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EFFECT OF GREEN INNOVATION ON RENEWABLE ENERGY CONSUMPTION IN NIGERIA

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ABSTRACT

Renewable energy plays a critical role in addressing global energy needs while mitigating climate change. With an emphasis on carbon intensity, domestic credit to the private sector, and electricity accessibility, this study investigates how green innovation affects Nigeria's use of renewable energy. The study uses secondary data from the World Bank Development Indicators (WDI) for the years 1990–2023 and employs an ex post facto design. The statistical link between the dependent variable, renewable energy consumption, and the independent variables, such as carbon intensity (CI), domestic credit to the private sector (DCPS), and access to electricity (AE), is evaluated using a multiple regression analysis. The results show that carbon intensity has no discernible effect on the use of renewable energy, indicating that the adoption of renewable energy is not solely influenced by emissions reduction. Investment in sustainable energy is increased with support. Conversely, access to electricity negatively affects renewable energy consumption, implying that grid expansion may reduce reliance on renewable sources. These results highlight the critical role of financial incentives in promoting renewable energy while underscoring the need for strategic electrification policies. The study recommends that policymakers introduce low-carbon technology incentives, enhance green financing through low-interest loans, and prioritize decentralized renewable energy solutions, such as off-grid solar systems, to ensure sustainable electrification. This information contributes to the broader discourse on green innovation and energy sustainability in Nigeria, offering empirical guidance for policymakers and investors.

Introduction

The International Renewable Energy Agency (IRENA) reported that global renewable energy capacity reached a record 3,865 GW in 2023, marking an increase of 473 GW from 2022—the largest annual growth ever recorded (Qery, 2024; IRENA, 2024a). This surge was led by solar PV, which grew by 346 GW to 1,419 GW, and wind energy, which increased by 116 GW to a cumulative 1,017 GW (IRENA, 2024b). Notably, renewables accounted for 83% of all newly installed power capacity, signaling a decisive shift toward cleaner energy sources (IRENA, 2024a). While hydropower remains the largest source of renewable electricity, offshore wind is rapidly expanding, especially in Europe and China. Additionally, advancements in energy storage technologies are improving the reliability of renewable power grids. Countries like the U.S., India, and Brazil are also accelerating their renewable energy investments to meet climate goals and enhance energy security.

Renewable energy plays a critical role in addressing global energy needs while mitigating climate change. In 2024, global investments in the energy transition reached $2.1 trillion, with China leading in renewable energy supply chain investments (Financial Times, 2024a). The International Energy Agency's World Energy Outlook 2024 projects that global electricity demand will double by 2050, largely driven by China's energy transition (MarketWatch, 2024), highlighting the urgent need for large-scale renewable infrastructure investments to meet future demands sustainably. Research shows that increased renewable energy consumption significantly reduces CO_2 emissions, contributing to environmental sustainability (Wang et al., 2024). In line with this, Nigeria is actively developing its renewable energy sector to address electricity shortages and promote sustainable development, aiming for 30% of energy generation from renewable sources by 2030 (Adedokun, 2024). With its high solar irradiance, particularly in the northern regions, solar power investments are a priority, exemplified by projects like the 200 MW Ashama Solar Power Station in Delta State (Okoye & Choji, 2019). The government has also partnered with international organizations to develop hydroelectric power stations, including the 360 MW Gurara II project (Ajaelu & Okereke, 2020), all part of a broader strategy to diversify the energy mix, reduce greenhouse gas emissions, and enhance energy access for the growing population.

Wang, Dong & Dong (2021) found that carbon intensity affects renewable energy transitions across Belt and Road countries but did not differentiate between renewable sources, making it unclear which energy types are most responsive. Rapih (2021) notes international capital inflows but does not affect allocation to renewables. Ishaku et al. (2022) focus on regional energy strategies, ignoring localized issues like unreliable grids and funding constraints. Jia et al. (2021) explored regional differences, revealing that carbon-intensive economies in Europe and North America exhibit stronger renewable transitions than other regions. This suggests that carbon intensity acts as a policy catalyst; however, the study did not control for policy variations, creating uncertainty about whether regulatory interventions drive these shifts. Grim et al. (2020) emphasized that carbon-intensive energy systems necessitate technological advancements in renewable electricity but overlooked economic barriers that may hinder adoption.

Addressing the barriers through stronger regulations, infrastructure improvements and better credit access, is vital for clean energy transition in Nigeria. These results highlight the critical role of financial incentives in promoting renewable energy while underscoring the need for strategic electrification policies.

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The study recommends that policymakers introduce low-carbon technology incentives, enhance green financing through low-interest loans, and prioritize decentralized renewable energy solutions, such as off-grid solar systems, to ensure sustainable electrification. This information contributes to the broader discourse on green innovation and energy sustainability in Nigeria, offering empirical guidance for policymakers and investors.The paper is structured into five sections: Introduction, Literature Review, Methodology, Results and Discussion, and Conclusion and Recommendations.

Literature Review

Renewable energy refers to energy derived from naturally replenished resources such as sunlight, wind, water, and geothermal heat, recognized for its sustainability and minimal environmental impact (IPCC, 2011; Jacobson et al., 2017; Hansen et al., 2019). Delucchi and Jacobson (2011) emphasize its abundance and renewability, while Creutzig et al. (2017) highlight its non-depleting nature. Green innovation, as defined by the OECD (2009), involves the development of products, processes, and services that reduce environmental harm and foster sustainability. Rennings (2000) and Chen et al. (2012) similarly stress its role in mitigating pollution and climate change through environmentally friendly technologies, business models, and sustainable materials (Horbach et al., 2012; Kemp & Pearson, 2007). This study adopts the definitions by IPCC and OECD, reflecting the essential characteristics of renewable energy and green innovation.

Tudor & Sova (2021) examined the global economic impact of renewable energy consumption (REC), finding that carbon intensity significantly influences REC in both low- and very high-income countries. While high carbon intensity can either drive or hinder REC depending on economic and institutional contexts, the study does not analyze sector-specific responses, leaving gaps in understanding industry-level reactions. Similarly, Wang, Dong & Dong (2021) found that carbon intensity affects renewable energy transitions across Belt and Road countries but did not differentiate between renewable sources, making it unclear which energy types are most responsive. Jia et al. (2021) explored regional differences, revealing that carbon-intensive economies in Europe and North America exhibit stronger renewable transitions than other regions. This suggests that carbon intensity acts as a policy catalyst; however, the study did not control for policy variations, creating uncertainty about whether regulatory interventions drive these shifts. Grim et al. (2020) emphasized that carbon-intensive energy systems necessitate technological advancements in renewable electricity but overlooked economic barriers that may hinder adoption.

At a macro level, Tudor et al. (2023) found that economic growth influences how carbon intensity impacts REC. Carbon-intensive economies with strong economic growth transition more easily, whereas weaker economies struggle. However, the study does not account for industry-specific responses, limiting insights into sectoral variations. Albaker et al. (2023) focused on the MENA region, showing that high carbon intensity has driven REC, but economic growth and energy intensity continue to contribute to emissions. While the study provides regional insights, it does not compare MENA's transition with other fossil-fuel-dependent regions, leaving gaps in understanding diverse economic structures. Zhang et al. (2023) analyzed electricity consumption in China, showing that higher carbon intensity correlates with increased renewable energy integration. However, the study does not assess the role of regulatory measures, making it unclear whether carbon intensity alone drives adoption. Similarly, Li et al. (2023) found that reducing energy intensity increases REC in Beijing, moderated by economic growth. However, their findings are geographically limited and may not apply to economies with different industrial compositions.

Waheed (2022) investigated factors affecting carbon intensity in Saudi Arabia using a non-linear ARDL model. The study found that adverse shocks in energy intensity increase carbon intensity, while blue economic factors significantly reduce it. However, green factors had little impact post-Vision 2030, suggesting policymakers should invest more in renewable energy and marine sectors. Oke (2024) reviewed carbon intensity metrics in the oil and gas industry, emphasizing the insufficiency of upstream-only metrics and the need for Scope 3 emissions accounting. While national oil companies (NOCs) could reduce emissions, their dependence on oil revenues presents diversification challenges. He et al. (2021) examined the impact of REC on carbon emission intensity (CEI) and economic growth in Belt and Road Initiative (BRI) countries. They found bidirectional causality among REC, CEI, and economic growth, highlighting high deployment costs as a barrier to low-carbon development.

Nawaz et al. (2020) highlight that while domestic credit theoretically supports green financing, its impact in Nigeria is weak due to financial market inefficiencies. However, they do not address the role of high lending rates and risk aversion among Nigerian banks, leaving uncertainty about whether the issue lies in credit availability or institutional reluctance to fund renewable energy projects. Similarly, Zhang et al. (2021) find that short-term credit has little impact on renewable energy, while long-term credit remains inaccessible due to strict collateral requirements. However, they fail to examine the specific lending practices of Nigerian banks, limiting the study's applicability.

Government domestic debt, according to Kulu et al. (2022), drives out private sector finance, limiting investment in renewable energy. They fail to distinguish

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between borrowing that only widens fiscal deficits and effective government spending that promotes infrastructure for renewable energy. Although Danisman and Demir (2020) point out that financial crises result in less lending to the private sector, they do not evaluate whether domestic credit flows recover sufficiently to support investments in renewable energy during recessions. Rapih (2021) looks at how foreign capital inflows affect the growth of domestic credit, but it doesn't say if these influxes are going towards renewable energy. The degree to which foreign investments impact the sector's domestic credit availability is unclear as a result of this absence.

In their study of power system planning in Southern Africa, Justo, Tafula, and Moura (2022) highlight how renewable energy might increase access to electricity. Their work focusses on regional energy planning rather than on country-level barriers, even if it offers methods for integrating renewables into national systems. The analysis ignores Nigeria's particular difficulties, including patchy policy implementation and lax regulatory frameworks. In a similar vein, Talebpour et al. (2024) look into how distributed energy systems might provide fair access to electricity. Their study draws attention to socioeconomic differences in the distribution of power, but it does not go into great detail about how these systems may be successfully expanded in underserved and rural areas of Nigeria.

However, the study’s lack of long-run relationships between GDP and electricity consumption in Nigeria suggests that additional factors, such as governance and infrastructure, need to be examined. Puig et al. (2021) discuss decentralized electrification through renewable energy mini-grids, highlighting their advantages over fossil-fuel-based generation. While relevant, the study does not address Nigeria’s specific financial and policy barriers to deploying such solutions. Kennedy and Stanić (2023) review the role of renewable energy in future electricity supply, focusing on European policies. While their insights are valuable, the study lacks applicability to Nigeria’s energy landscape. Ogunniyi et al. (2023) examine Nigeria’s renewable electricity potential, identifying key energy sources but not providing detailed policy recommendations or implementation strategies. Alonge (2021) assesses Nigerian laws and policies on renewable energy, finding them inadequate for fostering widespread adoption. However, the study does not explore alternative policy mechanisms that could be more effective.

Research Method

The study employs a quantitative research approach to ensure objectivity and generalizability of findings. The quantitative method is chosen because it facilitates statistical analysis, enabling the measurement of relationships between variables. Moreover, quantitative analysis provides empirical evidence that enhances decision-making for policymakers and stakeholders in Nigeria's renewable energy sector (Creswell & Creswell, 2018). Data for this study will be sourced from the World Bank Development Indicators (WDI), covering the period from 1990 to 2023. The choice of this period is justified by the need to capture long-term trends in green innovation indicators and their impact on renewable energy adoption in Nigeria.

The study considers the following key variables: Green innovation metrics include Carbon Intensity, which calculates CO2 emissions per GDP unit to show how energy use affects the environment, Access to Electricity, which shows the percentage of the population with access to electricity that is essential for the growth of renewable energy use, and Domestic Credit to the Private Sector, which represents financial assistance for enterprises and investments in renewable energy infrastructure. The primary indicator of the adoption of renewable energy is the dependent variable, Renewable Energy Consumption, which shows the percentage of energy consumption that comes from renewable sources. Regression analysis is used in the study to ascertain how green innovation factors affect the use of renewable energy. Regression analysis was chosen because of its capacity to demonstrate connections between a number of independent factors and a dependent variable (Gujarati & Porter, 2020). By adopting an ex post facto design, utilizing quantitative methods, and relying on World Bank data, this study ensures a robust methodological approach to analyzing the role of green innovation in driving renewable energy adoption in Nigeria. The findings will provide empirical information to guide policy formulation and investment in sustainable energy solutions. The study model as adapted from Ahmed et al. (2023) is as follows:

$$\mathbf{REit = \beta 0 + \beta 1CIit + \beta 2DCPSit + \beta 3AEit + \varepsilon it}$$

Where:
RE = Renewable Energy
DCPS = Domestic Credit to Private Sector
AE = Access to Electricity
ε= random error term that takes care of the effects of other factors which are not fixed in the model, on dependent variable.
i = Firm Subscript
t = Year Subscript
β1 β2 β3 = Regression coefficients associated with independent variables.

Result and Discussion

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Table 1 shows the mean values indicate that renewable energy consumption (RE) averages 84.49%, suggesting that a significant portion of Nigeria's energy mix is still dependent on renewables. However, carbon intensity (CI) stands at 0.432, showing that a considerable amount of CO_2 is still emitted per unit of GDP. Meanwhile, DCPS averages 8.64% of GDP, highlighting the relatively low financial support provided to private sector investments, which could influence green innovation adoption. Access to electricity (AE) remains at 47.67%, revealing that nearly half of Nigeria's population lacks access to stable electricity, a critical challenge for sustainable development. The standard deviation shows variations within each variable.

Renewable energy consumption fluctuates by 2.66 percentage points, suggesting relative stability. However, carbon intensity (0.148) and domestic credit (3.374) demonstrate moderate and significant fluctuations, respectively, indicating variations in CO_2 emissions and financial support. The access to electricity measure (8.21) reflects disparities in energy availability across different regions. Examining the minimum and maximum values, renewable energy ranges from 79.90% to 88.60%, showing a narrow spread. In contrast, carbon intensity fluctuates from 0.218 to 0.645, signaling changes in emissions over time. Domestic credit ranges from 3.697% to 19.626%, indicating inconsistent financial sector contributions to energy investments. Electricity access varies significantly (27.3% to 60.5%), highlighting large inequalities in energy access. The skewness values indicate the distribution shape. RE (-0.269) and CI (-0.297) are slightly negatively skewed, meaning that more observations are concentrated toward higher values. DCPS (1.121) is positively skewed, reflecting a few extreme high values pulling the distribution. AE (-0.415) is also negatively skewed, suggesting more frequent higher access rates but still showing disparities. Regarding kurtosis, RE (1.812), CI (1.474), and AE (2.449) exhibit platykurtic distributions, meaning their distributions are flatter with fewer extreme values. However, DCPS (4.109) is leptokurtic, showing that financial support for the private sector is highly variable, with occasional extreme values.

Table 1: Descriptive Statistics

	Mean	Std. Dev.	min	max	skewness	kurtosis
RE	84.487	2.662	79.900	88.6	-0.269	1.812
CI	0.432	0.148	0.218	0.645	-0.297	1.474
DCPS	8.638	3.374	3.697	19.626	1.121	4.109
AE	47.673	8.21	27.300	60.5	-0.415	2.449

Source: STATA output, 2025

Table 2: Pairwise Correlation

Variables	(1)	(2)	(3)	(4)
(1) RE	1.000			
(2) CI	0.613*	1.000		
	(0.000)			
(3) DCPS	-0.338	-0.708*	1.000	
	(0.059)	(0.000)		
(4) AE	-0.763*	-0.838*	0.700*	1.000
	(0.000)	(0.000)	(0.000)	

**** p<0.01, ** p<0.05, * p<0.1*

Source: STATA output, 2025

The pairwise correlation results reveal significant relationships among Renewable Energy (RE), Carbon Intensity (CI), Domestic Credit to the Private Sector (DCPS), and Access to Electricity (AE) in Nigeria. A moderate positive correlation (0.613, p<0.1) between RE and CI suggests that increasing renewable energy use has not significantly reduced carbon intensity, possibly due to continued fossil fuel reliance. The relationship between RE and DCPS (-0.338, p>0.05) is negative but not statistically significant, indicating that financial support to the private sector does not directly influence renewable energy adoption. A strong negative correlation (-0.763, p<0.01) between RE and AE suggests that increased renewable energy does not necessarily translate to better electricity access, likely due to infrastructure constraints. Meanwhile, CI and DCPS (-0.708, p<0.01) show a strong negative correlation, implying that increased private sector credit reduces carbon intensity, possibly through green investments. The strong negative correlation (-0.838, p<0.01) between CI and AE indicates that improved electricity access is associated with lower carbon intensity. Additionally, the positive correlation (0.700, p<0.01) between DCPS and AE highlights the role of financial support in expanding electricity access (Table 2).

The study conducted multicollinearity, normality, and heteroscedasticity tests to ensure the reliability of regression estimates (Table 3). The Variance Inflation Factor (VIF) test assesses multicollinearity, with a mean VIF of 3.40, indicating moderate correlation among predictors but not severe enough to affect model validity (Gujarati & Porter, 2020). Individual VIF values remain below the critical threshold of 10, confirming that multicollinearity is not a major concern (Wooldridge, 2021). The Shapiro-Wilk test for normality shows that RE (p=0.058) and AE (p=0.355) are normally distributed, while CI (p=0.000) and DCPS (p=0.000) violate normality assumptions. Non-normality in CI and DCPS suggests potential transformation needs or robust estimation techniques (Razali & Wah, 2011). The

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Breusch-Pagan/Cook-Weisberg test for heteroscedasticity returns a chi2(1) = 0.05, p = 0.8263, indicating homoscedasticity, meaning error variance is constant, and OLS estimates remain efficient (Greene, 2018). Overall, the results validate the model's robustness, with no severe multicollinearity or heteroscedasticity issues. However, non-normality in some predictors suggests potential estimation adjustments.

Table 3: Diagnostic Test

Test Type	Test Method	Variables/Test Statistic	Results/Remarks
Multicollinearity	Variance Inflation Factor (VIF)	Mean VIF = 3.40; Individual VIF < 10	Moderate correlation; no severe multicollinearity (Gujarati & Porter, 2020; Wooldridge, 2021)
Normality	Shapiro-Wilk Test	RE (p = 0.058), AE (p = 0.355)	Normally distributed
		CI (p = 0.000), DCPS (p = 0.000)	Violate normality assumptions; transformation or robust methods suggested (Razali & Wah, 2011)
Heteroscedasticity	Breusch-Pagan/Cook-Weisberg Test	$Chi^2(1) = 0.05$, p = 0.8263	Homoscedasticity confirmed; OLS estimates efficient (Greene, 2018)
Overall Model Assessment	-	-	Model robust; no severe issues detected

Source: STATA output, 2025

According to Table 4, the regression model examines the effect of carbon intensity (CI), domestic credit to the private sector (DCPS), and access to electricity (AE) on renewable energy (RE) in Nigeria. Given the normality violations observed in the Shapiro-Wilk test, robust standard errors were applied to improve estimation reliability. The R-squared value of 0.667 indicates that 66.7% of the variation in RE is explained by the independent variables, demonstrating a strong model fit. The F-test (18.497, p = 0.000) confirms the overall model's statistical significance. Carbon Intensity (CI) has a positive but insignificant effect on renewable energy ($\beta = 3.767$, p = 0.303), implying that changes in CI do not significantly influence RE at conventional significance levels. Domestic Credit to the Private Sector (DCPS) shows a significant positive effect (β = 0.343, p = 0.012), indicating that increased financial support enhances renewable energy adoption. Access to Electricity (AE) has a highly significant negative effect (β = -0.302, p = 0.000), suggesting that greater electricity access reduces reliance on renewable sources. The Akaike (AIC = 125.307) and Bayesian (BIC = 131.170) criteria provide goodness-of-fit measures for model comparison. Overall, DCPS significantly promotes renewable energy, while AE hinders its expansion, requiring policy adjustments.

Table 4: Regression

RE	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
CI	3.767	3.592	1.05	0.303	-3.59	11.124	
DCPS	0.343	0.127	2.70	0.012	0.083	0.604	**
AE	-0.302	0.059	-5.13	0	-0.422	-0.181	***
Constant	93.788	3.905	24.02	0	85.789	101.787	***

Mean dependent var	84.487	SD dependent var	2.662
R-squared	0.667	Number of obs	32
F-test	18.497	Prob > F	0.000
Akaike crit. (AIC)	125.307	Bayesian crit. (BIC)	131.170

**** p<.01, ** p<.05, * p<.1*

Source: STATA output, 2025

Hypothesis Testing

H_{O1}: Carbon intensity has no significant effect on renewable energy in Nigeria
The coefficient for carbon intensity (CI) is 3.767, meaning that a 1-unit increase in CI leads to a 3.767-unit increase in renewable energy (RE). However, the p-value (0.303) is not statistically significant, indicating that this effect is not reliable. Therefore, the null hypothesis (H_{01}) stating that carbon intensity has no significant effect on renewable energy in Nigeria is not rejected. This finding contradicts the TAM theory, as it suggests that higher CI does not significantly drive renewable energy adoption.

H_{O2}: Domestic credit to private sector has no significant effect on renewable energy in Nigeria
The coefficient for domestic credit to the private sector (DCPS) is 0.343, meaning that a 1-unit increase in DCPS leads to a 0.343-unit increase in renewable energy (RE). The p-value (0.012) is statistically significant at the 5% level, indicating a meaningful effect. Therefore, the null hypothesis (H_{02}) stating that domestic credit

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to the private sector has no significant effect on renewable energy in Nigeria is rejected. This finding aligns with the TAM theory, as access to financial resources supports the adoption of renewable energy technologies.

H_{O3}: Access to electricity has no significant effect on renewable energy in Nigeria
The coefficient for access to electricity (AE) is -0.302, meaning that a 1-unit increase in AE leads to a 0.302-unit decrease in renewable energy (RE). The p-value (0.000) is statistically significant at the 1% level, indicating a strong negative effect. Therefore, the null hypothesis (H_{03}) stating that access to electricity has no significant effect on renewable energy in Nigeria is rejected. This finding contradicts the TAM theory, as increased electricity access appears to reduce reliance on renewable energy rather than promoting its adoption.

Discussion findings

The findings reveal relationships between carbon intensity, domestic credit to the private sector, access to electricity, and renewable energy in Nigeria, with partial alignment to the Technology Acceptance Model (TAM). The insignificant effect of carbon intensity (p-value = 0.303) suggests that environmental degradation does not currently incentivize renewable energy adoption. This finding diverges from TAM, which emphasizes perceived external pressures as drivers for technology adoption. In contrast, previous studies, such as Adeyemi and Olayemi (2019), emphasize carbon intensity as a critical factor influencing renewable energy investments in emerging economies, underscoring the need for stronger regulatory frameworks in Nigeria.

Access to power has a negative and statistically significant influence (p-value = 0.000), which runs counter to TAM's claim that easier access to resources promotes the adoption of technology. This result is consistent with research by Bolarinwa and Hassan (2022), who contend that in developing countries, off-grid renewable energy sources frequently compete with expanded grid access, decreasing the incentives for implementing decentralised energy systems. The findings imply that rather than only enlarging the central grid infrastructure, strategies supporting renewable energy should concentrate on decentralised alternatives.

TAM's focus on perceived resource availability for technology adoption is supported by the notable favourable impact of domestic lending to the private sector (p-value = 0.012). This result is consistent with research by Asogwa and Chukwuma (2020) and Nwankwo et al. (2021), which emphasise the importance of financial access in supporting renewable energy initiatives. The engagement of financial institutions can facilitate the deployment of clean energy technologies and lessen capital limitations, highlighting the significance of financial sector reforms in advancing Nigeria's green energy transition.

Conclusion and Recommendations

Renewable energy plays a critical role in addressing global energy needs while mitigating climate change. In 2024, global investments in the energy transition reached $2.1 trillion, with China leading in renewable energy supply chain investments (Financial Times, 2024a). The International Energy Agency's World Energy Outlook 2024 projects that global electricity demand will double by 2050, largely driven by China's energy transition (MarketWatch, 2024), highlighting the urgent need for large-scale renewable infrastructure investments to meet future demands sustainably. Research shows that increased renewable energy consumption significantly reduces CO_2 emissions, contributing to environmental sustainability (Wang et al., 2024).

With an emphasis on carbon intensity, domestic lending to the private sector, and electricity access, this study investigated how green innovation affected renewable energy in Nigeria. The findings imply that cutting emissions by itself might not have a direct impact on the adoption of renewable energy since carbon intensity (CI) has no discernible impact on renewable energy ($p = 0.303$). On the other hand, renewable energy is positively impacted by domestic credit to the private sector (DCPS) (coef = 0.343, $p = 0.012$), suggesting that financial support increases investment in renewable energy. On the other hand, renewable energy is adversely affected by access to electricity (AE) (coef = -0.302, $p = 0.000$), suggesting that greater grid access could lessen dependency on renewable sources. These results imply that while improvements in electrical infrastructure should be coordinated, financial incentives are essential for growing renewable energy.

Based on the findings, it is recommended that: Since carbon intensity does not significantly affect renewable energy, the government should introduce policies that incentivize industries to adopt low-carbon technologies while integrating renewable energy into their operations. Furthermore, given the positive effect of domestic credit to the private sector on renewable energy, financial institutions should offer low-interest loans and grants to businesses investing in renewable energy projects. Finally, as increased access to electricity negatively impacts renewable energy adoption, policymakers should prioritize decentralized renewable energy solutions, such as off-grid solar systems, to ensure sustainable electrification.

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