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Effect of Financial Efficiency and Depth On Renewable Energy Expenditure in Nigeria

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Abstract*: This study examines the effect of financial efficiency and Depth 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 depth (2.0837) has a positive relationship with the dependent variable but are insignificant due to its p-value (0.4747) 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 deepen Financial Markets to Support Green Financing Options. Deepening the financial system by expanding green bond markets, promoting renewable energy-focused venture capital funds, and encouraging innovative financing mechanisms such as crowdfunding for clean energy projects can enhance the financial depth needed to drive significant investments.*

Keywords: financial depth, 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 efficiency reflected in streamlined loan processing, competitive interest rates, and low transaction costs critically influences the feasibility of investments in renewable energy technologies such as biomass, hydro, wind, solar by reducing capital barriers and accelerating fund disbursement. In Nigeria, inefficiencies in the financial system, such as bureaucratic delays and high borrowing costs, directly impede expenditure on renewables like solar PV systems and small-scale hydropower plants (Ma et al., 2022). Empirical studies indicate that improved financial efficiency could lower transaction costs by 15–25%, making technologies such as solar panels more economically viable for households and businesses (Calcaterra et al., 2024). While direct Nigerian studies are limited, evidence from developing economies confirms that efficient financial intermediation 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) demonstrated that financial system efficiency stabilises necessary financial support for renewable investments, a finding applicable to Nigeria’s context where interest rates and loan processing speed determine project viability (Ma et al., 2022).

Financial depth measured by the diversity of financial products and services expands funding avenues for renewable energy projects, directly driving expenditure on biomass, wind, solar, and hydro technologies. Deeper financial markets enable innovative instruments like green bonds, energy-specific loan schemes, and venture capital, which address the high upfront costs of renewables. In Nigeria, where the financing landscape is "extremely shallow," limited product diversity constrains investment in large-scale solar farms and hydropower plants (Adeshina et al., 2024). For example, while Nigeria’s hydroelectric potential exceeds 36,000 GWh annually, only 24% of large-scale and 4% of small-scale potential has been exploited due to insufficient long-term financing tools. Recent research emphasises that green bonds could mobilize $9.2 billion annually for distributed solar and mini-grid projects in rural areas, but regulatory gaps hinder their scalability (WEF, 2023). Cross-country studies show that financial depth in emerging economies correlates with a 10–15% increase in renewable energy expenditure by broadening investor participation and mitigating risks through diversified portfolios (Ngcobo & De Wet, 2024).

The interplay between financial efficiency and depth creates a self-reinforcing cycle that accelerates renewable energy expenditure. Efficient markets lower transaction costs for green bonds and other depth-driven instruments, while product diversity attracts institutional investors, further enhancing market liquidity (Ma et al., 2022). In Nigeria, however, macroeconomic instability (e.g., 28.9% inflation in 2024) and currency fluctuations erode both dimensions, raising financing costs for solar and wind projects by 4–6% compared to global averages (WEF, 2023). Policy interventions such as digital lending platforms, risk-sharing facilities, and regulatory reforms for green finance could reduce renewable energy financing costs by 1–4 percentage points by 2030, making technologies like biomass gasification economically viable. International risk-pooling mechanisms, as proposed in Nigeria’s Energy Transition Plan, are essential to align financial depth with efficient capital allocation, potentially increasing renewable expenditure by $1.9 trillion by 2060 (Adeshina et al, 2024).

In Nigeria, systemic inefficiencies such as bureaucratic delays and high borrowing costs directly impede expenditure on renewables. Studies indicate that financial inefficiencies elevate the cost of capital for solar PV and small-scale hydropower projects by 15–25%, reducing their economic viability for households and businesses (Olaniyan et al., 2024). Financial efficiency reflected in streamlined loan processing, competitive interest rates, and low transaction costs critically influences the feasibility of investments in renewable energy technologies such as biomass, hydro, wind, solar. While Nigeria's fintech sector shows growth in payment systems, this innovation has not translated into efficient renewable energy financing. Research confirms that inefficient resource allocation discourages private investment in high-capital renewables like wind farms and utility-scale solar installations (CPI, 2025). The absence of specialised credit assessment frameworks for renewable projects further exacerbates these inefficiencies, delaying loan disbursement for biomass and solar initiatives (Olaniyan et al., 2024).

Financial depth measured by the diversity of financial products and services remains critically underdeveloped for renewable energy financing in Nigeria. Despite abundant solar and hydropower potential, the market lacks specialised instruments like green bonds, energy-specific loan schemes, and venture capital tailored to renewables' long payback periods (Eweka et al., 2022). Consequently, expenditure on biomass gasification and grid-connected solar projects faces a $27.2 billion annual climate finance gap. The financing landscape is characterized by heavy reliance on debt (constituting 89% of climate finance), which is unsustainable given Nigeria's fiscal constraints over 80% of government revenue services existing debt (CPI, 2025). This shallow depth particularly affects hydropower development, where only 17% of the 11,250 MW potential is utilised due to insufficient long-term financing tools. Without deepening financial markets through diversified instruments, Nigeria's renewable expenditure cannot meet its 2060 target of 60% clean energy adoption (Adeshina et al., 2024). The main objective of the study is to evaluate the effect of financial efficiency and financial depth on the expenditure on renewable energy in Nigeria. 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 Depth
Financial depth encompasses indicators such as private sector credit and broad money as proportions of GDP, showcasing the ability of the financial sector to facilitate credit access and liquidity in the economy (Polemis et al., 2020). According to Mustapha et al. (2023) financial depth indicates the level of financial development in an economy, often measured by the assets of financial institutions and the availability of diverse financial products relative to GDP. Financial depth is defined as the magnitude and utilisation of financial services and instruments within an economy, which contributes to both the mobilisation of savings and the enhancement of economic growth (Salas, 2018). According to Shapoval (2021), financial depth refers to the saturation of an economy with financial resources, indicating the financial system's capacity to mobilise and allocate resources efficiently to support sustainable economic development. Financial depth measures the size of the banking system and financial markets relative to the economy, reflecting the extent to which financial services and instruments are integrated into economic activities (Bui, 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

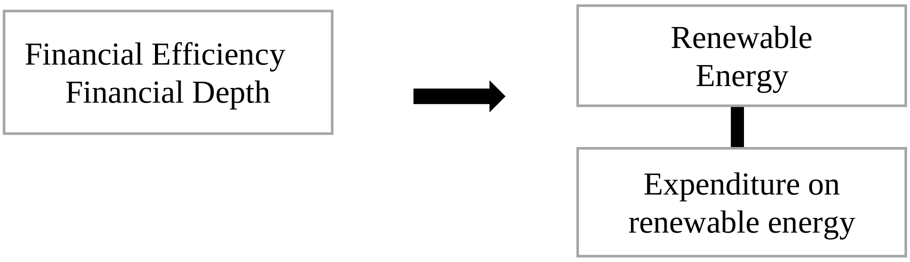

Figure 2.1 Conceptual Framework
Source: Author's Compilation, (2025).

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 depth diversifies funding options, enabling innovative instruments like green bonds to finance solar and wind energy projects, fostering growth in these sectors. 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 depth creates a robust financial ecosystem by introducing diverse products, such as green loans, to stimulate private-sector participation in renewable energy development. 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 depth, 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.

Koç et al. (2022) investigated the relationship between renewable energy consumption, financial development, and economic growth, focusing on evidence from 12 IEA (International Energy Agency) countries. The study used the ARDL approach to examine both short-term and long-term cointegration among the variables, covering the period from 1996 to 2017.The findings from the panel cointegration tests revealed that the long-term variables were statistically significant, indicating a strong relationship between the variables over time. In the short term, economic growth was found to positively influence renewable energy consumption. Additionally, the panel causality tests showed a short-term relationship between financial development and renewable energy consumption, as well as between economic growth and renewable energy consumption. Notably, the use of subcomponents of financial development indicators provided valuable insights, effectively capturing the various dimensions of financial systems that influence renewable energy consumption.

Umeji et al. (2023) assessed renewable energy consumption and economic growth in Nigeria. The study utilised secondary data from the World Bank database covering the period from 1990 to 2020. It employed the Toda-Yamamoto augmented Granger causality test to determine the nature of the relationship between renewable energy consumption and economic growth. Additionally, the Autoregressive Distributed Lag (ARDL) bounds test was used to assess the impact of renewable energy consumption on economic growth. The findings revealed a bi-directional relationship between renewable energy consumption and economic growth, indicating that both variables influence each other. The regression results further demonstrated a significant positive impact of renewable energy consumption on economic growth, highlighting its potential to drive economic progress in Nigeria. The study concluded that renewable energy consumption plays a crucial role in enhancing Nigeria's economic growth. It recommended that the government should actively promote investments in the renewable energy sector by creating a supportive business environment and raising public awareness about the importance of renewable energy for the country's development.

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.

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.

Fu et al. (2022) in their work, does financial development and renewable energy consumption impact on environmental quality: A new look at China's economy examined the impact of China's financial development and renewable energy consumption on environmental quality between 2009 and 2019. Using the ARDL (Autoregressive Distributed Lag) method, the research also incorporates the NARDL (Non-Linear Autoregressive Distributed Lag) model to analyse asymmetries in the data caused by positive or negative changes in financial development. The findings from the NARDL bound test indicated that the variables are long-term co-integrated, allowing for the application of the ARDL methodology. Results from the ARDL bound test revealed a long-term positive relationship between financial development, trade openness, renewable energy consumption, economic growth, and CO_2 emissions. Additionally, the error correction model (ECM) showed that, at least in the short term, CO_2 emissions are connected to financial development, economic growth, and energy consumption. The dynamic multiplier graph suggested that the positive aspects of financial development have a more prolonged influence on carbon emissions compared to the effects of unfavorable financial development shocks. However, the findings also show no significant asymmetry between CO_2 emissions and financial development, indicating that both positive and negative changes in financial development have an equally significant impact on environmental quality.
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.
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.

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.

Xu et al. (2022) in their work, financial development, renewable energy and CO_2 emission in G7 countries: New evidence from non-linear and asymmetric analysis covered the period from 1986 to 2019, utilising the non-linear Autoregressive Distributed Lag (NARDL) model and two-stage least squares (2SLS) techniques to analyse the data. Based on the findings, the study proposed an SDG-oriented policy framework aimed at addressing the goals of SDG 13 (Climate Action) and SDG 7 (Affordable and Clean Energy). Although the policy framework is specifically designed for the G7 countries, its principles are generalizable and can be applied to other nations. A key contribution of this study is its focus on the environmental policy challenges faced by the G7, accompanied by actionable recommendations aligned with the Sustainable Development Goals (SDGs).

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.

Financial depth, which represents the range and diversity of financial products, has been increasingly recognised as a key factor in renewable energy investments. Ji and Zhang (2019) conducted a time-series analysis in China and found that financial depth plays a significant role in driving renewable energy growth, particularly through capital markets. Their study revealed that financial depth accounted for over 42% of variations in renewable energy expenditure. However, they also cautioned that financial depth alone is insufficient to overcome all investment barriers, highlighting the need for complementary measures.

Similarly, Kassi (2020) analysed data from 123 countries and found that financial depth, measured by stock market capitalisation, has a positive impact on renewable energy expenditure. Using the two-stage least squares (2SLS) method, the study showed that financial depth promotes innovation and resource mobilisation for renewable energy projects. However, it also highlighted that low-income countries struggle to fully leverage financial depth due to underdeveloped capital markets, limiting their ability to fund renewable energy initiatives effectively.

In Nigeria, Lorember et al. (2020) explored the role of financial depth in promoting renewable energy development. Using the ARDL model, they found that financial depth boosts renewable energy expenditure by facilitating access to innovative financing tools such as green bonds. However, the study also highlighted that financial depth alone is not enough; complementary policies are needed to address infrastructural and regulatory challenges that hinder investment in the sector.

Empirical evidence highlights the vital role of financial development in driving renewable energy investments. While financial access, depth, and stability consistently boost renewable energy expenditure, the impact of financial efficiency tends to vary depending on the region and context. In Nigeria, strengthening financial institutions and introducing innovative financial products, such as green bonds, could significantly accelerate renewable energy adoption. However, addressing gaps in governance and economic structures is essential for implementing policies that effectively align economic growth with environmental sustainability.

Literature Gap

From the empirical review above, several gaps in the literature have been identified. These include data gaps, variable-related gaps, scope or geographical gaps, theoretical gaps, and methodological gaps. Understanding these gaps is essential for recognising the limitations of previous studies and establishing the need for this research on the impact of financial development on renewable energy in Nigeria.

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.

Some studies fail to include essential proxies for financial development and renewable energy. Several studies, such as Anton and Nucu (2020), focused on broad aspects of financial development, such as banking and capital markets, but overlooked specific proxies like financial efficiency or stability. These dimensions are essential for understanding the more nuanced ways financial development influences renewable energy investments. Pharm (2019) examined the impact of financial development on innovation in renewable energy but did not consider renewable energy expenditure as an outcome variable. Similarly, Köksal et al. (2021) analysed renewable energy demand rather than expenditure, limiting the relevance of their findings for financial resource allocation decisions.

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 depth 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

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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,FDB--Equation 3.2
RE = EXPRE---Equation 3.3

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

ARDL Model
$\Delta\ In\ EXPRE = \beta_0 + \beta_1 InEXPRE_{t-1} + \beta_2 InFEt_{-1} + \beta_3 InFDB_{t-1} + \sum^{p}{}_{i} =_0 \beta_4 \Delta InEXPRE_{t-i}$
$+ \sum^{p}{}_{i} =_0 \beta_5 \Delta InFE_{t-i} + \sum^{p}{}_{i} =_0 \beta_6 \Delta InFDB_{t-I} + \mu_t$---Equation 3.5
Where; FD = Financial Development; RE = Renewable Expenditure; FE = Financial Efficiency FDB = Financial Depth; EXPRE = Expenditure on renewable energy which are biomass, hydro, wind and solar technologies; ε = Error term; $\mu_{t\,=}$ 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 Depth	FDB	Stocks traded, total value (% of GDP)
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.

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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 Depth (FDB)	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 depth has the lowest mean value of 0.79 whereas the mean value of financial access, financial efficiency and financial stability are 2.79, 10.16 and 4.44 respectively. 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 depth has the lowest mean value of 1.27 whereas the mean value of financial access is 2.61, financial efficiency is 3.71 and that 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 and financial access 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)
FDB	-2.9484	-2.6094	-2.9540	-5.9082**	I(1)

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 Access (FA), and Financial Efficiency (FE) were 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	FDB
EXPRE	1	0.2560	0.1682
FE	0.2560	1	0.5232
FDB	0.1682	0.5232	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 access (0.1966), financial efficiency (0.2560), financial stability (0.1373) and financial depth (0.1682) respectively. 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 access and all other four variables, it shows that financial access has a strong positive correlation with financial efficiency (0.7834) but moderate to strong correlation with financial stability (0.6175) and moderate correlation with financial depth (0.5350). This means that financial access and financial efficiency are highly correlated, indicating a strong interdependence.

Nevertheless, financial efficiency has a strong positive correlation with financial stability (0.7224) whereas with financial depth (0.5232) , it is moderate correlation meaning that financial efficiency has strong correlations with financial access and financial stability, suggesting that these factors are closely related. Looking at financial stability, it has a weak to moderate correlation with financial depth (0.3139) meaning that financial stability and financial depth have a relatively weak connection compared to financial stability's ties with financial access and financial efficiency. 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 depth and renewable energy proxied by expenditure on renewable energy such as biomass, hydro, wind and solar technologies.

4.1 Model selection criteria Graph

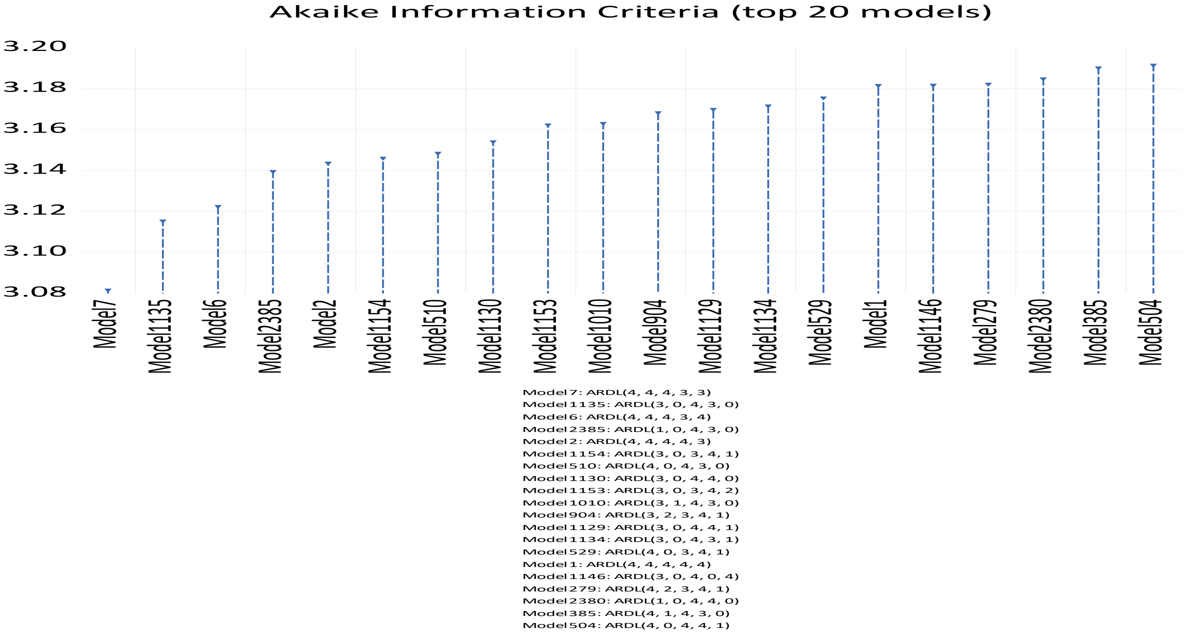

Figure 4.1: The best 4 models, among which the overall best is automatically chosen for the estimation of the ARDL
Source: Author's Compilation (2025).

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, FA, FE, FS and FDB
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.
FA	0.9581	1.6792	0.5705	0.5823
FE	-4.5956	3.3223	-1.3832	0.1999
FS	1.6002	1.4124	1.1330	0.2865
FDB	2.0837	2.7931	0.7460	0.4747
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 four specifications estimated using ARDL approach and based on the results, financial access (0.9581), financial stability (1.6002) and financial depth (2.0837) has a positive relationship with the dependent variable but are insignificant due to their p-values (0.5823, 0.2865 and 0.4747) 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.
CointEq(-1)*	-0.3528	0.0765	-4.6097	0.0013

Source: Author's Compilation (2025).

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.

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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.

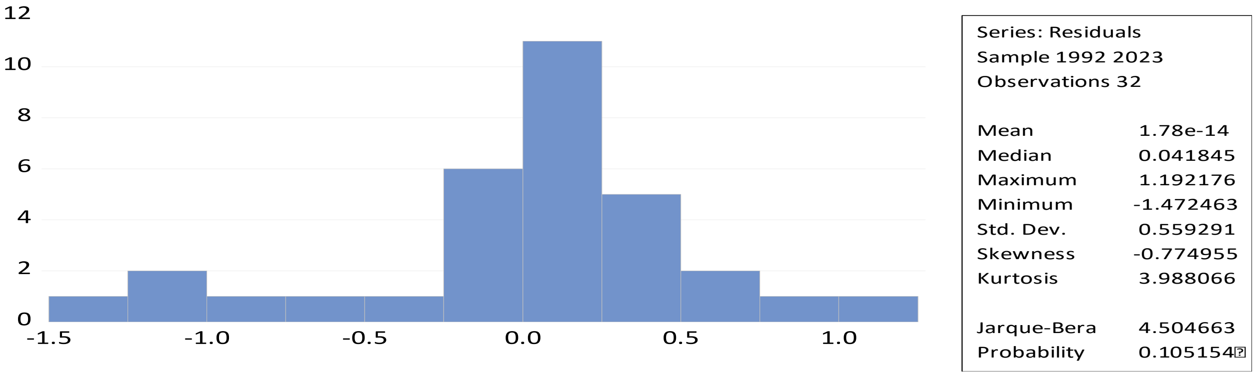

Figure 4.2: Normality test Graph
Source: Author's Compilation (2025).

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 depth has no significant effect on the expenditure on renewable energy technologies in Nigeria.

The fourth hypothesis of this research is to examine the effect of financial depth on the expenditure on renewable energy in Nigeria. The finding of this study reveals that financial depth (2.0837) has a positive relationship with the dependent variable but are insignificant due to their p-values (0.4747) 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 access, efficiency, stability, depth and the expenditure on renewable energy. However, the long run test result shows that the coefficients of the four specifications estimated using ARDL approach and based on the results, financial depth (2.0837) has a positive relationship with the dependent variable but are insignificant due to its p-value (0.4747) 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. Deepen Financial Markets to Support Green Financing Options. The positive association between financial depth and renewable energy expenditure suggests potential, but the lack of significance points to underdeveloped or poorly targeted financial markets. Deepening the financial system by expanding green bond markets, promoting renewable energy-focused venture capital funds, and encouraging innovative financing mechanisms such as crowdfunding for clean energy projects can enhance the financial depth needed to drive significant investments. Moreover, financial literacy campaigns specifically oriented toward renewable energy financing can attract a broader pool of investors.

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 four specific dimensions of financial development which are financial efficiency and depth 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 depth 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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