	0.886	0.608

Discriminant Validity

Table 5 shows the discriminant validity result using the Fornell-Larcker criterion. Based on this criterion, discriminant validity is said to be achieved when the square root of the AVE of the construct of interest is greater than any correlation between the construct and other constructs in the model (Hair *et al.,* 2014). As shown in Table 5, the diagonal values which represent the square root of the AVE of each construct are higher than the inter-correlations between other constructs in the model, thus satisfying the discriminant validity criterion.

Table 5. Discriminant Validity

Constructs	Economic Green Inno. Comp.	Environmental Green Inno. Comp.	Sustainable construction practices	Social Green Inno. Comp.	Technical Green Inno. Comp.
Economic Green Inno. Comp.	0.794				
Environmental Green Inno. Comp.	0.725	0.755			
Sustainable construction practices	0.553	0.464	0.635		
Social Green Inno. Comp.	0.619	0.562	0.429	0.693	
Technical Green Inno. Comp.	0.603	0.670	0.510	0.591	0.786

In addition, to verify the attainment of discriminant validity, the Heterotrait-Monotrait (HTMT) approach was also used. The HTMT approach is regarded as the most conservative and the most appropriate criterion for assessing discriminant validity (Henseler *et al.,* 2015). The decision rule for establishing discriminant validity in the HTMT approach is for all inter-correlations between the construct of interest and the remaining constructs to be less than 0.85 ($r < HTMT_{0.85}$) (Henseler *et al*., 2015). Table 6 show the results of the HTMT ratio in respect of the constructs in the research model. All the reported values were less than the $HTMT_{0.85}$ criterion thus further confirming the achievement of discriminant validity.

Table 6. Heterotrait-Monotrait Ratio (HTMT)

Constructs	Economic Green Inno. Comp.	Environmental Green Inno. Comp.	Sustainable construction practices	Social Green Inno. Comp.	Technical Green Inno. Comp.
Economic Green Inno. Comp.					
Environmental Green Inno. Comp.	0.828				
Sustainable construction practices	0.627	0.521			
Social Green Inno. Comp.	0.657	0.636	0.401		
Technical Green Inno. Comp.	0.683	0.763	0.566	0.635	

Assessment of the Structural Model

In the previous section, it was shown that all the recommended criteria for measurement model validity were satisfied thus accomplishing the first stage of the two-staged PLS-SEM evaluation process. In this section, the second stage of the process is presented. The structural model evaluation in this study considered four-stages this include, the assessment of the path coefficient, significance testing of the structural model relationships, assessment of level of R^2 and assessment of effect size (Hair *et al.*, 2014). Figure 3 shows the structural model indicating the t-values of the respective path coefficients and factor loadings.

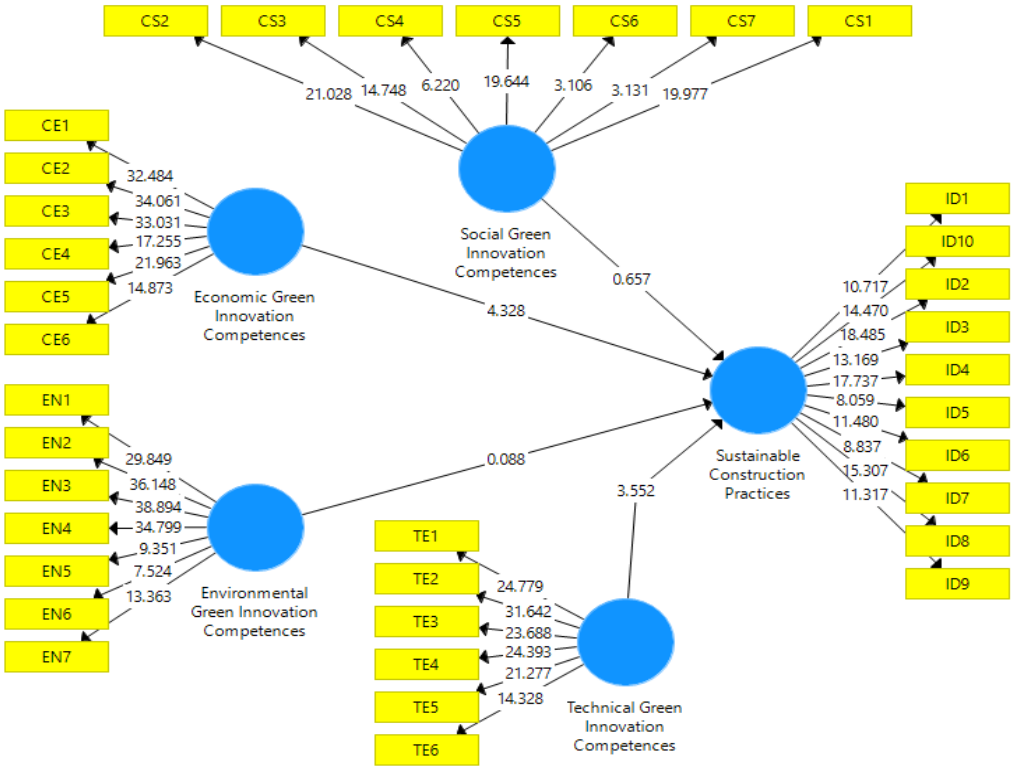


Figure 3. Structural Model (Inner Model Measurement)

Assessment of Path Coefficient

The path coefficients are the estimates of the hypothesized relationship between the endogenous latent construct (Sustainable construction practices) and the exogenous latent constructs (Green innovation competencies) in the structural model. The strength of the relationship is indicated by the magnitude and significance of the estimates. Path coefficients that are close to +1 are considered to represent strong positive relationships while those that tend towards -1 are considered to represent strong negative relationships (Hair *et al.*, 2014). The significance of the path estimates was determined through the bootstrapping procedure in the Smart PLS-SEM 3.0 software using the critical t-value for significance testing at 5 percent level of significance.

Table 7 show that three paths show significant positive relationships while one path shows a negative significant relationship. Economic green innovation competencies demonstrate the strongest positive and statistically significant impact on SCP, with a β value of 0.368 (t = 3.923, p = 0.000). Similarly, technical competencies show a significant positive impact on SCP, with a β value of 0.263 (t = 3.187, p = 0.002). Social green innovation competencies, with a β value of 0.050 (t = 1.967, p = 0.045), also positively and significantly influence SCP, albeit to a lesser extent. Conversely, environmental competencies exhibit a negligible and statistically insignificant effect on SCP (β = - 0.007, t = 0.079, p = 0.937). This unexpected

result may suggest contextual or implementation challenges in leveraging environmental strategies directly for SCP. These findings suggests that sustainable construction practices are positively influenced by economic, technical and social green innovation competencies while environmental green innovation competencies have a strong negative effect on SCP. This limited effect may be attributed to weak regulatory enforcement, low adoption of environmental policies, and cultural barriers that hinder the translation of environmental awareness into tangible sustainable construction practices as suggested by prior works of Munaro *et al.* (2020) and Frempong *et al.* (2021).

Table 7. Structural model assessment

Path	β	t- statistics	p-values	f^2	R^2
Economic Green Inno. Comp. → SCP	0.368	3.923	0.000	0.342	
Environmental Green Inno. Comp. → SCP	-0.007	0.079	0.937	0.022	
Social Green Inno. Comp. → SCP	0.050	1.967	0.045	0.289	
Technical Green Inno. Comp → SCP	0.263	3.187	0.002	0.323	0.356

Assessment of Effect Size Values

The effect sizes represent the strength of the relationship between each competency dimension and SCP. The effect size is measured according to Cohen's (1988) guidelines where f^2 values of .02, .15 and .35 are considered as small, medium and large effects respectively. Economic green innovation competency has a moderate effect size of 0.342, which is considered a medium effect (Hair Jr. *et al.,* 2010; Duarte *et al.,* 2010; Hair *et al.,* 2014a). The effect size f - results presented in Table 7 show a more pronounced impact of the green innovation competencies on sustainable construction practices (SCP) compared to the previous set of results. The environmental green innovation competency has an effect size of 0.022, which is categorized as a very small effect (Hair *et al.,* 2014a). While this suggests some minimal contribution of environmental competencies to sustainable construction practices, the effect is negligible. Social and technical green innovation competencies show effect sizes of 0.289 and 0.323, respectively. Both values fall within the medium effect range, with economic competencies showing the strongest impact among the four constructs.

Assessment of Coefficient of Determination

The structural model's quality was assessed using the coefficient of determination (R^2), which measures the variance in the endogenous construct explained by exogenous constructs. The analysis revealed that the R^2 value for sustainable construction practices (SCP) was 0.356, indicating that 35.6% of the variance in SCP was explained by the entire four exogenous latent constructs in the structural model. The adjusted R^2 value, accounting for predictors and sample size, was slightly lower at 0.346, reflecting a more refined estimate of the model's explanatory power as shown in Table 7. This suggests that the structural model exhibits moderate explanatory strength in predicting sustainable construction practices.

Hypothesis Testing

In the introductory part of this paper, four hypotheses were formulated to guide the research. This section inferentially tests the hypotheses in order to establish the statically significant paths, evaluate the relationships between latent and observed variables, assess causal pathways, and determine the fit of the proposed model. The hypotheses were tested via the PLS-SEM analysis to determine the impact of different competencies: economic, environmental, social, and technical on sustainable construction practices. The result of the test is shown in Table 8. As shown in the table, three of the hypothesized relationships were accepted based on the 95 percent confidence interval, however, hypothesis three was rejected.

Table 8. Assessment of hypothesis

Hyp.	Relation	B	t – statistics	p-values	Decision
H_1	Social Green Innovation Comp. → SCP	0.050	0.657	0.045	Supported
H_2	Economic Green Innovation Comp. → SCP	0.368	3.923	0.000	Supported
H_3	Environmental Green Innovation Comp → SCP	-0.007	0.079	0.937	Not Supported
H_4	Technical Green Innovation Comp. → SCP	0.263	3.187	0.002	Supported

Discussion of Findings

The impact or limited impact of the four competencies dimensions have been linked to policy and enforcement gaps by several authors such as Windapo *et al.* (2021), Usman *et al.* (2021), Yu *et al*. (2021) and Fang *et al.* (2018); while practical implications for professional capacity building and curriculum integration are further highlighted from the findings of this study as follows; Hypothesis 1 (H_1) predicted a significant but modest positive effect of social green innovation competencies on SCP, with $\beta = 0.050$ ($t = 0.657$, $p = 0.045$). This indicates that fostering collaboration, stakeholder engagement, and social networks contributes to sustainable construction, albeit with a smaller impact than economic or technical competencies. Gopinath *et al.* (2020) corroborate this, noting that social competencies enhance teamwork and innovation diffusion, which indirectly support sustainability, hence supporting hypothesis H_1. In hypothesis 2 (H_2), the study also predicted that economic green innovation competencies have a significant positive effect on SCP, with a β value of 0.368 ($t = 3.923$, $p = 0.000$). This suggests that economic strategies, such as cost management and financial planning, play a critical role in achieving sustainable outcomes. These findings are supported by Windapo *et al.* (2021) and Usman *et al.* (2021), who emphasized that financial viability is a cornerstone of sustainable practices, particularly in resource-constrained settings like developing countries thus supporting hypothesis, H_2 which is postulated that economic green innovation competencies positively influence sustainable construction practices in Nigeria.

However, for hypothesis 3 (H_3), environmental green innovation competencies demonstrate a negative and statistically insignificant relationship with SCP ($\beta = -0.007$, $t = 0.079$, $p = 0.937$). This lack of significance might reflect implementation gaps or contextual challenges, such as insufficient environmental regulations or inadequate integration of environmental policies into construction processes. Edomah *et al*. (2019) similarly found that the direct influence of environmental initiatives often requires alignment with economic and technical competencies to yield tangible sustainability outcomes. Therefore, the findings conclude that the hypothesis that environmental green innovation competencies significantly impact sustainable construction practices in Nigeria is not supported in this study. Lastly, hypothesis 4 (H_4) postulated a significant and positive influence of technical green innovation competencies on SCP with ($\beta = 0.263$, $t = 3.187$, $p = 0.002$). This finding highlights the importance of technical expertise, including adopting cutting-edge technologies and improving operational efficiency. The findings support the postulation of Zhong *et al.* (2022) who underscore similar observations, identifying technical innovations as pivotal enablers of green practices hence justifying the positive support of hypothesis, H_4.

Conclusion

This study contributes to policy and practice by emphasizing the need for regulatory authorities to enforce green construction standards, and for professional bodies to integrate green innovation training into curricula and continuous development programs. Government incentives for firms adopting green technologies are also recommended.

Based on the findings in this study, it is concluded that:

i. Economic, social, and technical competencies demonstrated notable positive impacts on sustainability outcomes in Nigeria.
ii. Environmental competencies showed limited direct influence on Sustainable Construction Practices in Nigeria.
iii. Given the moderate predictive relevance of the model, future research should explore additional contextual factors that may strengthen the relationship between green innovation competencies and sustainability indicators.

References

Adedeji, A., Ibrahim, Y., Abdul-azeez, I. A. & Oladejo, A. (2021). Sustainable Construction Practices in Nigeria: An evaluation of the role of stakeholders in compliance with green building rating tools. *Sustainable Cities and Society,* 68, 102821.

Amoah, P. & Oduro-Kwarteng, S. (2019). Drivers of Green Innovation Among Construction Firms in Ghana. *Journal of Sustainable Development,* 12(3):38-50.

Aram, H. M, Sahar, J. F. & Mohammed, E. A (2019). Incorporating Green Innovation to Enhance Environmental Sustainability. *WSEAS Transactions on Business and Economics,* 16: 477 – 486

Bhatia, M. S. (2021). "Green Process Innovation and Operational Performance: The Role of Proactive Environment Strategy, Technological Capabilities, and Organizational Learning." *Business Strategy and the Environment,* 4: 45 -57

Cai, H. & Dai, Q. (2021). Green Innovation Competencies in the Construction Industry: A Multilevel Perspective. Springer. 19(1): 25 – 36

Correia, M. S (2019). Sustainability: An overview of the triple bottom line and sustainability implementation. *International Journal of Strategic Engineering,* 2 (1): 29 - 38

Duarte, P. & Raposo, M. (2010). A PLS Model to Study Brand Preference: An Application to the Mobile Phone Market. In V. Esposito Vinzi, W. W. Chin, J. Henseler & H. Wang (Eds.), *Handbook of Partial Least Squares*: Springer Berlin Heidelberg.

Fang, D., Zhao, X., Li, H. & Shen, L. (2018). Understanding green innovation competencies in the Chinese construction industry. *Journal of Cleaner Production,* 203:71-81.

Fredrick, F (2019). Key competencies required of Project Managers in green construction. An unpublished Msc. Thesis submitted to the Department of Construction Technology, College of Arts and Build. University of Accra

Frempong, M. F., Mu, Y., Adu-Yeboah, S. S., Hossin, M.A. & Adu-Gyamfi, M. (2021). Corporate sustainability ad firm performance: The role of green innovation capabilities and sustainability -oriented supplier-buyer relationship. *Sustainability,* 13 (18): 10414

Guthrie, G. (2010). *Basic Research Methods: An Entry to Social Scientific Research.* New Delhi: Sage Publications India PVT Ltd.

Hair, J. F., Sarstedt, M., Ringle, C. M. & Mena, J. (2011). An Assessment of the Use of Partial Least Squares Structural Equation Modeling in Marketing Research An assessment of the use of partial least squares structural equation modeling in marketing research. *Journal of the Academy Marketing Sciences*.

Hair, J. F., Hult, G. T. M., Ringle, C. M. & Sarstedt, M. (2014). *A Primer on Partial Least Squares Structural Equation Modelling (PLS-SEM)*. Thousand Oaks: Sage Publications.

Henseler, J., Ringle, C. M. & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science*, 43:115–135.

Hossain, M.U., Antwi-Afari, S.T. & Amor, B. (2020). Circular economy and the construction industry: existing trends, challenges and prospective framework for sustainable construction, *Renewable and Sustainable Energy Reviews,* 130: 109948

Kock, N. (2014). *One-tailed or two-tailed P values in PLS-SEM* December.

Marcoulides, G. A. & Saunders, C. (2006). Editor's comments – PLS: a silver bullet MIS Quarterly 30 (2): 3 - 9

Munaro, M.R., Tavares, S.F. & Bragança, L. (2020). Towards circular and more sustainable buildings: a systematic literature review on the circular economy in the built environment, *Journal of Cleaner Production,* 260:121134

Ringle, C. M., Sarstedt, M. & Straub, D. W. (2012). A Critical Look at the Use of PLS-SEM in MIS Quarterly. *MIS Quarterly,* 36(1): 3 - 14

Usman, N. D., Bustani, A. B., Igwe, C. O. & Adamu, S (2021). Understanding Sustainability in Building Construction. *Proceedings of the 51st Builders Annual General Conference and Annual General Meeting*, held on 23 – 26th August 2021, 110 – 114

Waziri, G. A. (2016). Investigating Factors Influencing Green Practices at Different Level in Nigerian Construction Industry. An Unpublished PhD Thesis submitted to the School of Housing, Building and Planning, Universiti Sains Malaysia

Windapo, A. O., Oboirein, M. O. & Omeife, C. A (2021). Sustainable Construction Practices and Indicators: A Critical Review. *Proceedings of the 51st Builders Annual General Conference and Annual General Meeting*, held on 23 – 26th August 2021, 11 – 20

Wong, K. K. (2016). Technical note: Mediation analysis, categorical moderation analysis and higher- order constructs modeling in Partial Least Squares Stru. *The Marketing Bulletin*. (26) May.

Yu, J., Chen, Y. & Gao, Y. (2021). Analysis of the Mechanism of Green Innovation Competencies in the Construction Industry. A paper presented at the International Conference on Civil Engineering, Architecture and Building Materials, Beijing, China.

Yusuf, R. O., Ojedokun, A. T. & Aderamo, A. J. (2017). Energy and Sustainable Development in Nigeria: The Way Forward. *Energy Reports,* 3: 278-288.

Zhong, W., Schroder, T. & Bekkering, J. (2022). Biophilic design in architecture and its contributions to health, well-being, and sustainability: a critical review, *Frontier Architect Research,* 11 (1): 114–141