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Effect of Financial Efficiency and Stability on Renewable Energy Expenditure in Nigeria

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Abstract: *This study examines the effect of financial efficiency and Stability on the expenditure on renewable energy in Nigeria. This study adopts ex-post facto research design because the data for the study is already stored in the data base of World Development Indicator (WDI) which cannot be altered by any researcher. The population of the study comprises of data from the Nigerian economic factor which includes financial development index relationship to financial access and efficiency as well as the expenditure on renewable energy which are biomass, hydro, wind and solar technologies. The sample period that is adopted is from 1988 to 2023 (35 years). The data collected was analysed using Autoregressive Distributed Lag Estimation Techniques for data analysis. However, the long run test result shows that the coefficients of the specifications estimated using ARDL approach and based on the results, financial stability (1.6002) has a positive relationship with the dependent variable but is insignificant due to its p-value (0.2865) being greater than 5% respectively while financial efficiency (-4.5956) has a negative relationship with the dependent variable with an insignificant p-value (0.1999) because it is also greater that than 5%. In the light of the findings, this study recommends that improve Financial Efficiency to Facilitate Renewable Energy Investments. Financial institutions should streamline their processes, reduce bureaucratic bottlenecks, and lower transaction costs related to renewable energy financing and enhance Financial Stability with a Focus on Renewable Energy Investment. Regulatory authorities should, therefore, enhance financial sector resilience with a specific focus on promoting renewable energy investments.*

Keywords: financial stability, financial efficiency, expenditure, renewable energy

INTRODUCTION

In emerging economies, including Nigeria, one of the key areas of research relevance is the nexus between financial development and renewable energy consumption. Financial development, as characterised by financial efficiency and stability, indicates the degree to which a financial system can mobilise resources, allocate capital, and promote economic growth. Financial efficiency, characterised by streamlined loan processing, competitive interest rates, and low transaction costs, critically influences the feasibility of renewable energy investments in Nigeria. Efficient financial systems reduce capital barriers for biomass, solar, wind, and hydro projects by accelerating fund disbursement and minimising financing expenses. While direct Nigerian studies are limited, evidence from developing economies indicates that financial efficiency stabilises long-term capital allocation to renewables, even if it does not directly boost demand (Sun et al., 2023). For instance, Köksal et al. (2021) observed that efficient intermediation lowers transaction costs for renewable projects, enhancing affordability for households and businesses. In Nigeria, improved financial efficiency could incentivise shifts from fossil fuels to renewables by making technologies like solar panels or small-scale hydropower more economically viable through accessible credit mechanisms.

Financial stability reflecting low inflation, exchange rate consistency, and resilient banking systems is essential for sustaining renewable energy expenditures, particularly given the high upfront costs and extended payback periods of biomass, wind, solar, and hydro projects. Stable financial conditions mitigate investment risks during economic fluctuations, encouraging private-sector participation in Nigeria's renewable sector. Emerging economy studies demonstrate that stable financial systems facilitate long-term financing (e.g., low-interest loans) for capital-intensive renewable infrastructure, directly correlating with increased renewable consumption (Alsagr and Van Hemmen, 2021; Skare et al., 2023). Conversely, financial instability, such as currency fluctuations or banking crises, heightens perceived risks, deterring investment in renewables (Horky and Fidrmuc, 2024). For Nigeria, reinforcing monetary and banking stability could bolster investor confidence in large-scale, long-duration projects, such as grid-connected solar farms or hydropower plants, aligning with findings that macroeconomic resilience underpins renewable transitions in comparable economies (Sun et al., 2023).

The interplay between financial efficiency and stability creates a self-reinforcing framework for renewable energy expenditure. Efficient markets channel capital swiftly to viable projects, while stability ensures continuous funding through economic cycles. In Nigeria, enhancing both proxies requires targeted policies: streamlining regulatory processes to improve efficiency (e.g., digital loan approvals, reduced collateral requirements) and instituting macroeconomic safeguards (e.g., inflation controls, green bond guarantees) to fortify stability (Qaysi 2025). Cross-country evidence from developing economies underscores that coordinated reforms in these dimensions significantly boost renewable energy investments by de-risking capital and optimizing its flow (Sun et al, 2023). Prioritising such synergies could accelerate Nigeria's transition to biomass, solar, wind, and hydro technologies, advancing both energy security and climate goals.

In Nigeria, biomass, hydro, wind, and solar technologies are viable renewable energy sources for sustainable energy transition. However, this transition is not, and cannot be, in isolation from the issue of financial development and its intertwined nature with the renewable energy sector. Financial development, which emphasises financial efficiency and stability, is an important driver of renewable energy investments and the accomplishment of Nigeria's renewable energy ambitions. Nevertheless, these parts of financial development experience many issues that can affect the monetary capacity for financing renewable energy funding, implicating a holistic evaluation of their impact on renewable energy expenditures. Financial efficiency reflected in streamlined loan processing, competitive interest rates, and low transaction costs critically influences renewable energy expenditure by determining the affordability and feasibility of biomass, solar, wind, and hydro projects. However, Nigeria's financial system exhibits significant inefficiencies, with high borrowing costs and bureaucratic delays increasing capital barriers for renewable investments (Adesina et al., 2024). Concurrently, financial stability characterised by low inflation, exchange rate consistency, and resilient banking systems is essential for sustaining long-term renewable expenditures due to the high upfront costs and extended payback periods of these technologies (Johnson et al., 2025). Methodologically, studies often aggregate financial development into a single metric, obscuring the distinct roles of efficiency and stability. This oversight is critical, as financial instability (e.g., currency fluctuations) heightens investment risks, discouraging private capital flow into renewable projects despite Nigeria's abundant solar and hydropower potential (CPI, 2025).

The underdeveloped state of Nigeria's financial system manifests in acute challenges for both financial efficiency and stability. High transaction costs and interest rates which is driven by resource misallocation directly impede expenditure on renewable technologies like solar PV and small-scale hydropower (Mordor Intelligence, 2025). Simultaneously, macroeconomic instability, including record-high inflation and foreign exchange fluctuations, undermines investor confidence in large-scale, long-duration projects such as the 700 MW Zungeru hydropower plant. These constraints are exacerbated by Nigeria's substantial debt burden, which diverts public funds from renewable investments; over 80% of government revenue services debt, leaving minimal fiscal space for climate-compatible infrastructure (CPI, 2025). To address these dual barriers, coordinated policy interventions are vital: enhancing financial efficiency through digital lending platforms and risk-sharing facilities (e.g., green guarantees) while bolstering stability via macroeconomic reforms and dedicated renewable investment frameworks like the Energy Transition Plan. Without such measures, Nigeria's renewable expenditure will remain insufficient to meet its 2060 net-zero target, perpetuating reliance on fossil fuels (ETP, 2025). The main objective of the study is to evaluate the effect of financial efficiency and stability on the expenditure on renewable energy in Nigeria.

The importance of the study is that it tries to explain how financial efficiency and financial stability affects Nigeria's renewable energy expenditure in the specific biomass, hydro, wind, and solar technologies. This study is very important due to the increasing relevance of clean energy investment with regard to environmental goals and economic development in Nigeria. These are the main stakeholders who need empirical evidence of how financial systems in

Nigeria can best contribute to renewable energy; policy makers, financial institutions, investors in renewable energy, and environmental organisations.

LITERATURE REVIEW

Conceptual Review

Financial Efficiency

Financial efficiency is conceptualised as the capacity of a financial system to maximise returns on investments while minimising the cost of resources, thereby enhancing the profitability and sustainability of firms and institutions (Velykykh, 2023). Trinks et al. (2020) refers to financial efficiency as the ability of financial institutions and systems to allocate resources effectively, ensuring minimal waste and maximum productivity. It is an essential measure of a system's capacity to generate financial performance while maintaining operational stability. Filippova (2021) defines financial efficiency as the operational ability of financial organisations to manage costs and resources effectively, with an emphasis on reducing waste and optimising resource allocation for improved financial health. Financial efficiency refers to the productive management of financial resources, enabling systems to improve sustainability and adapt to technological advancements like digital finance, which can further optimise operational outcomes (Luo et al., 2022). According to Diallo (2018), Financial efficiency measures the ability of financial institutions, particularly banks, to intermediate savings and investments efficiently, often assessed through operational metrics like cost-to-income ratios and overhead costs.

Financial Stability

Financial stability refers to the ability of the financial system, including institutions, markets, and infrastructure, to withstand shocks and disruptions while continuing to perform its essential functions of intermediation and risk management, thereby supporting economic growth (Kálmán, 2023). Stanciu (2019) described financial stability as a fundamental condition for macroeconomic balance, ensuring the effective functioning of financial markets and participants, which protects the economy from systemic risks and financial crises. Financial stability signifies the ability of a commercial bank or financial entity to meet its obligations and ensure profitability while managing external and internal risks, which is critical for maintaining trust and effective operations (Fedyshyn & Chebotar, 2023). According to Yudina et al. (2023), financial stability is defined as a state where financial resources are effectively managed to support the long-term goals of enterprises and economies, ensuring equilibrium between internal dynamics and external pressures. Financial stability reflects the resilience of an organization to maintain solvency and adapt to changing economic conditions, ensuring sustainable operations and minimal dependence on external support (Vinnytska et al., 2020).

Renewable Energy

Renewable energy refers to energy derived from natural and sustainable processes, such as solar, wind, geothermal, and biomass, which are replenished naturally and continuously over time (Nixon, 2023). According to Kumar et al. (2022), Renewable energy encompasses energy sources that are naturally replenished and provide alternatives to fossil fuels, offering environmental benefits by reducing greenhouse gas emissions and supporting sustainable development. Renewable energy is energy produced from natural resources such as sunlight, wind, and geothermal heat, which are constantly replenished and offer a cleaner, sustainable alternative to conventional energy sources (Assad et al., 2021). Renewable energy is energy generated from "virtually inexhaustible" natural sources, either due to their immense availability or their ability to regenerate naturally, including solar, wind, geothermal, and tidal energy (Baydyk et al., 2019). Ray (2019) characterised renewable energy as sources that are naturally replenished and can sustain energy production without depleting resources, such as solar radiation, wind, and hydropower.

Expenditure On Renewable Energy

Expenditures on renewable energy refer to the financial resources allocated for the development, implementation, and maintenance of renewable energy systems, including costs associated with infrastructure, technology, and operational management (Ali et al., 2019). According to De La Cruz and Celis (2020), Expenditures on renewable energy encompass investments made in renewable energy technologies such as solar, wind, hydro, and biomass, which are essential for integrating renewable energy into national grids and meeting sustainability targets. Expenditures on renewable energy refer to financial outlays required for renewable energy projects, including investments in research and development, deployment of technologies, and operational costs to ensure reliable and clean energy generation (Rahamat et al., 2022). According to Ullah et al. (2021), Expenditures on renewable energy involves funding directed toward innovative hybrid systems, combining solar, wind, hydro, and biomass energy to optimise efficiency and sustainability in energy production. Expenditures on renewable energy systems include the capital costs, operational expenses, and associated investments in renewable technologies to reduce environmental impacts and support energy transitions (Sayed et al., 2021).

Conceptual Framework

This framework explores the intricate relationship between financial development and renewable energy strategies, with a focus on how well-managed finance can affect the expenditure on renewable energy in Nigeria. This is therefore presented in figure 2.1

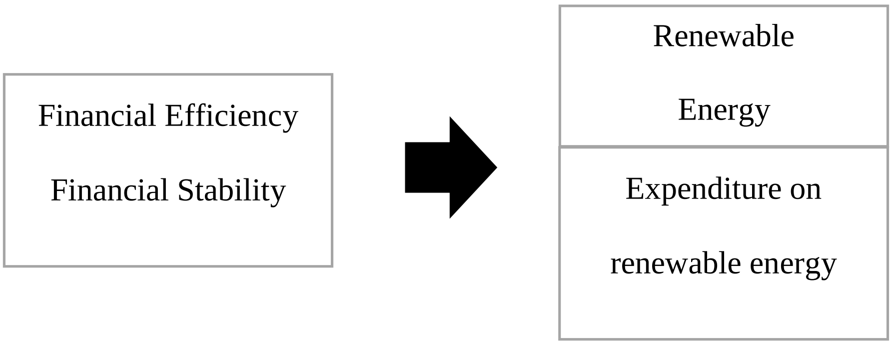

Figure 2.1 Conceptual Framework
Source: Author's Compilation, (2025).

Theoretical Review

Even though any of these theories could be significant, the study adopts the Financial Intermediary theory. In line with the theory, financial efficiency within Nigeria's financial sector ensures that capital flows smoothly toward renewable energy projects, reducing delays and costs in infrastructure investments for hydro and wind technologies. Financial stability creates a predictable financial environment, essential for the long-term viability of renewable energy projects. For instance, biomass plants, which require substantial initial investment and ongoing funding, benefit greatly from a stable financial system. The Financial Intermediation Theory highlights the role of the financial system as a bridge between savers and investors, addressing inefficiencies in resource allocation. In Nigeria, where mobilising financial resources for renewable energy projects remains a challenge, this theory provides a valuable lens. Financial efficiency ensures that these funds are allocated optimally to minimise costs and delays. Financial stability helps mitigate risks, ensuring long-term investment in critical sectors like wind and hydro energy. This framework illustrates how financial systems can drive renewable energy investments by overcoming barriers and enhancing resource allocation.

The theoretical position of this study is, it proposes that financial development, through its dimensions of financial efficiency and stability significantly impacts renewable energy expenditure in Nigeria. Grounded in the principles of the Financial Intermediation Theory, the study emphasises that a well-structured financial system can mobilise and allocate resources effectively, fostering investments in renewable energy technologies. By leveraging these financial dimensions, Nigeria can advance its renewable energy sector, supporting its transition toward sustainable energy solutions.

Empirical Review

The relationship between financial development and renewable energy expenditure has gained growing attention for its critical role in facilitating sustainable energy transitions. Recent research has explored how various dimensions of financial development and influence investments in renewable energy sectors. This review brings together insights from empirical studies, organising them by theme and region while also examining their progression over time.

Atoyebi et al. (2024) analysed the relationship between renewable energy sources, financial development, and economic growth in Nigeria. The study explored the interconnectedness of renewable energy consumption, financial development, and economic growth over a 32-year period (1980 to 2022). The variables included GDP (as a proxy for economic growth), financial development (measured by domestic credit to the private sector), foreign direct investment, access to electricity, and renewable energy consumption. The study employed an Autoregressive Distributed Lag (ARDL) model to examine the short- and long-term dynamics of these variables. In the short run, all explanatory variables positively influenced GDP. However, in the long run, foreign direct investment, renewable energy consumption, and domestic credit to the private sector maintained a positive relationship with GDP, with coefficient values of 0.6388, 0.5870, and 0.6655, respectively. This indicates that a one-unit increase in these variables would, on average, result in GDP growth of 63.88%, 58.7%, and 66.55%, respectively. In contrast, access to electricity showed a negative but statistically insignificant relationship with GDP, with a coefficient value of -0.6064. This implies that a one-unit increase in access to electricity could potentially reduce GDP by 60.64%, though the result lacks statistical significance. The study recommended that the government create a supportive policy environment, improve regulatory frameworks, and launch public awareness campaigns to encourage the alignment of financial resources through financial institutions with renewable energy initiatives. These steps are expected to promote economic growth in the long run.

Wang et al. (2024) investigated the role of mineral resource (MR) use in mediating the relationship between renewable energy (RE) and key factors such as globalisation (GI), financial development (FD), technological progress (TI), and industrial structure upgrades (IS). The analysis covered 119 countries from 1996 to 2019, using the ARDL approach to explore these dynamics. The findings revealed (i) In high-income countries, financial development negatively impacts renewable energy, while mineral extraction and technological progress contribute positively to renewable energy development; (ii) In middle-income countries, financial development supports renewable energy growth, but globalisation and mineral resource use act as constraints; (iii) The interaction between mineral resources and financial development has a negative effect on renewable energy, suggesting that mineral resource dependence may weaken the positive influence of financial development on clean energy transitions. These results underscored the global influence of mineral resource use and financial development on renewable energy adoption. Policymakers should recognize the dual role of mineral resources and financial development and incorporate these factors into strategies that support the shift to clean energy.

Saqib et al. (2024) investigated the impact of economic growth, financial development, eco-friendly ICT, renewable energy, and human capital on reducing the carbon footprint in the world's top polluting economies from 1993 to 2020. To achieve this, the research employed advanced econometric techniques, including the Cross-Sectional Autoregressive Distributed Lag (CS-ARDL) model, with robust long-run estimations validated through Augmented Mean Group (AMG) and Common Correlated Effects Mean Group (CCEMG) methods. The panel causality test revealed a bidirectional relationship between renewable energy, environmental technology, and carbon footprints. Additionally, a unidirectional relationship was observed between economic growth, financial development, and carbon footprints. The findings suggested that eco-friendly ICT can significantly reduce pollution. Moreover, financial development, renewable energy, and environmental technology are identified as critical tools for curbing carbon emissions during the study period. The study concluded with policy recommendations aimed at addressing environmental challenges, emphasising the importance of promoting eco-friendly technologies, investing in renewable energy, and leveraging financial development to achieve sustainable reductions in carbon footprints.

Prempeh (2023) examined the long-term impact of financial development on renewable energy consumption, taking into account energy prices and economic growth. The study achieved its objectives through the utilisation of several advanced econometric techniques, including ARDL bounds testing, Bayer-Hanck, Gregory and Hansen cointegration, VECM, FMOLS, CCR, and DOLS tests. The results confirmed a cointegration relationship among the variables. The findings showed that financial development plays a significant role in increasing renewable energy use in Ghana. However, energy costs and economic growth were found to have a negative impact on renewable energy consumption. The study made a valuable contribution to the renewable energy literature and provides insights for policymakers. It highlighted the importance of financial development in promoting renewable energy adoption and emphasised the need for exploring alternative energy sources to meet Ghana's growing energy demands.

Olulu-Briggs and Goya (2023) investigated the impact of financial sector development on Nigeria's economic growth, focusing on how financial access, financial depth, financial stability, and financial efficiency influence the country's gross domestic product (GDP). Using annual data from 1986 to 2021 sourced from the Central Bank of Nigeria database, the study employed descriptive statistics, unit root tests, cointegration analysis, the Parsimonious Error Correction Model (PECM), and the Granger Causality test, all conducted at a 95% confidence level. The analysis revealed that all variables were integrated at order one, with evidence of long-run cointegration. The Parsimonious Error Correction Model showed that financial access and financial depth had a positive and significant impact on GDP, while financial stability and efficiency were also positive but statistically insignificant. The Granger causality test identified a one-way causality from GDP to financial access, and a two-way causality between financial depth and GDP. The study concluded that the expansion of Nigeria's financial sector has a significant impact on the nation's economic growth. It recommended that financial institutions allocate more funds to the private sector through increased credit to stimulate further growth. Additionally, interest rates paid to depositors should be improved to attract more savings, while interest rates on business loans should be reduced to encourage investors to borrow and invest in profitable ventures, ultimately accelerating economic growth.

Elzaki (2023) analysed the impact of financial development shocks on renewable energy consumption in Saudi Arabia. This study explored the impact of Saudi Arabia's financial development indicators on renewable energy consumption (REC) and examines the causal relationship between financial development and REC. Using annual data from 1990 to 2021, the research employs various analytical techniques, including the Basic Vector Autoregressive (VAR) model, Granger causality test, forecast error variance decomposition (FEVD), and impulse response function (IRF). The findings indicated that financial development indicators have a significant positive impact on REC. However, the causality results between REC and financial development indicators were mixed. The study also revealed that variations in REC are primarily driven by its own innovative shocks and respond positively to shocks in financial development. The study recommended that authorities promote investment in renewable energy consumption by offering financial incentives and fostering national and international partnerships among investors, policymakers, and industry stakeholders. Additionally, incorporating various financial development indicators and population factors into the REC function would help better understand and shape renewable energy demand in Saudi Arabia.

Tran (2023) used the Feasible Generalised Least Squares (FGLS**)** method to examine the impact of financial development on environmental quality, measured through carbon dioxide (CO_2) emissions, across 148 countries from 1990 to 2019. FGLS offers the advantage of addressing heteroskedasticity, as well as serial and cross-sectional correlations, providing more efficient results compared to Ordinary Least Squares (OLS) estimates. The research introduced innovative regression models to explore the connections between financial liberalization, renewable energy use, and economic development in an area largely overlooked in previous studies. The findings revealed that the overall effect of financial development on CO_2 emissions depends on economic growth and renewable energy consumption. Some key insights of the study included (1) Renewable energy use reduces the emissions-increasing effects of economic growth, but its effectiveness is limited to high- and middle-income countries. In low-income countries, renewable energy consumption showed no significant impact on environmental quality; (2) Economic growth worsens the negative impact of financial development on environmental quality in high- and middle-income countries, while it improves environmental quality in low-income countries; (3) The magnitude of these effects varies by income group, highlighting the need for tailored strategies to address environmental challenges. The study's findings remained consistent across different dimensions of financial development, including financial institutions and financial markets. The study recommended that governments in high- and middle-income countries implement green credit policies and focus on promoting environmentally friendly technological innovations. These measures would help mitigate the adverse effects of economic growth on environmental quality and encourage the use of renewable energy to reduce CO_2 emissions.

Liu et al. (2023) investigated the dynamic effects of renewable energy investment, financial structure, and environmental regulations on the transition to renewable energy, focusing on evidence from the G7 countries during the period 2000–2020. The analysis employed the cross-section autoregressive distributed lag (CS-ARDL) model, which addresses slope heterogeneity and cross-sectional dependency in panel data. The results demonstrated that green energy investment, financial development, and stringent environmental regulations significantly drive the shift toward sustainable energy in the long run. Importantly, the interaction between financial development and ecological regulations has a stronger impact than either factor alone, highlighting how effective environmental policies can channel financial resources toward renewable energy initiatives. These findings are further validated by the augmented mean group estimator, reinforcing the importance of integrated approaches. The study recommended that policymakers implement cohesive strategies to strengthen environmental regulations and foster financial sector development. This includes reducing financial barriers and introducing innovative green financial products to accelerate the renewable energy transition.

Miao et al. (2022) used the Method of Moments Quantile Regression (MMQR) technique to evaluate the impact of financial globalisation and renewable energy consumption on the ecological footprint in newly industrialised countries (NICs) from 1990 to 2018. The analysis also included other key factors influencing ecological footprint, such as natural resources and economic growth. The findings revealed that financial globalisation and renewable energy consumption contribute positively to environmental quality across all quantiles (0.1–0.90). Conversely, economic growth and natural resource usage increase the ecological footprint at every quantile, indicating their negative environmental impact. Furthermore, the study validated the Environmental Kuznets Curve (EKC) hypothesis across all quantiles, suggesting that environmental degradation initially rises with economic growth but eventually declines as economies develop further. The analysis also showed that financial globalisation indirectly improves environmental quality via its effect on natural resources, particularly in middle and higher quantiles (0.4–0.90). These results are supported by alternative heterogeneous panel estimators, though the magnitude of their parameters varies. The panel causality test further revealed that financial globalisation, renewable energy, natural resources, and economic growth are predictive of the ecological footprint. These findings provided valuable insights for policymakers. They emphasised the potential of renewable energy sources and financial globalisation to achieve sustainable economic growth while addressing environmental challenges in NICs.

Literature Gap

There are notable data gaps in the timeframes and datasets used in previous studies. Many studies, such as Mukhtarov et al. (2020), rely on outdated or short timeframes, with data only extending up to 2015. While this period offers useful insights, the rapidly evolving nature of financial systems and renewable energy investments highlights the need for more recent and up-to-date datasets. Studies like Sun et al. (2023) utilised global panel data but lacked localised data specific to Nigeria or other developing countries. This absence of detailed, country-specific data limits the ability to fully understand how financial development impacts renewable energy expenditures in Nigeria. Scope and geographical gaps are apparent, as most studies concentrate on developed economies or regions with well-established financial markets. Many studies, such as Köksal et al. (2021) and Le et al. (2020), focus on OECD and high-income countries with advanced financial markets. While these studies provide valuable insights, they offer limited relevance to developing economies like Nigeria, where financial systems are less developed, and renewable energy sectors are still emerging. Research by Mukhtarov et al. (2020) and Shahbaz et al. (2021), which analysed countries like Azerbaijan and other developing nations, may not fully reflect Nigeria's context due to differences in financial systems, regulatory frameworks, and local economic conditions.

Theoretical gaps arise from the limited exploration of frameworks that are specifically relevant to the connection between financial development and renewable energy. Many studies, such as Sun et al. (2023) and Raza et al. (2020), rely on general economic or financial development theories without delving into more specific frameworks like Financial Intermediation Theory or Resource Mobilisation Theory. These theories are particularly well-suited for understanding renewable energy financing in emerging markets like Nigeria but remain underexplored. While Ecological Modernisation Theory has been applied in studies like Shahbaz et al. (2021), it is often limited to high-income countries. There is a need to examine its relevance in low-income and resource-constrained contexts, such as Nigeria, to provide a more nuanced understanding of renewable energy transitions in these settings.

Methodological limitations in previous studies restrict the ability to conduct a comprehensive analysis. Many studies, such as Le et al. (2020) and Saygın & İskenderoğlu (2022), rely on traditional econometric methods like fixed-effects or GMM models. While these methods are robust, they often fail to capture the non-linear relationships or dynamic interactions between financial development and renewable energy variables. The approach used by Raza et al. (2020), which employed panel smooth transition regression, highlights the importance of adopting more advanced methodologies to address these complexities. Several studies, including Köksal et al. (2021) and Pharm (2019), rely on limited proxies for financial development, focusing only on metrics like stock market data or banking sector performance. These studies often overlook more comprehensive dimensions, such as financial access, stability, and depth, which are crucial for a thorough analysis of financial development's impact on renewable energy.

These gaps underscore the need for a study that leverages recent, localised data while incorporating comprehensive proxies for both financial development and renewable energy expenditure. Using advanced methodological approaches would further enhance the analysis, capturing dynamic and non-linear interactions. Additionally, exploring underutilised theoretical frameworks, such as Financial Intermediation Theory, and applying them specifically to Nigeria could offer deeper, more targeted insights into the relationship between financial development and renewable energy investment.

METHODOLOGY

This study adopts ex-post facto research design because the data for the study is already stored in the data base of World Development Indicator (WDI) which cannot be altered by any researcher. The population of the study comprises of data from the Nigerian economic factor which includes financial development index relationship to financial efficiency and stability as well as the expenditure on renewable energy which are biomass, hydro, wind and solar technologies. The sample period that is adopted is from 1988 to 2023 (35 years). The source and methods of data collection are vital instruments needed in any research work to be able to carry out the analysis of this research work. The source used for this study is World Development Indicator and the method used for data collection is secondary data being the Time series from 1988 to 2023.
The model specification is as follows:
Functional Model
RE = FD---Equation 3.1
FD = FE,FS--Equation 3.2
RE = EXPRE--Equation 3.3

Econometric Model
$EXPRE = \beta_0 + \beta_1 FE_t + \beta_2 FS_t + \varepsilon$---Equation 3.4

ARDL Model
$\Delta \text{ In } EXPRE = \beta_0 + \beta_1 InEXPRE_{t-1} + \beta_2 InFEt_{-1} + \beta_3 InFSt_{-1} + \sum^{p}{}_{i} ={}_{0}\beta_4 \Delta InEXPRE_{t-I}$
$+ \sum^{p}{}_{i} ={}_{0}\beta_5 \Delta InFE_{t-i} + \sum^{p}{}_{i} ={}_{0}\beta_6 \Delta InFS_{t-i} + \mu_t$---Equation 3.5

Where; FD = Financial Development; RE = Renewable Expenditure; FE = Financial Efficiency FS = Financial Stability; EXPRE = Expenditure on renewable energy which are biomass, hydro, wind and solar technologies; ε = Error term; μ_{t} = Error term which captures the effects of other factors or variables on the dependent variable but not included in the model; β_0 = Beta coefficient for the constant; β_1, β_2, β_3, β_4 = Coefficients of the parameters of the model

$_t$ = Time. The variables remains as they have been described earlier, Δ represents the difference in respective variables and (-) is a lag sign. ARDL bound test requires a null hypotheses for no co-integration: $H_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4$; which means non-existence of long run relationship for equation 3.5

This study used Autoregressive Distributed Lag Estimation Techniques for data analysis. Autoregressive Distributed Lag (ARDL) was chosen for the estimation due to some of its obvious merits. It is a dynamic approach which is capable of estimating the lag of the dependent variables, thus, can eliminate multicollinearity issues; it has the capability of choosing different lags for each variables; it can be estimated when variables are stationary at a level or first difference.

Table 3.1: Measurement of Variable

S/NO	VARIABLE	ABBREVIATION	MEASURING UNIT
1	Financial Efficiency	FE	Domestic credit to private sector by banks (% of GDP)
2	Financial Stability	FS	Bank non-performing loans (%)
3	Expenditure on renewable energy	EXP	Renewable energy consumption (% of total final energy consumption)

Source: World Development Index (2025)

A priori Expectation
Based on the explanatory/independent variables in the model, the a priori expectations below reflect the propositions of the selected empirical review concerning the dependent variable.

Table 3.2 A priori expectation for the explanatory variable in the model

S/NO	Explanatory Variable	Relationship with dependent variable
1	Financial Efficiency (FE)	Positive
2	Financial Stability (FS)	Positive

Source: Author's Compilation, (2025).

RESULTS AND DISCUSSIONS

The dataset obtained from World Development Index in this study was firstly exported and prepared in an Excel spreadsheet and then imported into the E-views 12 software, respectively, to carry out descriptive statistics, unit root test, correlation matrix and ADRL analysis on the variables. Many factors informed the choice of software for each analysis; for instance, it is easy to obtain a correlation matrix with probability values using the E-views software. This informed the use of the software in this study's analysis.

Descriptive Statistics
Descriptive statistics of expenditure on renewable energy, financial efficiency and financial stability of Nigeria for the period of 1988–2023 is presented in Table 4.1 below.

Table 4.1: Descriptive Statistics for variables in model for the period of 1988-2023

CHARACTERISTICS	EXPRE	FE	FS
Mean	79.59105	10.16563	4.446809
Std. Dev.	19.75532	3.715523	7.507380
Skewness	-3.764145	0.767956	2.721315
Kurtosis	15.49479	3.103911	11.53084
Jarque-Bera	319.1922	3.554735	153.5962
Probability	0.000000	0.169083	0.000000
Observations	36	36	36

Source: Author's Compilation (2025).

The summary of the statistics used in this empirical study is presented in the table 4.1 above. As observed from the table, expenditure of renewable energy has the highest mean value of 79.59 while financial stability has the lowest mean value of 4.44 whereas the mean value of financial efficiency is 10.16. The standard deviation measures how concentrated the data are around the mean, hence it can be observed from the study presented in table 4.1 that expenditure on renewable energy has the highest mean value of 19.75 while the financial efficiency has the lowest mean value of 3.71 whereas the mean value of financial stability is 7.50 giving the implication that the values for the operational data are further from the mean on averages. The measure of how asymmetric distribution can be called skewness. All the variables were positively skewed except that of expenditure on renewable energy meaning that the mass of the distribution is concentrated on the right (that is, it is said to be left-skewed). The implication of this is that the skewness tends to say more on the mean value of the distribution being higher or lower than the median. Hence, positively skewed value indicates a higher mean value over the median value. On the part of Kurtosis, all the variables used present positive kurtosis value which means that the distribution is leptokurtic (too tall).

Pre-test estimation Analysis

Unit Root Test

Before analysis the effect of financial development on renewable energy in Nigeria, this study examined the stochastic properties of the series considered in the model by analysing their order of integration on the basis of a series of unit root tests. In general, the unit root tests for non-stationarity (that is, Augmented Dickey-Fuller) as shown in the table below failed to accept the null hypothesis of non-stationarity at 5% level for all the variables both at levels and first-differenced terms, as shown in Table 4.2.

Table 4.2: Showing the Unit Root Test

VARIABLES	LEVELS		FIRST DIFFERENCE		ORDER OF INTEGRATION
	t-STAT	ADF Critical Value	t- STAT	ADF Critical Value	
EXPRE	-2.9484	-5.5160**	-2.9511	-5.8942**	I(0)
FE	-2.9511	-2.0573	-2.9511	-4.1273**	I(1)
FS	-2.9484	-2.9633**	-2.9511	-6.7717**	I(0)

Source: Author's Compilation (2025).

At a 5% level of significance, the unit root tests reveal that Expenditure on Renewable Energy (EXPRE), and Financial Stability (FS) were all stationary at level (that is, integrated of order zero or I(0) while Financial Efficiency (FE) was stationary at first difference (that is, integrated of order one or I(1).

Correlation Matrix

The tool used to measure the direction and strength of a linear link among variables is the correlation coefficient (r). In the correlational study, the coefficients of the variables are shown in the correlation matrix table. This matrix tests the link among variables based on the hypothesis of the study. The range of -1 to +1 movement indicates negative or positive signs that explain the direction of the link. When the result is +1, it is said to be a positive and perfect link; however, when it is -1, it indicates negative link, and when it is 0, it shows that there is no link among the variables. A common instrument used for the interpretation of the association between variables in the study is the correlation matrix.

Correlation for variables in model

Correlation analysis of all the study's variables in model is presented in Table 4.3 below

Table 4.3: Correlation Matrix for variable in Model

	EXPRE	FE	FS
EXPRE	1	0.2560	0.1373
FE	0.2560	1	0.7224
FS	0.1373	0.7224	1

Source: Author's Compilation (2025).

From the correlation matrix table above, it shows that the expenditure revenue experiences a weak positive correlation with financial efficiency (0.2560) and financial stability (0.1373). This means that expenditure on renewable energy has a weak correlations with all variables, suggesting limited direct influence. However, in the part of association between financial efficiency and financial stability (0.7224) there is a strong positive correlation meaning that financial efficiency has strong correlations financial stability, suggesting that these factors are closely related. One of the limitations of the correlation matrix in data analysis is that it only shows the direction of the relationship between two variables: not strength of the relationship. Thus, multicollinearity was not an issue in this model. Hence, in line with similar studies conducted in other climes, this study adopted an autoregressive distributed lag analytical approach.

Estimation of ARDL Model Selection Criteria

Model selection criteria are rules used to select the best statistical model among a set of candidate models. The result of the best model selection criteria is presented in Figure 4.1 below, after which relationship between financial development proxied by financial efficiency, financial stability and renewable energy proxied by expenditure on renewable energy such as biomass, hydro, wind and solar technologies.

4.1 Model selection criteria Graph

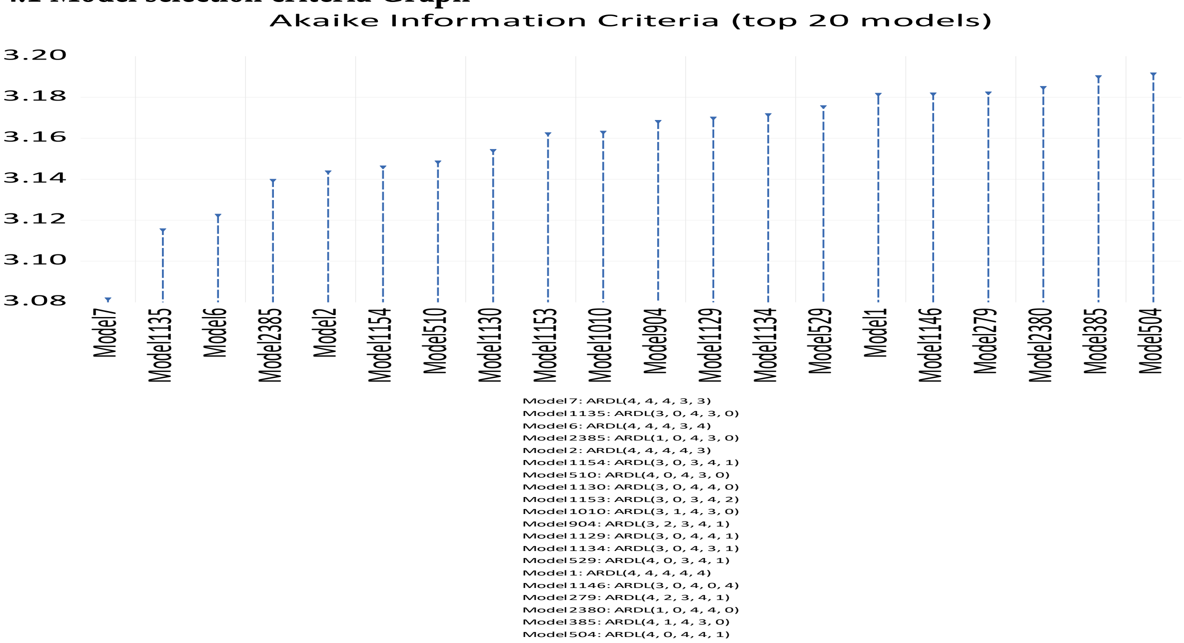

Figure 4.1: The best 4 models, among which the overall best is automatically chosen for the estimation of the ARDL

Source: Author’s Compilation (2025).

Figure 4.1 gives the values of the Akaike information criterion (AIC) for the estimated ARDL model, the purpose is to see clearly that the model that minimises the AIC is chosen given the maximum lag selected.

ARDL Bound test estimates for variables EXPRE, FE and FS

Table 4.4: Summary of the estimation of Bound Test ADRL Model

F-Bounds Test		**Null Hypothesis: No levels relationship**		
Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	2.276681	10%	2.2	3.09
k	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37

Source: Author's Compilation (2025).

The bound test cointegrating is used to check the long-run relationship that exists between all the variables in the model. If the F-statistic has lower integration, that is <I(0) bound, it means that there is no long-run relationship between the variables or has failed to reject hypotheses whereas, if the F-statistic has higher integration, that is >I(1) bound this means that long-run relationship exists between the all the variables in the model or it rejects the hypotheses but if the F-statistic is between I(0) and I(1) meaning the result is inconclusive. From the result presented on Table 4.4 above, the F-statistic (2.276681) at 5% which is 2.56 fails to reject hypotheses because it is less integration I(0) and this means that there is no relationship between all variables in the model.

ARDL long run estimates for Variables

Table 4.5: Summary of the Estimation of the Long run ARDL Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
FE	-4.5956	3.3223	-1.3832	0.1999
FS	1.6002	1.4124	1.1330	0.2865
C	118.0809	23.1645	5.0975	0.0006

Source: Author's Compilation (2025).

Table 4.5 above presents the long run coefficients of the two specifications estimated using ARDL approach and based on the results, financial stability (1.6002) has a positive relationship with the dependent variable but are insignificant due to their p-values (0.2865) being greater than 5% respectively while financial efficiency (-4.5956) has a negative relationship with the dependent variable with an insignificant p-value (0.1999) because it is also greater that than 5%. Nevertheless, the constant (118.0809) has a highly positive relationship with the dependent variable and also a highly significant p-value (0.0006) which is very much less than 5%. This means that the findings for EXPRE model specification may not be strong predictors of the dependent variable in the long-run or there might be multicollinearity issues.

Error correction Result

Table 4.6: ARDL Error Correction Regression

Variables	Coefficient	Std.Error	t-Statistic	Prob.
D(EXPRE(-2))	-0.045830	0.012344	-3.712693	0.0048
D(FE(-1))	1.454086	0.294386	4.939393	0.0008
D(FE(-2))	1.263066	0.296992	4.252862	0.0021
D(FE(-3))	0.679662	0.163982	4.144748	0.0025
D(FS)	0.338114	0.101233	3.339961	0.0087
D(FS(-1))	-0.416571	0.085005	-4.900545	0.0008
D(FS(-2))	-0.252644	0.076972	-3.282280	0.0095
CointEq(-1)*	-0.3528	0.0765	-4.6097	0.0013
Dependent Variable = EXPRE **R-squared = 0.846924** **Adjusted R-squared = 0.661047** **Durbin-Watson stat = 2.215111**				

Source: Author's Compilation (2025).

In the short-run, about seven variables are found to be significant at 5% which are D(EXPRE(-2)) (0.0048), D(FE(-1)) (0.0008), D(FE(-2)) (0.0021), D(FE(-3)) (0.0025), D(FS) (0.0087), D(FS(-1)) (0.0008), D(FS(-2)) (0.0095) respectively. The coefficient -0.3528 represents the speed of adjustment back to the long-run equilibrium after a short-run deviation. The negative sign is expected and confirms that the model is stable and adjusts back toward its equilibrium. The absolute value 0.3528 suggests that about 35.28% of the disequilibrium from the previous period is corrected in the current period. The p-Value 0.0013 is less than 5% reflecting high significance at 5% level and the t-statistic -4.6097 which is the high absolute value, further confirms strong statistical significance. The adjustment speed of 35.28% per period means that the system corrects itself relatively quickly but not instantaneously. If there is a shock causing deviation from long-run equilibrium, it will take approximately three periods which is 1 divided by 0.3528 approximately equal to 2.8 for the system to return to its full equilibrium. The R-squared shows that about 85% of changes in the dependent variable is being accounted for by the independent variables. The Durbin-Watson stat is ideally supposed to be between the range of 1 to 4 and from the result above it shows 2.2151 which rules out the possibility of serial correlation.

Post-test estimation Analysis

Residual Diagnostics Test Result – Histogram – Normality Test

One of the most common assumptions for statistical tests is that the data used are normally distributed. Normality tests are used to determine if a data set is well-modelled by a normal distribution and to compute how likely it is for a random variable underlying the data set to be normally distributed. Furthermore, in order to test for the diagnostic test in this study, the result is obtained from the figure 4.2.

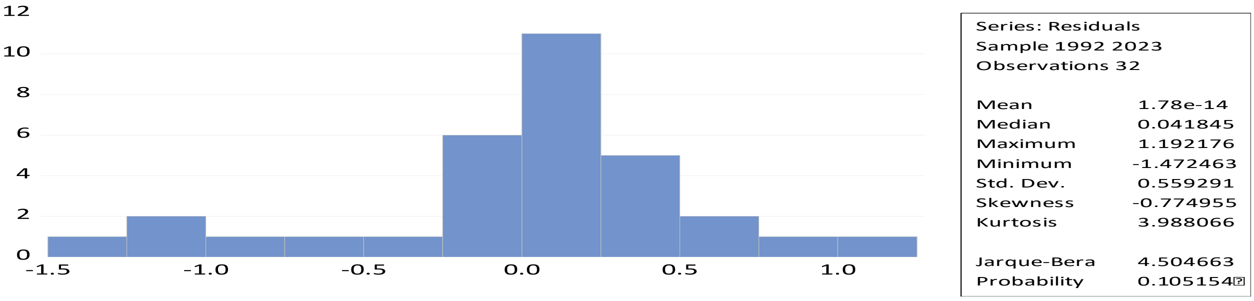

Figure 4.2: Normality test Graph
Source: Author’s Compilation (2025).

From the Normality test graph, it can be seen that the p-value is more than 0.05, meaning the null hypothesis indicates that the data follows a normal distribution will be rejected and therefore accept the alternative hypothesis which says that the data is normally distributed.

Serial correlation LM test Result

Table 4.7: Breusch-Godfrey Serial Correlation LM Test

Null hypothesis: No serial correlation at up to 2 lags			
F-statistic	4.367054	Prob. F(2,7)	0.0587
Obs*R-squared	17.76341	Prob. Chi-Square(2)	0.0001

Source: Author’s Compilation (2025).

Looking at table 4.7 above, the F-statistic p-value (0.0587) is greater than 5%, meaning we fail to reject the null hypothesis, implying no serial correlation. However, the Chi-Square p-value (0.0001) is less than 5%, meaning we reject the null hypothesis, suggesting presence of serial correlation. The F-test is more reliable in small samples, while the Chi-Square test can sometimes overstate significance. Given that the p-value of the F-test is close to 5%, there may be weak serial correlation, but it is not strong enough to be definitively concluded. If serial correlation is present, it can lead to inefficient estimates and biased standard errors, making hypothesis testing unreliable. If the F-test is preferred due to small sample size, the model may not suffer from serious autocorrelation.

Heteroskedasticity test Result
Table 4.8: Heteroskedasticity Test: Breusch-Pagan-Godfrey

Null hypothesis: Homoskedasticity			
F-statistic	0.474145	Prob. F(22,9)	0.9259
Obs*R-squared	17.17847	Prob. Chi-Square(22)	0.7534
Scaled explained SS	2.030157	Prob. Chi-Square(22)	1.0000

Source: Author’s Compilation (2025).

The Breusch-Pagan-Godfrey test checks whether the variance of the residuals errors in a regression model is constant **(**homoskedasticity) or if it varies across observations (heteroskedasticity). From the table above, we can see that the model has homoskedasticity (constant variance of errors). If we reject the null hypothesis (H_0)**,** the model suffers from heteroskedasticity, which can lead to inefficient estimates. Since all p-values are greater than 5%, we fail to reject the null hypothesis (H_0). This means that there is no evidence of heteroskedasticity in the model and the variance of the residuals is constant, so the standard errors and hypothesis tests in the model are reliable.

Stability diagnostics test Result
Table 4.9: Ramsey Reset Test

	Value	df	Probability
t-statistic	1.299682	8	0.2299
F-statistic	1.689173	(1, 8)	0.2299
Likelihood ratio	6.130160	1	0.0133

Source: Author's Compilation (2025).

The Ramsey RESET (Regression Specification Error Test) is used to check whether a regression model suffers from functional form misspecification. It tests whether the model excludes important variables or has an incorrect specification. The t-statistic and F-statistic both have p-values greater than 5%, indicating that there is no strong evidence of model misspecification. However, the Likelihood Ratio (LR) test has a p-value of 0.0133 is less than 5%, which suggests some degree of misspecification. While the F-statistic and t-statistic suggest that the model is correctly specified, the LR test indicates a potential issue in the model.

DISCUSSIONS of Findings

This section of the study presents the discussion of major findings which are related to the hypotheses testing of the study. The discussions are presented based on the research hypotheses for this study.

H_{01}: Financial efficiency has no significant effect on the expenditure on renewable energy in Nigeria.

The second hypotheses of this research is to analyse the effect of financial efficiency on the expenditure on renewable energy in Nigeria. The finding of this study reveals that financial efficiency (-4.5956) has a negative relationship with the dependent variable with an insignificant p-value (0.1999) because it is also greater that than 5%. based on the long run co-integration of the independent variables and dependent variable. The finding of this study agrees with the finding of (**Köksal et al. (2021);** Pham (2019), Mukhtarov et al. (2020); Sun et al. (2023); Saygin and Iskenderoglu (2021); Le et al. (2020), and Anton and Nucu (2020).

H_{02}: Financial stability has no significant effect on the expenditure on renewable energy projects in Nigeria.
The third hypotheses of this research is to investigate the effect of financial stability on the expenditure on renewable energy in Nigeria. The finding of this study reveals that financial stability (1.6002) has a positive relationship with the dependent variable but are insignificant due to its p-value (0.2865) being greater than 5% based on the long run co-integration of the independent variables and dependent variable. The finding of this study agrees with the finding of (**Shahbaz et al. (2021);** Raza et al. (2020); Eren et al. (2019); Kassi (2020); and Tran (2023).

CONCLUSION AND RECOMMENDATIONS

The findings of this study reveals that there is a short run relationship between the dependent and the independent variables. The coefficient -0.3528 of Error Correction Mechanism in the model represents the speed of adjustment back to the long-run equilibrium after a short-run deviation. The negative sign is expected and confirms that the model is stable and adjusts back toward its equilibrium. The absolute value 0.3528 suggests that about 35.28% of the disequilibrium from the previous period is corrected in the current period. The p-Value 0.0013 is less than 5% reflecting high significance at 5% level and the t-statistic -4.6097 which is the high absolute value, further confirms strong statistical significance. The adjustment speed of 35.28% per period means that the system corrects itself relatively quickly but not instantaneously. If there is a shock causing deviation from long-run equilibrium, it will take approximately three periods which is 1 divided by 0.3528 approximately equal to 2.8 for the system to return to its full equilibrium.

Based on the bound test co-integration of the independent variables, the study concluded that the long run there is no relationship between the variables in the model which are financial efficiency, stability and the expenditure on renewable energy. However, the long run test result shows that the coefficients of the specifications estimated using ARDL approach and based on the results, financial stability (1.6002) has a positive relationship with the dependent variable but is insignificant due to its p-value (0.2865) being greater than 5% respectively while financial efficiency (-4.5956) has a negative relationship with the dependent variable with an insignificant p-value (0.1999) because it is also greater that than 5%. Nevertheless, the constant (118.0809) has a highly positive relationship with the dependent variable and also a highly significant p-value (0.0006) which is very much less than 5%. This means that the findings for EXPRE model specification may not be strong predictors of the dependent variable in the long-run or there might be multicollinearity issues.

In the light of the findings and based on the conclusions, this study evaluates the effect of financial development on renewable energy in Nigeria. Therefore, this study recommends that:

i. Improve Financial Efficiency to Facilitate Renewable Energy Investments. The negative relationship between financial efficiency and renewable energy expenditure, although insignificant, highlights an inefficiency in resource allocation towards renewable energy projects. Financial institutions should streamline their processes, reduce bureaucratic bottlenecks, and lower transaction costs related to renewable energy financing. Introducing digital financial services tailored for renewable energy investors, automating loan approval processes, and providing financial advisory services for renewable energy entrepreneurs can improve the efficiency of capital allocation, making renewable energy investments more attractive and accessible.

ii. Enhance Financial Stability with a Focus on Renewable Energy Investment. The positive yet insignificant relationship between financial stability and renewable energy expenditure implies that although stability exists, it may not yet fully translate into confidence among investors. Regulatory authorities should, therefore, enhance financial sector resilience with a specific focus on promoting renewable energy investments. This can be achieved through the introduction of renewable energy investment funds, the establishment of risk mitigation facilities, and the strengthening of institutional frameworks that ensure long-term financial sector stability, particularly encouraging long-term investments in clean energy.

Contributions to Knowledge

This study offers several important contributions to the existing research on the relationship between financial development and renewable energy spending in Nigeria. One of its key strengths is the use of the Autoregressive Distributed Lag (ARDL) model to examine the long-term impact of two specific dimensions of financial development which are financial efficiency and stability on investments in renewable technologies like biomass, hydro, wind, and solar. By breaking financial development down into these distinct areas, the study provides a more detailed and insightful analysis than many previous works, which often rely on broad or aggregated financial indicators. This disaggregated approach gives a clearer picture of how each aspect of the financial system influences clean energy investment in the Nigerian context.

Secondly, the study reveals that although financial stability show positive relationship with renewable energy spending, these connections are not statistically significant. Interestingly, financial efficiency has a negative but also insignificant impact. These findings challenge the common belief that all aspects of financial development automatically boost renewable energy investments. Instead, they suggest that structural and institutional barriers such as limited regulatory hurdles, or lack of investor confidence may be weakening the influence of financial development in Nigeria's renewable energy space.

Thirdly, the study makes a valuable methodological contribution by using the Autoregressive Distributed Lag (ARDL) model. This approach is especially well-suited for small sample sizes and can handle variables with different levels of integration, making it a reliable tool for producing robust long-run estimates in this type of economic analysis.

Finally, the study puts forward context-specific policy recommendations that aim to strengthen the role of financial development in supporting renewable energy growth. These insights serve as a practical guide for policymakers, development planners, and financial institutions, helping them design inclusive, targeted financing strategies tailored to the realities of emerging economies like Nigeria. By focusing on the unique challenges and opportunities within the local financial and energy landscape, the study supports more effective and sustainable pathways toward clean energy development.

Suggested Areas for Further Studies

For future studies, efforts should be made to increase scope of work and time frame. Other variables that can be used to proxy financial development such as green bonds, climate funds and sustainable finance are innovations in financial products while renewable energy proxies such as energy access rate, renewable energy jobs, grid integration and energy storage capacity should be adopted. The need to extend this type of study to cover more African countries is also suggested. Further methodologies such as general method of moments (GMM) technique can be incorporated because it is well-suited for addressing endogeneity issues in panel data and can be used to explore the impact of financial development on renewable energy in studies with larger sample sizes and more extensive time series data. Also, Qualitative case studies or mixed-methods research can complement quantitative findings by providing contextual insights into how financial policies, institutional dynamics, and stakeholder behavior influence renewable energy financing on the ground.

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