Socioeconomic Drivers of Renewable Energy Adoption in Nigeria

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ABSTRACT

In light of the ongoing global energy shift, this paper examines the socioeconomic factors influencing Nigeria's adoption of renewable energy. By reviewing how income distribution, public spending, energy prices, and job arrangements affect outcomes related to renewable energy, it closes a gap in the body of prior work. This study examines the short- and long-term correlations between important variables using annual data from 1990 to 2022 and an Autoregressive Distributed Lag (ARDL) bounds testing method. The results demonstrate a long-term equilibrium relationship in which income inequality, energy costs, and employment in the fossil fuel sector all significantly impede the adoption of renewable energy. There is no statistically significant long-term impact from government spending, renewable energy employment, or foreign direct investment. However, there is a slight negative link between renewable energy adoption and economic growth. The results emphasise the need for targeted legislative measures to remove societal and sectoral barriers to Nigeria's transition to sustainable energy.

Keywords: Renewable Energy Adoption, economic Growth, Income Inequality, Government Expenditure, Energy prices.

INTRODUCTION

The pressing need to switch from fossil fuels to renewable energy sources is causing a significant shift in the world's energy landscape. At the national and international levels, this shift is essential to attaining sustainable economic growth, safeguarding the environment, and improving energy security (Pokubo et al., 2024). The current energy revolution offers opportunities as well as difficulties for growing economies like Nigeria. Nigeria offers enormous potential for energy diversification, with abundant renewable energy resources including solar, wind, hydro, and biomass (Chanchangi et al., 2022; Ugwu et al., 2021). The country has been heavily reliant on oil and gas, which account for over 80% of export revenues and a large share of government revenue, despite the country's great solar energy potential—estimated at over 400,000 MW (Adeleye et al., 2024). This further indicates that less than 2% of the nation's energy comes from renewable sources, underscoring a persistent gap between what is possible and what is actually being done. Institutional and socioeconomic barriers have long prevented Nigeria from adopting renewable energy on a large scale; as a result, this situation persists (Adeleye et al., 2024; Emodi & Ebele, 2016; Nwozor et al., 2020).

Socioeconomic factors largely explain the slow uptake of renewable energy. For example, economic disparities limit access to renewable energy technologies for low-income households with financial constraints (Acheampong et al., 2023; Asongu & Odhiambo, 2021; Owolabi et al., 2024). In the same vein, fossil fuel subsidies distort energy pricing by artificially lowering the cost of conventional fuels and discouraging investments in renewable alternatives (Hvelplund et al., 2011, 2012; Matallah et al., 2023).

Public spending is identified as a key determinant, as government spending on infrastructure, R&D, and financial incentives can accelerate the diffusion of renewable energy technologies (Azhgaliyeva et al., 2019; Enongene et al., 2019; Husein et al., 2024). Employment dynamics also shape the social and political acceptability of the energy transition: oil- and gas-dependent communities usually resist structural change out of job insecurity and economic displacement, while renewable energy job creation fosters support for transition policies (Abe & Azubike, 2024; Hlongwane & Khobai, 2025; Saha et al., 2023). Economic growth, as measured by GDP, is another crucial determinant, as it reflects a country's capacity to invest in renewable energy infrastructure and sustain technological innovation (Iormom et al., 2024).

While Nigeria's energy sector has been studied extensively, most studies have concentrated on macroeconomic stability, policy design, or technology viability (Nwozor et al., 2020; Adedokun et al., 2024; Adeshina et al., 2024). Very few studies have provided an in-depth analysis of how socioeconomic factors interact to influence renewable energy uptake. This limited approach has considerably restricted understanding of how the distribution of income, public expenditure, energy pricing, and the employment structure cumulatively affect the outcomes of renewable energy in poorer countries (Chou et al., 2023). Addressing this gap is essential for creating integrated policy solutions that consider economic, social, and environmental dimensions.

The current study aims to determine the short-run and long-run dynamics of economic growth, income inequality, energy prices, government expenditure, and employment on renewable energy adoption in Nigeria. The study used the Autoregressive Distributed Lag (ARDL) bounds testing approach, which is suitable for small-sample time-series data with mixed orders of integration. This method allows for consistent estimation of both short-run adjustments and long-run equilibrium relationships among the variables.

To meet this objective, the study seeks to clarify how employment changes across the fossil and renewable energy sectors interact to influence overall adoption outcomes, how energy prices and public spending determine the pace of renewable energy expansion, and how economic growth, along with income inequality, affects the adoption of renewable energy. It is expected that income disparity will negatively affect renewable energy adoption by restricting affordability and inclusivity, while economic growth will positively and significantly impact it. Energy prices are expected to have a mixed effect, depending on affordability and the presence of fossil fuel subsidies. Public spending is expected to have a positive impact through fiscal incentives and infrastructure financing to promote renewable energy. Employment dynamics, on the other hand, are expected to have an adverse effect due to opposition from fossil-based industries and a positive impact due to the creation of renewable jobs.

The present study contributes to the broader discourse on sustainable development by empirically evaluating the stated assumptions, pinpointing key socioeconomic levers that could expedite Nigeria's transition to renewable energy. It presents policy-relevant recommendations for achieving an inclusive and balanced energy policy that accelerates economic growth, reduces inequality, and promotes environmental sustainability. This analysis employs annual time series data from 1990 to 2022, sourced from the World Bank's World Development Indicators, the National Bureau of Statistics, and the Central Bank of Nigeria Statistical Bulletin, to ensure comprehensive and reliable results.

The remaining part of the work is organised as follows: the next section presents the theoretical framework and literature review, followed by the research methodology and model specification. The results and discussion of the study are then presented, followed by policy implications and recommendations for future research.

LITERATURE REVIEW

Conceptual and Theoretical Framework

The conceptual framework for this study presents the proposed relationships among key socioeconomic drivers (independent variables) and the adoption of renewable energy (dependent variable) within Nigeria's evolving energy landscape. Renewable energy adoption, as defined by Ashinze et al. (2021), entails integrating and utilising naturally replenishing energy sources, such as solar, wind, hydro, and biomass, into a country's overall energy mix. Nigeria's renewable energy initiative primarily aims to escalate the share of renewable energy in the country's energy mix (Nwozor et al., 2020). Such a transition is pivotal for enhancing energy security, reducing carbon emissions, and advancing sustainable development in the long term (Adeleye et al., 2024).

The conceptual framework for this study presents the proposed relationships among key socioeconomic drivers (independent variables) and the adoption of renewable energy (dependent variable) within Nigeria’s evolving energy landscape. Renewable energy adoption, as defined by Ashinze et al. (2021), entails integrating naturally replenishing sources of solar, wind, hydro, and biomass into a nation's total energy mix. Nigeria's renewable energy program seeks to increase the share of renewable energy in its total energy mix (Nwozor et al., 2020). Such an initiative is imperative for improving energy security, reducing carbon emissions, and achieving sustainable development in the long term (Adeleye et al., 2024).

Another key variable is income inequality, often measured by the Gini coefficient, which reflects differences in income distribution. High levels of income inequality are expected to hinder the uptake of renewable energy, as unequal access to financial resources makes clean energy technologies less affordable and accessible for low-income individuals (Acheampong et al., 2023; Fraser et al., 2023). Conversely, equitable income distribution may facilitate renewable energy adoption by enhancing energy access and fostering inclusive consumption patterns (Acheampong et al., 2023).

Energy prices significantly influence decisions about renewable energy. Due to the price distortions created by fossil fuel subsidies, renewable energy sources are often less competitive. Thus, it is postulated that subsidy reforms and transparent pricing mechanisms will stimulate more investment in and adoption of renewables by levelling the economic playing field.

Another important factor is public expenditures, particularly government spending on innovation, infrastructure, and research. By financing the necessary infrastructure, offering financial incentives such as tax breaks or subsidies, and promoting research and development that reduces the cost of technology, higher public spending on projects related to renewable energy is expected to foster adoption (Akhtaruzzaman et al., 2025; Azhgaliyeva et al., 2019; Wang et al., 2020; Zhao et al., 2021).

Finally, there are multiple dimensions to job dynamics in the energy transition. Potential job losses in the fossil fuel industry may generate resistance (Lim et al., 2023), while job creation in renewable energy firms could build political and social support for the transition (Briggs et al., 2022; Ram et al., 2019). A "Just Transition" approach that focuses on reskilling, social inclusion, and economic protection for affected workers is essential to secure broad support and ensure the sustainability of a shift toward renewable energy (Lim et al., 2023).

This conceptual framework thus establishes a multidimensional relationship among the institutional, social, and economic factors that shape Nigeria's transition to renewable energy. Several theoretical perspectives converge to form the conceptual model that provides a robust foundation for examining the empirical relationships between socioeconomic factors and Nigeria's adoption of renewable energy.

The first set of ideas based on the energy-growth nexus examines the dynamic link between economic growth and energy consumption. This literature has led to four major hypotheses: the growth hypothesis, in which energy consumption drives economic growth; the conservation hypothesis, in which economic growth drives energy consumption; the feedback hypothesis, which asserts bidirectional causality; and the neutrality hypothesis, which states that no causal relationship exists between them (Matei, 2018). In developing economies like Nigeria, it is challenging to foster growth while reducing environmental degradation stemming from reliance on fossil fuels (Bhuiyan et al., 2022). The paper adopts these perspectives to investigate Nigeria's growth trajectory in renewable energy use.

The study is also grounded in energy justice and energy poverty theories, which focus on equity in energy distribution and access. Energy justice advocates for equitable access to affordable, sustainable energy so that no demographic group is left behind during the transition to new energy forms (Ren et al., 2025; Volodzkienė & Štreimikienė, 2023). There is a substantial nexus between energy justice and economic inequality, as unequal income distribution restricts access to modern energy services. This is particularly true in low-income areas of Nigeria, where a large part of the population still lacks access to electricity (Acheampong et al., 2021). Renewable energy should be promoted to fill these gaps and realise equitable development (Toyin et al., 2024; Fraser et al., 2023).

The political economy of energy transition theory offers insights into how institutional inertia, political institutions, and vested interests shape energy policy. Nigeria's dependence on oil revenues has historically

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strengthened robust fossil fuel industry interests, which often translates into opposition to renewable energy initiatives (Edomah, 2021; Agu & Ogbeide-Osaretin, 2016). Such institutional and political barriers could undermine progress, notwithstanding the country's vast potential for renewable energy (Iormom et al., 2024). Understanding these dynamics is crucial in developing feasible and politically palatable policy recommendations.

The Diffusion of Innovations Theory (Miller, 2015), a behavioural perspective on the integration of renewable technologies in social systems, supports both views. Adoption rates are contingent on factors such as perceived relative advantage, compatibility with existing norms, complexity, and observability (Ashinze et al., 2021). These beliefs-and thus adoption outcomes-are heavily influenced by socioeconomic conditions, government assistance systems, and income distribution.

Lastly, the Just Transition Theory underscores the significance of equity in the low-carbon transition. It underlines the importance of job and capacity creation in renewable industries and reducing employment losses in fossil-based industries (Lim et al., 2023; Briggs et al., 2022; Frost, 2024). This theoretical framework reiterates the centrality of social justice and equity to achieving a sustainable energy transition in Nigeria. By integrating diverse theoretical perspectives from economics, social justice, political economy, and sustainability, it provides an elaborate framework for understanding the complex socioeconomic dynamics that shape renewable energy uptake in Nigeria. It discusses growth and equity, as well as the interlinkages between policy and innovation, to offer complex insights for practice and policy to steer toward a just and sustainable energy future.

The theoretical framework for this study is presented in Fig. 1, which depicts these interrelationships. This framework serves as the analytical basis for the econometric model developed in subsequent sections, guiding the empirical examination of the socioeconomic determinants of renewable energy adoption in Nigeria.

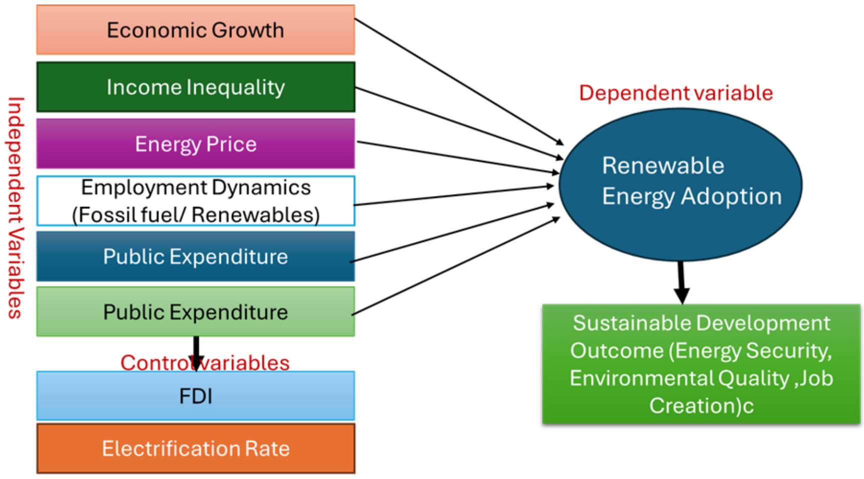

Fig. 1: Conceptual framework

Empirical Review

Globally, empirical research consistently demonstrates the central role of socioeconomic factors in shaping renewable energy adoption. Studies conducted in advanced economies highlight that robust economic growth and strategic public expenditure create enabling conditions for clean energy investment. For instance, Metawa et al. observed a strong positive correlation between economic growth and renewable energy adoption in 21 OECD countries, emphasising the role of economic progress in driving sustainable energy transitions. Similarly, Apergis and Payne provided evidence of both short-run and long-run relationships between economic growth and renewable energy demand across 20 developed nations. Public expenditure, particularly on research, infrastructure development, and technology diffusion, has also been identified as a significant catalyst for accelerating adoption. This expenditure can take the form of public banks providing capital, mitigating investment risks, and fostering financial learning, thereby building confidence in low-carbon technologies (Isah et al., 2023).

However, inequality and energy affordability have emerged as critical social barriers to the widespread integration of renewable energy. A study by Acheampong, Boateng, and Annor highlights that income inequality hinders energy transition. They state that "transitioning towards a renewable energy economy and improving energy efficiency depends on household purchasing ability, consumer behaviour and the affordability of renewable and nonrenewable energy." They further explain that "Poorer households tend to patronise nonrenewable energy, such as fossil energy, because of their affordability relative to renewable energy" (Acheampong et al., 2023). In a study focusing on Europe, Zhang and Vandenbergh revealed that regions characterised by lower income inequality and higher public trust exhibit faster adoption rates of solar and wind technologies.

Furthermore, the existing employment structures can significantly influence policy acceptance and the political economy of the energy transition. Armiento et al. argued that countries that experience robust growth in renewable energy employment tend to navigate energy transitions more smoothly. The creation of new jobs in the renewable sector can counterbalance potential job losses in the fossil fuel industry through labour reallocation and retraining initiatives.

These collective findings underscore that renewable energy adoption is not merely a technological process but fundamentally a profound socioeconomic transformation.

Evidence from developing countries further reinforces the multidimensional nature of renewable energy adoption. In Asia, empirical studies have shown that GDP growth and energy prices significantly affect renewable energy investment, with institutional quality acting as a crucial mediating factor. Bella et al. demonstrated that in Latin America, energy subsidies and fiscal imbalances impede the diffusion of renewable energy, while effective policy frameworks actively enhance the linkages between economic growth and energy. Within Africa, recent studies highlight the complex interactions among economic development, inequality, and the prevailing policy environment. Anku emphasised that various factors, including inadequate infrastructure, hinder the transition to renewable energy in Sub-Saharan Africa. Bekun et al. found that in Sub-Saharan Africa, urbanisation and energy demand positively correlate with renewable energy use, though this relationship is moderated by income inequality.

In South Africa, Baker & Phillips identified income inequality as a key inhibitor of household-level solar adoption, despite national renewable energy targets. Collectively, these studies demonstrate that socioeconomic factors such as growth, inequality, fiscal expenditure, and employment are central to understanding the dynamics of renewable energy adoption in developing economies. However, such cross-country evidence often masks significant national heterogeneities, thereby necessitating country-specific analyses that accurately reflect local institutional and social structures.

Empirical evidence from Nigeria remains fragmented, often focusing on energy access, pricing mechanisms, and technical potential, while under representing crucial socioeconomic dimensions. For instance, studies examining energy consumption and economic growth in Nigeria, such as that by Fasheyitan et al., have found various relationships, including the influence of energy use on the Nigerian economy (Fasheyitan et al., 2022). However, these studies often neglect the influential roles of inequality and employment variables. Research exploring renewable energy efficiency and its impact on macroeconomic performance, such as that by Somoye et al., has focused on the effect of renewable energy consumption on economic growth but did not account for fiscal and labour dynamics (Somoye et al., 2022). Similarly, studies assessing renewable energy investment under conditions of policy uncertainty (e.g., Isah et al., 2023; Okoh & Okpanachi, 2023) highlight challenges in mobilising investment due to policy uncertainty and weak financing mechanisms but overlook how social disparities profoundly shape adoption patterns.

Although Nigeria has implemented various energy reforms, including the Renewable Energy Master Plan and subsidy removal initiatives, the existing empirical literature rarely examines how these policies interact with income inequality, public spending, and shifts in employment. Income inequality, as indicated by the Gini index, persists and notably affects the affordability and accessibility of clean technologies for a significant portion of the population (Lawal et al., 2024; Odozi & Oyelere, 2023; Young, 2019). Furthermore, fossil fuel employment, predominantly concentrated in the oil and gas sector, presents significant structural resistance to

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the energy transition, as a substantial portion of government revenue and jobs are tied to this industry (Abe & Azubike, 2024a, 2024b; Iormom et al., 2024). Government expenditure on renewables remains primarily limited, characterised by inconsistent funding, corruption, and technical skill shortages, leading to a reliance on donor-supported programs rather than substantial, large-scale fiscal allocations (Adeshina et al., 2024; Isah et al., 2023; Onuoha et al., 2023). Consequently, current research provides limited evidence on the interactive mechanisms through which these socioeconomic factors jointly determine renewable energy adoption in Nigeria.

This study aims to bridge these identified gaps by offering an integrated econometric assessment of the socioeconomic determinants of renewable energy adoption in Nigeria. Unlike previous studies that often treat these drivers in isolation, this research simultaneously examines the intricate roles of economic growth, income inequality, energy prices, government expenditure, and employment structures within a unified analytical framework. By applying the Autoregressive Distributed Lag (ARDL) bounds testing model, the study captures both short-run adjustments and long-run equilibrium relationships, making it particularly suitable for Nigeria's small-sample time series context. Furthermore, this study extends the existing literature by emphasising the employment dimension of the energy transition and explicitly distinguishing between labour dynamics in the fossil and renewable sectors, an aspect frequently overlooked in Nigerian empirical studies. It also quantifies the influence of public expenditure as a critical fiscal lever for promoting renewable adoption, thereby connecting energy transition debates with broader macroeconomic policy. Finally, by highlighting the pervasive role of income inequality, the study advances the discussion towards an inclusive transition framework that meticulously aligns renewable energy policies with overarching social equity objectives.

The findings are expected to provide robust empirical evidence for policymakers, enabling targeted interventions that effectively address the economic and distributive challenges inherent in Nigeria's renewable energy sector. In doing so, this study contributes significantly to the global discourse on sustainable development. It provides actionable insights for designing a socially inclusive, economically viable, and environmentally responsible energy transition strategy for Nigeria.

MATERIALS AND METHODS

Data and Variables

This study employs annual time-series data from 1990 to 2022 from the World Bank, the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), and the International Labour Organisation (ILO). The dependent variable is renewable energy adoption (RE_t), proxied by the share of renewable energy in total final energy consumption. The explanatory variables include real gross domestic product (GDP_t), income inequality ($GINI_t$), energy prices (EP_t), government expenditure (GE_t), employment in the fossil fuel sector ($EmpF_t$), and employment in the renewable industry ($EmpR_t$).

B. Method and Model Specification

This study employs an econometric framework to examine the socioeconomic determinants of renewable energy adoption in Nigeria.

The baseline static specification is expressed as:

$$\boldsymbol{RE_t = \alpha_0 + \alpha_1 GDP_t + \alpha_2} GINI_t \boldsymbol{+ \alpha_3 EP_t + \alpha_4 GEX_t + \alpha_5 EMP\_RE_t + \alpha_6 EMP\_F_t + \square_1 E\_acc + \square_2 FDI + \epsilon_t} \text{------ (1)}$$

Where (RE_t) represents renewable energy adoption (dependent variable). Proxy: share of renewables in final energy consumption (%) **or** installed renewable capacity (MW), (GDP_t), denotes economic growth (proxy for income effect and energy demand expansion), ($GINI_t$) is income inequality (Gini index), (EP_t), is energy prices(proxy for market cost or affordability), (GEX_t), represents government expenditure on energy or overall fiscal spending, EMP_RE_t denotes renewable energy employment, and EMP_F_t captures fossil fuel sector

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employment and $Controls_t$ a vector of control variables such as electrification rate ($\boldsymbol{E\_acc}$) and FDI inflows, $\boldsymbol{\epsilon_t}$ is the Error term.

Equation (1) provides a preliminary estimation framework, but it does not account for potential dynamics and non-stationarity in time-series data. Given the likelihood that the variables are integrated of order zero I(0) or one I(1), the Autoregressive Distributed Lag (ARDL) bounds testing approach of Pesaran et al. (2001) is employed.

The ARDL framework then models changes (Δ) in RE with lags of ΔRE and ΔX (short-run effects) and includes lagged levels (RE_{t-1}, X_{t-1}) to capture the long-run equilibrium. If the system deviates from equilibrium, an error-correction term (ECT) measures the speed of adjustment back to the long-run balance.

C. Estimation Technique

The Augmented Dickey-Fuller (ADF) test will be used to check if a time-series variable is stationary, which is necessary to avoid misleading results. After confirming stationarity, the Autoregressive Distributed Lag (ARDL) bounds test will be used to examine long-run relationships, accommodating both I(0) and I(1) variables. If a long-run relationship is found, the Vector Error Correction Model (VECM) will be used to estimate the long and short-run dynamics, with a significant negative coefficient showing the speed of adjustment after a shock. Diagnostic tests for serial correlation, heteroskedasticity, normality, and stability will be conducted to confirm the model's reliability.

Empirical Results

The results in Table 1 indicate that most series are approximately normally distributed, as evidenced by all Jarque-Bera (JB) statistics with p-values > 0.05, indicating that none of the variables significantly deviate from normality at the 5% significance level, which is suitable for regression and ARDL estimation. Overall, the data are approximately normally distributed and contain no extreme outliers. This supports the dataset's reliability for further econometric modelling, including regression and ARDL estimation of the socioeconomic impacts of Nigeria's energy transition.

Table 1: Descriptive Statistics of Variables (1990–2022, N = 33), Source: EViews 13

Variable	**E_ACC**	**EMP_FE**	**EMP_RE**	**EP**	**FDI**	**GDP**	**GEX**	**GINI**	**RE**
Mean	47.27	2.34	0.93	3.68	21.44	166.37	6.15	48.25	27.08
Median	47.80	2.30	0.73	2.89	21.49	62.40	7.20	48.50	25.75
Maximum	59.50	3.20	2.00	8.86	22.90	568.50	9.57	53.50	41.86
Minimum	27.30	1.50	0.30	1.69	19.52	27.50	1.67	42.00	21.00
Std. Dev.	8.01	0.51	0.54	1.92	0.99	178.37	2.77	3.34	5.66
Skewness	-0.44	0.07	0.71	1.38	-0.26	0.90	-0.40	-0.15	0.83
Kurtosis	2.47	1.91	2.17	4.08	2.00	2.22	1.50	1.92	2.87
Jarque-Bera	1.42	1.60	3.62	11.68	1.69	5.16	3.83	1.67	3.73
Probability	0.49	0.45	0.16	0.00	0.43	0.08	0.15	0.43	0.15
Observations	32	32	32	32	32	32	32	32	32

B. Trends in Key Energy and Economic Variables

The graphical analysis (Fig. 2) shows that from 1990 to 2020, energy access improved due to better infrastructure, renewable energy, and supportive policies, especially in developing areas. Fossil fuel employment generally grew but was impacted by the 2008 financial crisis and 2014 oil price crash, while renewable energy jobs surged from the early 2000s. Energy prices remained volatile, and foreign direct investment fluctuated, peaking in the early 2000s, then dropping after 2008 and recovering later, partly due to China's growth. Global GDP rose steadily, with brief slowdowns; government spending increased post-2008; and income inequality worsened. Renewable energy adoption was slow at first, but it has accelerated recently due to climate initiatives and more investment.

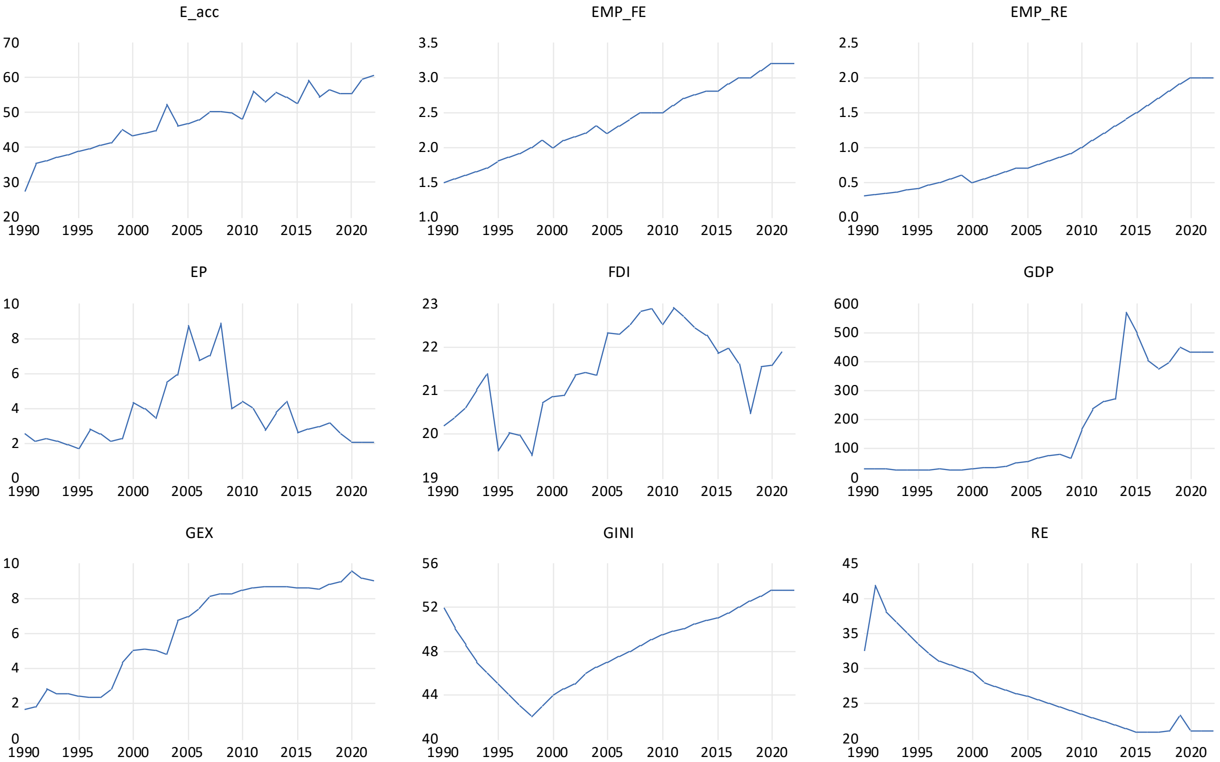

Fig 2. Graphical Analysis, Source: EViews 13

The Augmented Dickey-Fuller (ADF) test confirmed that all variables were stationary and not integrated of order two, validating the ARDL framework. Optimal lag length for the ARDL model was determined using AIC and UVAR criteria, with a lag of 2 selected based on Table 3.

Table 2: Unit Root Test Results and VAR Lag Order Selection

S/N	**Variable**	**ADF Unit Root Test Result**	**Order of Integration**	**Optimal Lag Length**
1	RE	Stationary at Levels Diff, C only	Order of integration I(0)	1
2	Ln(GDP)	Stationary at 1st Diff, C only	Order of integration I(1)	0
3	GINI	Stationary at 1st Diff, C only	Order of integration I(1)	0
4	EP	Stationary at 1st Diff, C only	Order of integration I(1)	2
5	Ln(GE)	Stationary at 1st Diff C only	Order of integration I(1)	0
6	EmpF	Stationary at 1st Diff C only	Order of integration I(1)	1

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7	EmpR	Stationary at 1st Diff C only	Order of integration I(1)	0
8	FDI	Stationary at 1st Diff C only	Order of integration I(1)	0
9	EL_A	Stationary at Levels @ C &T	Order of integration I(0)	0
	Note: C – Intercept C & T Intercept & Trend, source E-View 13.			

Table 3: VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-180.0371	NA	2.40e-06	12.60247	13.02283	12.73695
1	87.18553	356.2968*	1.24e-11	0.187631	4.391223*	1.532397
2	218.6893	96.43607	2.60e-12*	-3.179284*	4.807541	-0.624230*
Source E-View 13.						

The ARDL bounds test result in Table 4 confirms a long-run relationship, with the computed F-statistic of 43.669 exceeding the upper bound critical value of 4.445 at the 5% level for a sample size of 30. This indicates strong evidence against the null hypothesis of no cointegration. Therefore, we reject the null hypothesis and conclude that there is a long-run relationship between renewable energy adoption and independent variables. The t-statistic of -14.599 is highly negative and well below the 5% critical value, strengthening the rejection of the null hypothesis.

Table 4: Cointegration Test Result

Test Statistic	Value					
F-statistic	43.669202					
t-statistic	-14.598944					
	10%		5%		1%	
Sample Size	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
			F-Statistic			
30	2.384	3.728	2.875	4.445	4.104	6.151
35	2.300	3.606	2.753	4.209	3.841	5.686
Asymptotic	2.030	3.130	2.320	3.500	2.960	4.260
			t-Statistic			
Asymptotic	-2.570	-4.230	-2.860	-4.570	-3.430	-5.190

* I(0) and I(1) are respectively the stationary and non-stationary bounds.

The ARDL model's long-run results (Table 5) indicate that higher GDP is associated with a slight but significant reduction in renewable energy adoption. At the same time, greater income inequality (as measured by the GINI index) is associated with increased uptake, possibly due to targeted policies. Higher energy prices discourage renewable energy, likely for economic reasons. Government spending, renewable sector employment, and foreign direct investment do not significantly affect renewable adoption, but increased fossil fuel employment poses a significant barrier to renewable adoption.

Table 5: Estimating Long-run coefficient: Unrest. constant (Case 3)

Variable *	Coefficient	Std. Error	t-Statistic	Prob.
GDP(-1)	-0.004	0.002	-2.103	0.046
GINI(-1)	0.756	0.151	4.978	0.000
EP	-0.218	0.090	-2.325	0.028
GEX(-1)	-0.460	0.364	-1.263	0.218
EMP_RE(-1)	0.431	3.533	0.122	0.903
EMP_FE(-1)	-9.285	3.753	-2.473	0.020
FDI(-1)	-0.856	0.478	-1.787	0.086
source E-View 13.				

The short-run coefficients and the error correction term (ECT) are presented in Table 6. The ECT coefficient is negative and significant, indicating a stable adjustment mechanism towards long-run equilibrium after short-run shocks.

Table 6: Conditional Error Correction

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ*	-1.100	0.049	-22.409	0.000
D(GDP)	-6.550	0.001	-0.046	0.963
D(GINI)	0.492	0.125	3.917	0.000
D(GEX)	-0.044	0.189	-0.234	0.816
D(EMP_RE)	-15.584	2.765	-5.636	0.000
D(EMP_FE)	-0.612	1.993	-0.307	0.761
D(FDI)	0.062	0.157	0.395	0.695
C	38.578	1.744	22.111	0.000

The CUSUM line stays within the 5% significance boundaries; the model appears stable over the period analysed, and there is no indication of a structural break. Also, the CUSUM of Squares line remains within the

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5% significance boundaries (see Figure 3). This suggests that the residuals' variance is stable over the entire period; there is no evidence of significant instability in the model's variance, indicating that the model's error variance does not change significantly throughout the analysis period.

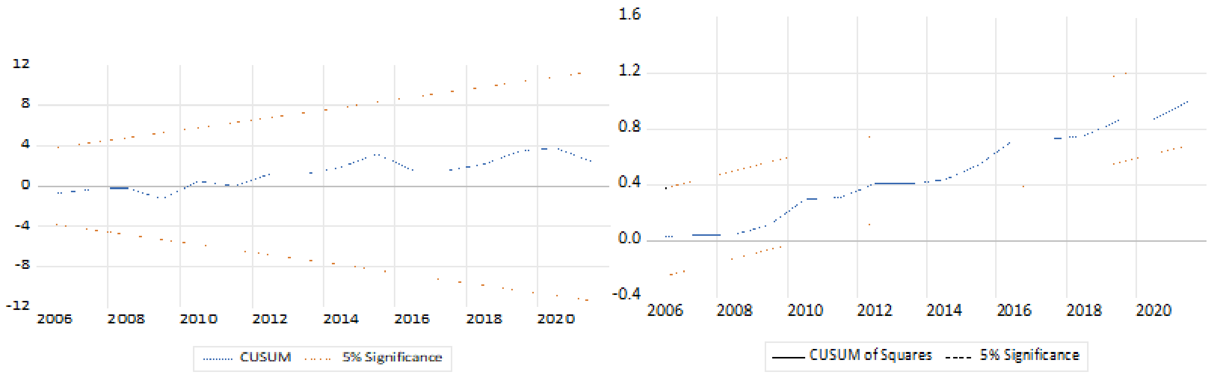
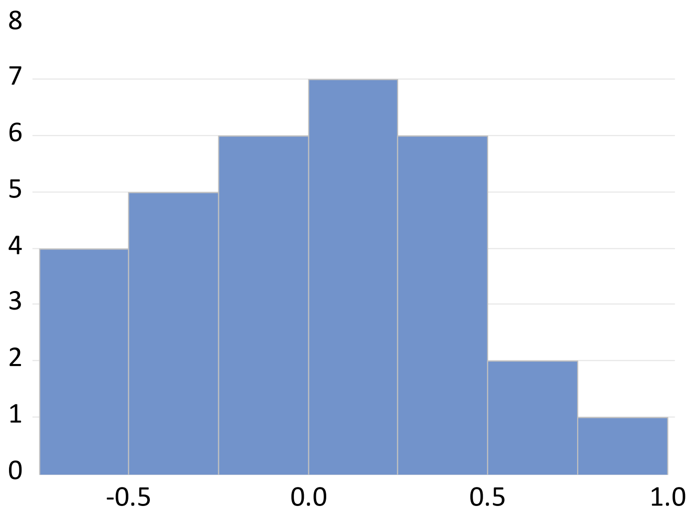


Figure 3: the CUSUM & CUSUMSQ plots

The results from both the visual inspection (histogram), Figure 4, and the formal Jarque-Bera test suggest that the residuals are approximately normally distributed. The p-value of 0.740334 is much greater than the typical significance level (e.g., 0.05), which indicates that we fail to reject the null hypothesis of normality. In other words, there is no evidence to suggest that the residuals deviate significantly from a normal distribution.



Series: Residuals	
Sample 1991 2021	
Observations 31	
Mean	8.26e-15
Median	0.004222
Maximum	0.958278
Minimum	-0.668968
Std. Dev.	0.411097
Skewness	0.154739
Kurtosis	2.391927
Jarque-Bera	0.601308
Probability	0.740334

Fig. 4 Normality test

RESULTS AND DISCUSSION

The results of the Augmented Dickey-Fuller (ADF) unit root test (Table 2) indicate that the variables are integrated of mixed orders, I(0) and I(1), but none is I(2). This validates the suitability of the ARDL bounds testing approach for cointegration analysis.

The ARDL bounds test results (Table 4) reveal that the computed F-statistics exceed the upper critical bound at the 5% level, confirming the presence of a long-run equilibrium relationship among renewable energy adoption, economic growth, inequality, energy prices, government expenditure, and employment dynamics. This provides strong evidence that socioeconomic determinants jointly influence renewable energy adoption in Nigeria.

The long-run ARDL estimates reveal several important insights into Nigeria's renewable energy transition. Economic growth exhibits a negative, statistically significant association with renewable energy adoption, indicating that periods of higher GDP growth have coincided with lower renewable energy penetration. This outcome reflects the structural characteristics of Nigeria's growth trajectory, which has historically been driven by fossil-fuel-intensive activities rather than green investment. In resource-dependent economies, growth often reinforces carbon lock-in by expanding oil production, increasing fuel consumption, and driving energy-intensive industrial activities, thereby crowding out renewable alternatives. The result, therefore, highlights a failure of growth-driven decoupling, where economic expansion does not automatically translate into cleaner energy systems in the absence of targeted green growth policies.

Energy prices also exert an adverse long-run effect on renewable adoption, suggesting that higher energy costs—when combined with persistent fossil fuel price distortions—discourage households and firms from switching to renewables. This finding reinforces the argument that price reforms alone are insufficient; without complementary affordability mechanisms and renewable financing frameworks, higher prices may suppress overall energy demand rather than stimulate clean energy substitution.

Government expenditure is found to be statistically insignificant in the long run. This outcome should not be interpreted as evidence that fiscal policy is irrelevant to renewable energy adoption. Instead, it reflects the aggregated nature of public expenditure data, which does not distinguish between renewable-focused spending and fossil fuel subsidies. In Nigeria, public expenditure has historically prioritised stabilising fuel prices, supporting the oil sector, and general infrastructure rather than dedicated renewable energy investment. As a result, the estimated coefficient captures general fiscal expansion rather than targeted green spending, diluting its observable impact on renewable uptake.

Employment dynamics further underscore the political economy of Nigeria's energy transition. Employment in the fossil fuel sector exerts a substantial adverse effect on renewable adoption, reflecting labour-based resistance and institutional inertia rooted in oil-dependent livelihoods and revenue structures. In contrast, renewable energy employment shows a positive but insignificant long-run effect, indicating that the renewable labour market remains too small to exert a meaningful influence on national energy outcomes. Together, these findings confirm that labour-market lock-in constitutes a significant structural barrier to the energy transition in fossil-dependent economies.

The short-run estimates indicate rapid convergence toward the long-run equilibrium, as evidenced by a large, statistically significant error-correction term. This suggests that deviations from equilibrium are corrected swiftly, highlighting the responsiveness of Nigeria's energy system to policy and economic shocks. Short-run changes in income inequality are associated with increased renewable adoption, potentially reflecting donor-supported and government-targeted renewable interventions in underserved communities. However, short-run increases in renewable energy employment are associated with a temporary decline in renewable adoption, likely reflecting construction-phase dynamics where employment expands before installed capacity becomes operational.

Overall, the short-run results reinforce the notion that renewable energy adoption responds asymmetrically across time horizons, with structural and institutional factors dominating long-run outcomes.

A battery of diagnostic and stability tests was conducted to validate the robustness and reliability of the ARDL estimates. The Breusch–Godfrey serial correlation LM test indicates no evidence of autocorrelation in the residuals up to two lags, as both the F-statistic and the Obs*R-squared statistics are statistically insignificant, confirming that the model is free from serial dependence. The Breusch–Pagan–Godfrey heteroskedasticity test further shows that the null hypothesis of homoskedasticity cannot be rejected, implying that the residuals exhibit constant variance over the sample period. In addition, the Jarque–Bera normality test confirms that the residuals are approximately normally distributed, satisfying a key assumption for valid statistical inference. Model stability is assessed using the CUSUM and CUSUMSQ tests, both of which remain within the 5% critical bounds throughout the sample period, indicating parameter stability and the absence of structural breaks. These diagnostic results confirm that the estimated ARDL model is well specified, stable, and suitable for reliable inference and policy interpretation.

The high R-squared (~0.96) and F-statistic confirm that the model fits the data well. All diagnostic tests passed: no autocorrelation (Breusch-Godfrey $p \approx 0.50$), homoskedastic residuals (Breusch-Pagan $p \approx 0.36$), and stable coefficients (CUSUM test). This provides confidence in the reliability of the findings for policy inference (the Table will be made available upon request).

Discussion of Findings

This study demonstrates that Nigeria's renewable energy transition is shaped less by aggregate economic expansion than by structural, institutional, and political-economy constraints. The negative relationship between economic growth and renewable adoption suggests that growth in resource-dependent economies can entrench fossil fuel dominance when green investment mandates are not accompanied by it. This finding challenges the assumption that higher income levels inherently facilitate clean energy transitions and instead underscores the importance of growth composition rather than growth magnitude.

The insignificance of government expenditure further reflects Nigeria's fiscal orientation toward fossil fuel support rather than renewable promotion. Without disaggregated renewable spending and subsidy reform, fiscal expansion alone is insufficient to drive clean energy adoption. Similarly, the strong negative influence of fossil fuel employment highlights labour-based resistance as a key transmission channel through which institutional inertia constrains energy transition.

Taken together, the results suggest that Nigeria's renewable energy challenge is not technological scarcity but political and economic misalignment. Renewable energy adoption remains constrained by subsidy distortions, employment lock-in, and growth strategies that prioritise short-term fossil fuel rents over long-term sustainability.

CONCLUSION AND POLICY RECOMMENDATIONS

Conclusion

This study provides robust empirical evidence that renewable energy adoption in Nigeria is governed by complex socioeconomic and institutional dynamics rather than by economic growth alone. Using an ARDL framework, the analysis shows that economic growth, energy prices, government expenditure, and employment structures interact in ways that often hinder, rather than support, the diffusion of renewable energy. Notably, economic growth exerts a negative influence on renewable adoption, reflecting Nigeria's fossil-fuel-dependent growth model and the absence of green growth safeguards.

The findings further demonstrate that aggregated government expenditure does not significantly promote renewable energy, underscoring the importance of targeted fiscal instruments rather than broad spending expansions. Labour market structures—particularly in the fossil fuel sector—emerge as a central barrier, underscoring the need for just transition strategies that address job displacement and institutional resistance.

Overall, the study advances the literature by showing that energy transition in resource-dependent economies requires deliberate policy coordination across fiscal, labour, and energy domains. For Nigeria, accelerating renewable adoption will depend not only on growth but also on reforming subsidy regimes, redirecting public spending toward renewables, and managing the political economy of transition through inclusive labour and social policies.

Policy Implications and Recommendations

The findings of this research underscore the multifaceted nature of Nigeria's renewable energy transition, shaped by the interplay of economic growth, income inequality, energy pricing, government expenditure, sectoral employment, and foreign capital flows. Drawing on both the results and extended recommendations, the following comprehensive policy implications and strategies are proposed to accelerate renewable energy adoption and ensure a just, equitable transition:

Promote Inclusive Growth and Reduce Inequality: Given the significant barrier that income inequality poses to renewable energy adoption, policymakers should implement targeted interventions to improve affordability and access to clean energy for low- and middle-income households. Recommended measures include micro-credit schemes, decentralised solar projects, and subsidies for vulnerable groups. Broader efforts to reduce inequality through enhanced access to education, healthcare, and clean energy will support a more equitable energy transition.

Rationalise Energy Prices and Reform Subsidies: The negative impact of energy prices and the distorting effects of fossil-fuel subsidies highlight the need for comprehensive pricing reform. A gradual subsidy phase-out, coupled with well-designed safety nets for disadvantaged populations, will help align energy prices with market signals and incentivise investment in renewable technologies. Governments should consider subsidising renewables, offering tax incentives, and introducing pricing mechanisms that favour green energy over fossil fuels.

Increase Government Expenditure on Renewable Infrastructure: Public spending is a critical driver of renewable energy adoption, although its current impact remains limited. Greater budgetary allocations should be directed to grid expansion, rural electrification, and renewable technology research and development. Strategic partnerships with private investors and development agencies can leverage additional financing for large-scale projects. National energy strategies must explicitly prioritise renewables to maximise the effectiveness of public investment.

Foster Employment in the Renewable Sector: While short-term sectoral employment frictions exist, long-term investment in green jobs is essential to reinforce transition pathways and offset employment losses in the fossil fuel sector. Policymakers should expand skill development programs, vocational training, and entrepreneurship support, incentivising renewable energy companies to employ local workers and facilitating a just transition for those affected by the contraction of the fossil fuel sector.

Ensure Policy Stability and Institutional Support: The stability of renewable energy adoption is closely linked to consistent, long-term policy frameworks. Strengthening institutional capacity, ensuring policy continuity, and integrating renewable energy targets into national development plans will provide certainty for investors and sustain momentum throughout the energy transition.

Adopt a Holistic and Coordinated Approach to Energy Transition: Given the interconnected relationships among economic growth, inequality, energy prices, employment, and foreign investment, Nigeria should adopt a coordinated policy approach that addresses these variables simultaneously. Energy transition strategies should move beyond technological solutions and integrate social, economic, fiscal, and institutional dimensions to achieve equitable and sustainable outcomes. Policymakers must also actively attract foreign direct investment into the renewable energy sector by creating favourable conditions, such as tax breaks, guaranteed returns, and long-term contracts.

Address Fossil Fuel Dependency and Support a Just Transition: The persistent negative impact of the fossil fuel sector on employment underscores the need to phase out fossil fuel subsidies gradually and to provide alternative livelihood opportunities for affected workers. Policies should facilitate retraining and redeployment, and support entrepreneurship in the green economy, ensuring that the transition does not exacerbate socioeconomic disparities.

Future Research Directions

This study highlights key socioeconomic factors influencing renewable energy adoption in Nigeria. Future work could use state-level panel data to examine regional differences, conduct household and firm surveys on micro-solar and clean cooking technologies, and compare Nigeria's progress with that of other African countries. Employing advanced methods such as structural VARs and dynamic panel models would also improve causal analysis and test ARDL results. Addressing these areas will yield more precise evidence for policymaking on Nigeria’s sustainable energy transition.

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