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Financial Development and Renewable Energy Consumption in Nigeria

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Abstract

Financial sector performance is increasingly linked with the transition to renewable energy in the sustainability discourse of developing economies. This paper examines the nexus and implication (s) of financial development on renewable energy consumption in Nigeria (the largest and most p opulous economy in Africa). Specifically, this study utilised the broad-based financial developm ent index data to effectively address the multidimensional nature of financial development and th e portion of renewable energy in total energy consumption as key variables, while other relevant pieces of information (growth rate of per capita GDP, foreign direct investment and consumer pri ce index) were incorporated. The study employed a blend of the ADF test and Zivot-Andrew test to ascertain stationarity properties as well as the likelihood of structural breaks, while the ARDL was utilized to determine the long-run relationship(s) using data from 1981 to 2019. The study estimation finds, among other things, that financial development is critical for renewable energy consumption in Nigeria and recommends policies to promote better outcomes for the financial and energy sectors, respectively.

Keywords: Financial development; Renewable energy consumption; Nigeria

1. Introduction

Inadequate and unclean energy consumption has been a major problem in Nigeria, which for decades has continued to grapple with significant energy issues (Bamisile et al 2020; Elum and Mjimba, 2020; Owebor et al. 2021). Notwithstanding the huge and diverse energy deposits in the country and several investments made over time in the sector, the efforts have yielded little progress in the country's power sector (Dimnwobi et al., 2017; Nwokoye et al., 2017). Worryingly, the electric power consumption per capita of Nigeria (Africa's most populated and economic powerhouse) is 144 kWh. This ranks poorly relative to other sub-Saharan African countries like Cote d'Ivoire (274 kWh), Ghana (351kWh) Zambia (717kWh), and Zimbabwe (609kWh) (World Bank, 2020). Similarly, the International Energy Agency (2020) reported that roughly 77 million Nigerians are without access to electricity. Nigeria seldom satisfies one-third of its power demands, with natural gas and hydropower sources dominating the country's electricity mix with environmental consequences (Adelaja, 2020; Elum and Mjimba, 2020; Omoju et al., 2020). One measure that could address Nigeria's energy poverty, and energy-related carbon emission and enhance sustainable development prospects is improving the renewable energy quota in the country's overall energy mix (Elum and Mjimba, 2020; Omoju et al. 2020).

Nigeria is blessed with several renewable energy sources ranging from biomass, solar, wind, and hydro which have largely remained untapped (Adelaja, 2020; Omoju et al., 2020). According to Adelaja (2020) and Elum and Mjimba (2020), one of the major challenges militating against renewable energy development in Nigeria is the cost of operation in the nascent renewable energy industry. In this situation, it is advantageous to have a solid financial system to better manage energy market risks, engender efficient capital allocation where public investments are insufficient, and advance the reallocation of resources away from less efficient and dirty conventional energy sources (Anton and Nucu, 2019; Eren et al. 2019; Shobande and Asongu, 2021).

Nigeria's financial sector has witnessed significant growth to emerge as the prime financial market in Africa (Nwokoye et al., 2020; Nwokoye et al., 2022). The Nigerian banking industry is fundamental to the economy's developmental process and plays an important role in fostering growth (Nwokoye et al., 2019). According to the National Development Plan 2021-2025 (NDP), the financial sector contributed ₦44.2 trillion to Nigeria's GDP between 2017 and 2020. Additionally, the report reveals that the overall size of the financial services sector was ₦78.10 trillion in 2017 but grew to ₦122.30 trillion by 2020. The banking industry accounts for the largest component of the Nigerian financial sector, contributing the most at ₦42.7 trillion in 2019, an upward trajectory from ₦37.8 trillion in 2018 and ₦34.6 trillion in 2017 respectively. Furthermore, by regional benchmarks, Nigeria has a reasonably well-structured banking industry, with a regionally good degree of banking adoption at 44.2 percent (above the West African average of 17.8 percent) and extensive utilisation of contemporary financial instruments in the domestic economy. Nigeria is equally connected to global financial markets, and since the 2016-17 oil shock, the country has experienced a surge in foreign capital inflows, which soared in the first quarter of 2018 to US$6.3 billion, representing a 594 percent year-on-year growth from $12.3 billion and $5.1 billion in 2017 and 2016 respectively. However, financial sector concerns such as regulatory insufficiency and supervisory weakness, financial inclusion issues, insufficient intermediation, and expensive lending rates, among others, continue to hinder accessibility to funds for smaller businesses, especially in the non-oil sector of the economy (Ude and Ekesiobi 2015; Okonji et al 2018; Ude and Ekesiobi 2018).

Therefore, this study investigates the effect of financial development on renewable energy use in Nigeria. The major contributions of this study are multi-fold. First, most works on the implications of financial development on renewable energy use have been explored in a group of countries (Hassine and Harrathi, 2017; Anton and Nucu, 2019; Raza et al 2020; Qamruzzaman and Jianguo, 2020). Although these existing studies contribute significantly to the extant literature, this study makes a modest attempt to address the Nigerian peculiar environment endowed with a clean energy mix but still an energy-poor country. Secondly, related studies have utilized one or two variables to measure financial development (Lin et al 2016; Hassine and Harrathi, 2017; Kutan et al 2017; Ankrah and Lin, 2020; Khan et al, 2020; Razmi et al, 2020) which are inadequate to capture the multifaceted make-up of financial development. Hence, this study utilizes a novel and comprehensive financial development measure (financial development index) developed by Svirydzenka (2016) and captured using three distinctive themes (access, depth, and efficiency)

Third, Omojolaibi (2016) and Iorember et al. (2020) represent the nearest works from existing literature similar to this study on Nigeria. This work improves upon these studies by establishing a direct interaction between financial development and renewable energy use. Other improvements are represented by the application of contemporary econometric techniques to capture the intervening effects of reforms and policies in a dynamic Nigerian environment, updating the data scope, utilizing the renewable energy portion of total final energy consumption to proxy renewable energy consumption as advocated by Lin et al (2016), Asongu et al (2019), Kwakwa (2020). Fourth, given the likely susceptibility of renewable energy use to economic and non-economic shocks in Nigeria, this study uniquely accounts for structural breaks by employing the Zivot-Andrew test. Lastly, to guarantee universal access to clean energy following the Sustainable Development Goals (SDGs), minimise greenhouse gases emission, promote green financing and climate change mitigation as well as fulfilling the expected future demand in Nigeria, this study is timely and the findings are essential for providing suitable policy insights.

What remains of this paper is outlined as follows. The literature review deals with the review of the related literature. Methodology and data explain the methodology and data employed in the study while the empirical results are profiled in the empirical results section. The conclusions section captures the study's conclusion

2. Literature Review

2.1 Studies on Financial development and energy use

This section reviews literature surrounding the implications of financial development on traditional energy use in two streams. In the first strand, studies that report a positive association between both variables are presented. Beginning with Sadorsky (2010), the study applied the Generalized Method of Moments (GMM) and found a significant connection between financial development (proxied by stock market variables) and energy use. Sadorsky (2011) utilized 9 frontier economies data from Central and Eastern Europe to unearth the influence of financial development on energy use from 1990 to 2006. Employing numerous financial development proxies, the study concludes that energy use is positively influenced by only banking sector proxies.

Employing the system-GMM model in a group of 27 European Union (EU) nations for the period 1990 to 2011, Çoban and Topcu (2013) established a positive link between both variables amongst the old EU partners. Conversely, in the newer EU countries, the effect is hinged on the financial development proxy utilized. Utilizing a bank-related proxy, the effect of financial development shows an inverted U-shaped, whereas no considerable connection was established when utilizing a stock index to measure financial development. Likewise, Islam et al. (2013) used the Vector Error Correction Model (VECM) and underlined a positive effect between both variables in Malaysia as well as a feedback effect between them. Likewise, Furuoka (2015) assessed the link among both variables in Asia and the study reported a long-run equilibrium between them as well as unidirectional causality running from energy use to financial development. Similarly, Agbanike et al. (2019) evaluated the causal relationship involving banking sector development and Nigeria's energy use from 1971to 2013. Their findings indicate a unidirectional causality running from banking sector development to energy use.

There are also recent studies on financial development and energy consumption that establish a direct association. For instance, Dumrul (2018) studied the relationship between financial development and Turkey's energy use and revealed that financial development and energy useare positively associated. For the next-11 nations, Danish et al. (2018) report that financial development promotes energy utilization. Premised on the Middle East and North Africa (MENA) region, Gaies et al. (2019) applied the dynamic panel GMM estimators and established that financial development promotes energy use during the period 1996 to 2014. In the same vein, Nkalu et al. (2020) applied VECM to explore the nexus between both variables for sub-Saharan Africa (SSA)and reported a positive and significant link between both variables. A study on Kazakhstan by Mukhtarov et al. (2020) concludes that financial development drives energy use. For a panel of 120 nations from 1991 to 2014, Ma and Fu (2020) employed the system GMM approach and found that energy use is stimulated by financial development

In contrast to the above views, some scholars provide contrary evidence that financial development decreases energy use. This position holds that a well-functioning financial system could ease financial constraints on firms to update production equipment and technologies, thereby enhancing energy efficiency. Additionally, financial development also encourages firms to improve research and development investment, design and production of energy-saving products which essentially lessens energy consumption (Tamazian et al, 2009)

Specifically, studies like Ali et al. (2015) utilized autoregressive distributed lag (ARDL) to investigate the implication of financial development on energy use in Nigeria and the authors conclude, among other things, that financial development has an insignificant effect on energy use in the country. Similarly, Shahbaz et al. (2016) used the ARDL technique and discovered that financial development reduces energy consumption in India. Analogously, for India, Shahbaz et al. (2017) confirmed the absence of causality between both variables.For 32 high-income nations over the period 1990 to 2014, Topcu and Payne (2017) indicated that improvements in the stock market index reduce energy consumption. The study further reported the absence of a statistical association between energy use andthe total financial development index. Likewise, in China, Ouyang and Li (2018) confirmed that financial development significantly reduces energy use. Employing the ARDL approach, Muhammad (2019) reported a negative effect of financial development on Nigeria's energy use.Likewise, Denisova (2020) reported an insignificant association between both variables in Germany.

2.2. Financial Development and Renewable Energy Consumption

This section focuses on studies that appraised the link between financial development and renewable energy use. One of the pioneer studies to investigate this phenomenon is Brunnschweiler (2010) which utilized a sample of 119 non-OECD nations between 1980 and 2006 and indicated a positive and significant connection for both variables.

Wu and Broadstock (2015) reported a direct effect of both institutional quality and financial development on renewable energy use for a group of 22 emerging market economies. Lin et al. (2016) conclude that financial development stimulates renewable energy consumption in China using data ranging from 1980 to 2011. Similarly, Omojolaibi (2016) appraised the effect of financial development on Nigeria's renewable energy development during the period 1980 to 2008. The GMM estimations outcome established that financial development exerts a positive significant effect on renewable energy production in Nigeria. Conversely, Saibu and Omoju (2016) found that financial development reduces renewable energy consumption in Nigeria using data from 1981 to 2011. Likewise, Ankrah and Lin (2020) applied the VECM to a dataset spanning from 1980 to 2015, concluding that renewable energy development is undermined by financial underdevelopment in Ghana.

Best (2017) utilized data from 137 nations during the period 1998 to 2013, to study the financial capital effects on the use of a diverse energy type. The findings revealed that for high-income nations, financial capital supports the switch towards clean renewable energy sources. Also, both domestic private debt securities and bank private credit were reported to stimulate the usage of renewable energy. Burakov and Freidin (2017) focused on the casual linkages between financial development, economic growth,and renewable energy usein Russia and the study indicates no causality running from renewable energy use to financial development. Focusing on 4 emerging economies, Kutan et al. (2017) discovered that stock market development stimulates renewable energy use.For a sample of the Gulf Cooperation Council (GCC) nations, Hassine and Harrathi (2017) confirmed a positive relationship between both variables. Ji and Zhang (2019) applied a vector autoregression (VAR) model and reported that financial development is critical for China's usage of renewable energy.

In a similar study in India, Eren et al. (2019) conclude that financial development stimulates renewable energy use. For a group of 28 EU nations for the period 1990 to 2015, Anton and Nucu (2019) discovered that financial development promotes the utilization of renewable energy. Razmi et al. (2020) assessed the nexus between the stock market, economic growth, and renewable energy utilization (proxied by total waste and combustible renewable and total solar, wind, nuclear, and hydropower energies) in Iran from 1990 to 2014. Applying ARDL, the study reported that stock market value affects both types of renewable energies.

Employing data from 15 top renewable energy consumption nations from 1997to 2017, Raza et al. (2020) conclude that consumption of renewable energy is increased by financial development. Kassi et al. (2020) studied the conditional role of governance quality on the dynamics between renewable energy use, financial development, and economic performance in 123 economies cutting across 5 continents from 1990 to 2017. The study performed both aggregated and disaggregated analyses and reported, among other things, that there exists a two-way causality between renewable energy use and financial development in Central Asia and Europe. However, for the case of the MENA, SSA, and America region, the study reports a unidirectional causality runs from renewable energy use to financial development. From selected samples of sub-sample groups (low, middle, and upper-income nations) between 1990 and 2017, Qamruzzaman and Jianguo (2020) used panel ARDL and found that renewable energy utilization is driven by financial development in all the sub-sample groups. For a panel of 192 nations and utilizing Panel quantile regression, Khan et al. (2020) reported a positive association between financial development and renewable energy consumption. Iorember et al. (2020) scrutinized the role of financial development in the nexus between renewable energy consumption and environmental quality from 1990 to 2016. The study shows that the consumption of renewable energy enhances environmental quality while the environment is hurt by financial development. However, the direct interaction between financial development and renewable energy use was not captured in the study.

3. Empirical Model, Data, and Methodology

3.1 Empirical Model

In modelling the impact of financial development on renewable energy consumption in Nigeria, we lean on the theoretical propositions documented by Sadorsky (2011) that brought forward the three-pronged dimensions (business, direct, and wealth effects) via which financial development may influence energy use. Hence, we adopt a similar model used by Anton and Nucu (2019)[1] to estimate the effect of financial development on renewable energy consumption in 28 EU countries. Our model, however, deviates from Anton and Nucu (2019) by using the broad-based financial development measure developed by Svirydzenka (2016) which compresses the various elements of financial development into an index that comprises both financial markets and financial institutions in three distinctive themes (*access*: companies and individuals capacities to obtain financial services; *depth*: markets size and liquidity; and *efficiency*: the ability of institutions to offer financial services at a lower rate and with sustainable revenues) (Svirydzenka, 2016; Iorember et al., 2020). Underpinning the foregoing, we hypothesize that renewable energy consumption (RENC) is a function of the financial development index (FIDI), growth rate of per capita GDP (GDPC), consumer price index (CPI), and foreign direct investment (FDI) resulting in the following equation:

$$RENC = f(FIDI, GDPC, CPI, FDI) \quad (1)$$

[1]Also based on Sadorsky (2011), Çoban and Topcu (2013), and Chang (2015)

Where RENC, FIDI, GDPC, CPI, and FDI are as earlier defined. Specifying Equation (1) in its full econometric form, we obtain Equation (2) as follows:

$$RENC = \beta_0 + \beta_1 FIDI + \beta_2 GDPC + \beta_3 CPI + \beta_4 FDI + \mu \qquad (2)$$

Where β_0= intercept term; β_1-β_4= parameters of interest; and μ = random error disturbance term.

3.2 Data

The study utilizes annualized secondary time series data from 1981 to 2019. The variables and years studied were chosen based on previous research and data availability. We use the financial development index (FIDI) following the Svirydzenka (2016) broad-based financial development measure that covers some elements of financial institutions, and financial markets in three distinct categories (access, depth, and efficiency). In computing the FIDI, we first standardized the data relating to the aforementioned sub-indices of financial institutions and financial markets to obtain values within the range of 0 and 1, using the *min-max* procedure which helped us to aggregate variables that are originally expressed in diverse units of measurements (Svirydzenka, 2016). Thereafter, we obtain the mean values of the 20 standardized indices of both financial institutions and financial markets to serve as the FIDI variable. The *min-max* procedure for the standardization of variables is based on the following formula:

$$X_s = (X - X_{min})/(X_{max} - X_{min}) \qquad (3)$$

Where X_s stand for the standardized/transformed X-variable with a range of values from 0 to 1; X represents the raw data; X_{max} is the maximum value of X, and X_{min} is the minimum value of X. The values of X_s range from 0 to 1 and show a country's performance when compared to the global minimum and maximum across all countries and years, with 0 indicating worst performance and 1 indicating best performance (Svirydzenka, 2016). However, for some indices (e.g. non-interest income to total income, net interest margin, overhead costs to total assets, and lending-deposits spread) where a high value denotes the worst performance on efficiency and a low value indicates the best performance on efficiency, the following alternative formula is used to standardize the series:

$$X_s = 1 - ((X - X_{min})/(X_{max} - X_{min})) \qquad (4)$$

Consistent with the existing literature on environmental sustainability (Asongu et al., 2019; Asongu and Odhiambo, 2020; Kwakwa, 2020), renewable energy consumption (RENC) which is measured as the percentage share of renewable energy in overall final energy consumption is adopted as the dependent variable. Similarly, following recent literature, the study introduced three control variables namely GDP per capita, energy price, and foreign direct investment. The GDP per capita growth rate (GDPC) is used to account for the role of income (usually in the form of GDP) in determining the level of renewable energy consumption. Income level (captured with GDPC) is seen as an important component in the development of renewable energy (Ankrah and Lin, 2020; Anton and Nucu, 2019; Ergun et al 2019; Kwakwa, 2020). The widely held belief regarding these two factors is that as the economy improves, so will income levels and living standards. The improvement in the living standard will allow for the usage of modern energy sources. The association between FDI and renewable energy usage is well-documented in the literature. FDI represents a significant pathway for transferring resources, talent, expertise, and resources into a nation's economy. Several related studies (Anton and Nucu, 2019; Ergun et al 2019; Ankrah and Lin, 2020) have utilized this variable and in this study, it was included solely to test the technological transfer hypothesis in Nigeria's adoption of renewable energy. On the other hand, when it comes to demand analysis, the economic theory of demand shows that price is critical. As a result, energy price has been widely utilized in previous studies (Anton and Nucu, 2019; Kwakwa, 2020). Price typically has a negative connection with renewable energy usage because higher prices compel consumers to reduce their consumption level owing to income and substitution effects. This study relates with Sadorsky (2010), Chang (2015), Yadzi and Shakouri (2017), Anton and Nucu (2019) and Kwakwa (2020) in choosing the consumer price index (CPI) as the best alternative proxy for energy prices. The various sources of data have been summarized in Table 1.

Names	Abbreviations	Definitions	Sources	Justification for inclusion
Renewable energy consumption (RENC)	RENC	Renewable energy consumption is the share of renewable energy in overall final energ y consumption.	IEA database	Dependent variable
Financial Development Index (FIDI)	FIDI	Broad-based index of financial access, depth, and efficiency	World Bank database based on Svirydz enka (2016) index	To ascertain if the development of the financial sector drives renewable energy utilization
Growth rate of per capita GDP (GDPC)	GDPC	Annual percentage change in the ratio of GDP to the country's population	World Bank database	To reflect the premise that people's economic well-being has a substantial impact on renewable energy usage
Consumer price index (2010=100)	CPI	The consumer price index is the changes in the prices of the average basket of goods and services available to a consumer, which may be either fixed or changed at specified intervals of time, usually a year.	World Bank database	To test the income and substitution effects
Foreign direct inve stment, net inflows (% of GDP)	FDI	Foreign direct investment is the net inflows of investment meant to acquire a prolonged managerial interest (up to 10% or more of voting stock) in an enterprise operating in an economy other than the investor.	World Bank database	To ascertain the "technology transfer" hypothesis

Table 1: Summary of Variable Definition, and Sources of Data

3.3.Methodology

Some relevant pre-test analyses, such as unit root and cointegration analyses are required before the estimation of the model. Due to the possibility of structural breaks likely to have occurred within the sampled period, the conventional unit root test procedures such as the ADF may be biased in reporting the exact order of integration of variables since breaks may likely lead to the non-rejection of the unit root hypothesis as the conventional procedures usually misinterpret breaks as unit-roots (Arranz and Escribano, 2000). To take the necessary precautions, the study complements the ADF test with the Zivot-Andrew (ZA) test, which is obtained from Zivot and Andrew (1992) to account for the likelihood of structural breaks in the chosen time series variables. The null hypothesis underlying the ZA test is the time series variable under consideration has a unit root with a structural break, as opposed to the substitute of trend stationary process with structural break both in slope and intercept. Thus, the ZA test is based on the following regressions:

$$Y_t = \mu + \phi_2 DU_t(t_b) + \beta T + \alpha Y_{t-1} + \sum_{t=1}^{p} \phi_1 \Delta Y_{t-1} + e \tag{5}$$

$$Y_t = \mu + \lambda DT_t(t_b) + \beta T + \alpha Y_{t-1} + \sum_{t=1}^{p} \phi_1 \Delta Y_{t-1} + e \tag{6}$$

$$Y_t = \mu + \phi DU_t(t_b) + \beta T + \lambda DT_t(T_b) + \alpha Y_{t-1} + \sum_{t=1}^{p} \phi_1 \Delta Y_{t-1} + e \tag{7}$$

Where DU_t and DT_t represent dummy variables for mean and trend shifts respectively; $DU_t\,(T_b) =$ 1 if t > T_b and 0 if otherwise, and $DT_t\,(T_b) = t\text{-}T_b$ if $t > T_b$ and 0 if otherwise. In other words, DU_t is a dummy variable that denotes a change in intercept, while DT_t signifies a shift in trend happening at time T_b.

In testing for cointegration, we utilized the Autoregressive Distributed Lag (ARDL) bounds testing approach advanced by Pesaran et al. (2001). This procedure has some merits over the traditional methods like the Engle-Granger residual-based and the Johansen cointegration procedures. First, it performs better than the traditional methods in the face of relatively small sample space, meaning that it has better small sample features. Second, variables are not required to be of a similar order of integration since it offers an avenue for examining the presence of a cointegrating relationship irrespective of whether all the variables are I(1) or I(0) or a combination of I(1) and I(0), thus the preliminary test of the unit root becomes optional. Third, it can overcome any problem of endogeneity bias since it distinguishes between the endogenous and explanatory variables in a single-equation setup. Fourth, this approach is hinged on the estimation of an unrestricted error correction model (ECM) which takes satisfactory lags and captures the data generating process in a general-to-specific modelling framework. Other advantages of the ARDL bound test can be found in Pesaran et al. (2001).

The ARDL bound test utilizes the F-statistic which asymptotically follows a nonstandard distribution that depends upon whether the underlying variables are I(0) or I(1); the number of regressors; and whether the model has an intercept and/or a trend. The null hypothesis of no cointegration is rejected if the F-statistic exceeds the upper bound critical value, while the null hypothesis cannot be rejected if the F-statistic is lower than the lower bounds. However, the decision to reject or not to reject the null of no cointegration remains inconclusive if the F-statistic falls between the lower and upper bound critical values (Pesaran, et al., 2001). The ARDL bound cointegration test is based on estimating the following unrestricted error correction model:

$$\Delta RENC_t = \alpha_0 + \Sigma\Omega_i\Delta RENC_{t-i} + \Sigma\delta_i\Delta FIDI_{t-i} + \Sigma\lambda_i\Delta GDPC_{t-i} + \Sigma\Phi_i\Delta CPI_{t-i} + \Sigma\Theta_i\Delta FDI_{t-i} + \chi_1 RENC_{t-1} + \chi_2 FIDI_{t-1} + \chi_3 GDPC_{t-1} + \chi_4 CPI_{t-1} + \chi_5 FDI_{t-1} + v \quad (8)$$

The estimation of Equation (8) is particularly meant to obtain the F-statistic for the joint significance of the coefficients of the lagged level variables which are represented by χ_i. More so, upon the rejection of the null of no cointegration, the ECM version of the ARDL model is estimated to reconcile the long-run behaviour of variables with their short-run responses, as well as to generate the speed of adjustment to the long-run equilibrium from the short-run shocks.

4. Empirical Results

4.1 Summary of Descriptive Statistics

We present the summary of descriptive statistics for the variables in Table 2. The results show that the average annual percentage share of renewable energy consumption in the overall final energy consumption (RENC) is about 5.04% from 1981 to 2019, with the lowest and highest shares (2.78% and 9.4%) observed in 1981 and 2012 respectively. This is suggestive of poor utilization of renewable energy by individuals and firms in the country. The average value of the financial development index (FIDI) is about 0.31 from 1981 to 2019, and this shows evidence of a poorly developed financial sector. There has been slow growth in per capita GDP (GDPC) with an annual average percentage growth rate of about 1.69% during the review period, while the annual average value of the consumer price index (CPI) stood at 51.34 from 1981 to 2019. Also, the percentage share of foreign direct investment net inflows (FDI) is about 3.0% over the period under review, meaning that the FDI had contributed minimally to the overall economy of Nigeria. With a standard deviation of about 1.57% and 0.24, there is a narrow gap between the mean value and the successive values of RENC and FIDI respectively, during the period under study. However, there is a wide gap between the successive values of GDPC, CPI, and FDI and their mean values since their standard deviation is relatively as high as 7.35%, 51.99, and 2.15 respectively, when compared to their mean values. The highest (lowest) values of FIDI, GDPC, CPI, and FDI are 0.74 (0.0087) in 2017 (1981), 30.34% (-15.46%) in 2004 (1981), 158.94 (0.494) in 2015 (1981), and 10.83% (0.637%) in 1994 (2015) respectively. Turning to the values indicated by the Skewness statistics, it can be said that all variables except FDI are symmetric series since the Skewness statistics fall within -1 and +1, while that of FDI is greater than +1, indicating a positive/right skew relative to normal distribution. The values of the Kurtosis statistics for all variables are larger than 1, meaning that the variables have leptokurtic distribution, indicating that the distributions are quite peaked. The Jaque-Bera (JB) statistics and their corresponding p-values show that the null hypothesis of normality cannot be rejected for RENC, FIDI, and CPI at the 5% level, meaning that they are normally distributed series. However, following the JB statistics and their p-values for GDPC and FDI, the null hypothesis of normality is rejected, meaning that they are not normally distributed series (see Table 2).

	RENC	FIDI	GDPC	CPI	FDI
Mean	5.040640	0.311617	1.689656	51.34057	3.000949
Std. Dev.	1.566933	0.238786	7.347944	51.98798	2.146116
Maximum	9.4	0.749821	30.34224	158.9435	10.83256
Minimum	2.799015	0.008749	-15.45826	0.493799	0.636954
Skewness	0.846713	0.655231	0.903868	0.647330	1.843283
Kurtosis	3.210678	1.873797	7.934780	1.951539	6.915935
Jaque-Bera	4.732130	4.851671	44.88244	4.510045	47.00363
Prob. (Jaque-Bera)	0.0938	0.0884	0.0000	0.1049	0.0000
Observations	39	39	39	39	39

Table 2: Summary of Descriptive Statistics

4.2 Unit Root Test Results

In as much as the test of unit root is optional when the ARDL bound cointegration test is involved, this test is necessary to guarantee that none of the series is I(2) because the ARDL bound test is meaningless in the face of I(2) variables (Pesaran et al., 2001). The ADF unit root results are reported in Table 3. The results show RENC, FIDI, and CPI are I(1) series, while GDPC and FDI are I(0) series. While these results may support some empirical findings, not much could be inferred from the results since the ADF unit root test did not explicitly account for the likelihood of structural breaks within the sampled period.

Variables	ADF Stat. @Level	ADF Stat. @First Diff.	I(d)
RENC	-1.117057	-4.817862***	I(1)
FIDI	-0.233549	-5.093744***	I(1)
GDPC	-4.878868***	---	I(0)
FDI	-3.808117***	---	I(0)
CPI	-2.179120	-2.996483**	I(1)

***(**) denotes rejection of the unit root hypothesis at the 1%(5%) level.

Table 3: ADF Unit Root Test

We present the results of the ZA unit root test, which accounted for the possibility of structural breaks in time series, in Table 4. The results show that only RENC and CPI are I(1) series, while FIDI, GDPC, and FDI are I(0) series. The unit root test results seem to be conclusive between the ADF and the ZA tests for all variables except for the FIDI which, according to the ADF is I(1) series, but becomes I(0) series in the ZA test. However, the non-rejection of the unit root hypothesis at the level of FIDI could be attributed to the prevalence of the structural break phenomenon which has been confirmed by the ZA test (see Table 4).

Interestingly, the various break dates have been reported by the ZA test. These break dates have important implications for understanding and evaluating the effects of economic shocks occasioned by reform policies and programmes such as reforms relating to taxation, trade, and the banking sector as well as regime shift (Piehl et al., 1999). For instance, the break date reported by the ZA test on RENC is 2016 could be attributed to the introduction of the national renewable energy and energy efficiency policy (NREEEP) in 2015which was meant to facilitate the development of renewable energy resources, and partly fulfilling the Paris Climate Agreement. The break date of the financial development index (FIDI) is 2005 is attributable to the implementation of the recapitalization policy of the Nigerian banking sector, which paved the way for mergers and acquisitions in the Nigerian banking sector in 2004 that saw the number of deposit money banks drastically reduced from 89 to 25 banks. The break dates of GDPC and CPI are the same (1987), while that of the FDI is 1988. This is equally attributable to the introduction and implementation of the Structural Adjustment Program (SAP) in 1986 which was meant to last till 1988. The introduction of SAP followed the advice of the International monetary fund and the World Bank and was primarily meant to open up all markets (products and financial markets) and the easing of government regulations.

Variables	ZA Stat. @Level	ZA Stat. @First Diff.	Break Date	I(d)
RENC	-2.879423	-8.151120***	2016	I(1)
FIDI	-5.606868**	---	2005	I(0)
GDPC	-6.134441***	---	1987	I(0)
FDI	-5.119835**	---	1988	I(0)
CPI	-3.263814	-5.635859**	1987	I(1)

***(**) denotes rejection of the unit root hypothesis at the 1%(5%) level.

Table 4: ZA Unit Root Test with Break

4.3 Cointegration Test

The unit root test results show that our variables are a combination of I(0) and I(1), with an I(1) dependent variable. This justifies the use of the ARDL bound cointegration procedure to examine the long-run relation between renewable energy consumption (RENC) and financial development (FIDI), alongside other relevant explanatory variables. The ARDL bound cointegration test result is reported in Table 5. According to the result, the F-statistic which measures the joint significance of the one-period lagged level variables in Equation (8) is 4.647610, which is greater than the upper bound critical value (4.01) at the 5% level of significance. Therefore, we reject the null hypothesis of no cointegration between the dependent and the explanatory variables and conclude that a stable long-run relation exists among the variables. This result implies that deviation from the short-run equilibrium is considered a temporary phenomenon as equilibrium is assured in the long run. Thus, a consistent estimate of both long-run and short-run coefficients is evident.

	5% Critical Value	
F-Statistic	Lower Bound I(0)	Upper Bound I(1)
4.647610**	2.86	4.01

** denotes rejection of the null hypothesis of no cointegration at the 5% level.

Table 5: ARDL Bound Cointegration Test

Having established the presence of a long-run association between renewable energy consumption and the relevant predictors, it becomes customary to report the normalized cointegrating coefficients of exogenous variables as generated from the level equation object of the ARDL model framework. The results are presented in Table 6. According to the results in Table 6, only the financial development index (FIDI) and the consumer price index (CPI) are individually statistically significant, while the rest (GDPC and FDI) are not significant. However, the signs of the estimated coefficients suggest that all variables conform to theoretical expectations. For instance, it is theoretically meaningful that the financial development (FIDI), the growth rate of per capita GDP (GDPC), and foreign direct investment (FDI) exert a positive influence on renewable energy consumption, while the consumer prices (CPI) has a negative influence on renewable energy consumption.

Financial development, measured using the broad-based index developed by Svirydzenka (2016), exerts a significant positive influence on renewable energy consumption in Nigeria. The possible explanation for this outcome is that financial institutions in Nigeria have continued to support or encourage the shift towards renewable energy improvement and usage in Nigeria so that the nation could meet its environmental targets. The positive influence of financial development on renewable energy use, as revealed in this study, has a great deal of similarity with the findings reported by some previous researchers in their respective case studies (see Lin et al., 2016; Ji and Zhang, 2019; Eren et al., 2019; Anton and Nucu, 2019; Raza et al., 2020; Qamruzzaman and Jianguo, 2020). However, this finding negates those of Saibu and Omoju (2016), and Ankrah and Lin (2020) who reported that financial development undermine renewable energy usage in their respective case studies.

Another significant determinant of the utilization of renewable energy in Nigeria, according to this study, is the level of consumer prices, which has been measured in terms of the consumer price index (CPI). The study found that the consumer price index has a significant negative influence on renewable energy consumption in Nigeria (see Table 6). This means that an increase in the level of consumer prices discourages the utilization of renewable energy by individuals and firms. Our finding agrees with Kwakwa (2020) for Ghana while contrasting with the finding by Anton and Nucu (2019) who reported a positive influence of consumer prices on renewable energy consumption for a panel of 29 EU countries. Our result agrees with the economic theory which posits that an increase in a price of a commodity will cause a decrease in the amount requested for that commodity, and vice versa owing to income and substitution effects. Because renewable energy is relatively expensive, a price increase may encourage consumers to switch to a cheaper option. Besides, an increase in the price of renewable energy affect consumers' purchasing power and, as a result, their consumption. It is worth noting that Nigeria's economy has battled to sustain reduced inflationary rates throughout the years and as a result, an increase in the general price level forces households and firms to shift away from the consumption of clean energy and toward alternative energy kinds

The remaining variables (GDPC and FDI) are insignificant in determining the level of utilization of renewable energy in Nigeria, even though their signs conform to the theoretical expectation (see Table 6). For instance, the growth rate of per capita GDP (GDPC) used to measure the influence of income, has a positive but not a significant influence on renewable energy consumption in Nigeria. This corresponds with the outcome of Anton and Nucu (2019) Ankrah and Lin (2020) Kwakwa (2020) while disagreeing with Lin et al (2016) and Eren et al. (2019). A possible explanation is that Nigeria's economic growth has not been environmentally friendly. Growth has not been supported by significant investment in renewable energy production and use by the government, firms, and households

Also, foreign direct investment (FDI) has a positive but not significant influence on renewable energy consumption in Nigeria. This means that increase in foreign direct investment does not significantly increase the use of renewable energy in the country. Our study did not find support for the technological transfer theory which holds that when a nation opens up, some skills, technology, and knowledge would become available in the economy. The reason for this outcome is not far-fetched given that foreign direct investment may result in inter-firm investment and technological innovation, both of which can enhance energy efficiency and reduce reliance on renewable energy. This finding matches Lin et al (2016), Anton and Nucu (2019), and Zhang et al (2021) while disagreeing with Ankrah and Lin (2020)

Dependent Variable: RENC				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
FIDI	0.605378**	0.129817	4.663311	0.0001
GDPC	0.004051	0.015242	0.265789	0.7929
CPI	-0.326918**	0.092366	-3.539370	0.0018
FDI	0.012296	0.047963	0.256360	0.8001

** (*) denotes significance at the 1% (5%) level.

Table 6: Longrun Estimates of the ARDL Model

We also estimated an error correction version of the ARDL model, to settle the long-run behaviour of variables with their short-run responses. The major concern of the ECM is to establish the speed of adjustment (measured as the coefficient of the error correction term) from short-run shocks to long-run equilibrium. According to our ECM results, the coefficient of the error correction term is -0.95 with a p-value of 0.0000, which is statistically significant at the 1% level. The negative coefficient (-0.95) of the error correction term is as expected, and the implication is that about 95% of the short-run deviation from equilibrium is restored annually as the variables adjust to the long-run equilibrium.

Our results are robust to different diagnostic tests such as the Breusch-Godfrey serial correlation LM test, Breusch-Pagan-Godfrey heteroskedasticity test, Jaque-Bera normality test, and the Ramsey RESET test for the model specification error since the various test-statistics have p-values greater than 0.05 (see Table 7). For instance, the probability value for the various diagnostic tests is greater than 0.05, meaning that the test statistics are statistically insignificant at the 5% level. Thus, we could not reject the null hypotheses of none-serially correlated residuals, the constant variance of residuals (homoskedasticity), normally distributed residuals, and an error-free model.

Test Type	**Test-statistic**	**Value Obtained**	**Prob.**
Serial Correlation LM Test (Breusch-Godfrey)	F-statistic	0.317358	0.7321
Heteroskedasticity Test (Breusch-Pagan-Godfrey)	F-statistic	0.922676	0.5594
Normality Test (Jaque-Bera)	JB-statistic	1.790718	0.4085
Specification Error Test (Ramsey RESET)	F-statistic	0.450638	0.5101

Table 7: Post-Estimation Diagnostic Tests (Robustness Check)

We also conducted a model stability test using both cumulative sum (CUSUM) and cumulative sum of squares (CUSUMQ) as reported in Fig. 1. Expectedly, the estimated coefficients of the

ARDL model are dynamically stable over the periods under review since the fitted line falls within the upper and lower critical bounds at the 5% level of significance for both tests.

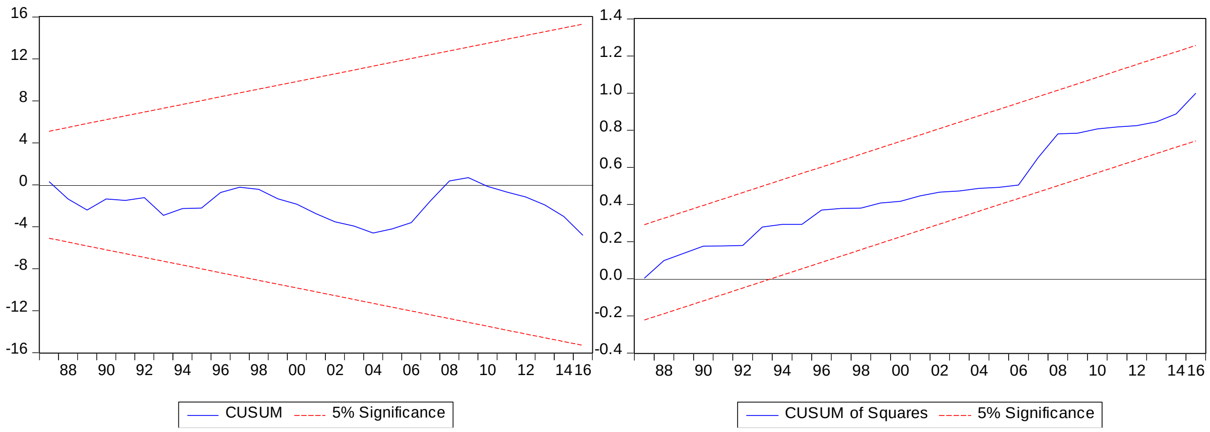

Fig. 1:Model Stability Tests- CUSUMand CUSUMQ

5. Conclusions

This study interrogated the implication of financial development on renewable energy development in Nigeria employing annual data spanning from 1981 to 2019. To adequately capture the multidimensional nature of financial development, the study utilized the broad-based financial development index developed by Svirydzenka (2016) which captures financial access, depth, and efficiency which is superior to the traditional indicators. The study employs a blend of the ADF test and Zivot-Andrew test to ascertain the stationarity properties of the variables as well as the likelihood of structural breaks, while the ARDL was utilized to determine the long-run connection between the variables. The results are synopsized as follows: First, financial development is critical for renewable energy consumption in Nigeria. This indicates that the development of the financial sector stimulates the shift towards the use of clean energy in Nigeria. Second, consumer prices have a significant negative influence on renewable energy use in Nigeria. Lastly, other variables such as the growth rate of per capita GDP and FDI are not significant in determining the level of utilization of renewable energy in Nigeria.

Premised on the foregoing, these policy suggestions are proposed. Having established that a robust financial sector positively engenders the deepening of renewable energy in Nigeria, financial sector policy targeting renewable energy development should take centre stage. Within the policy framework, financing efforts have to consider the creation of new renewable energy businesses and the extension of current renewable energy ventures, canvassing supplementary operating capital through the conversion of accessible assets to liquidity among others. The success of this policy endeavour is equally hinged on clear cooperation and productive partnership among the key actors (Government, financial organisations, and energy investors). This relationship will create a sustainable atmosphere for the successful transition to make the financial system green. On the part of the government, it is imperative to have a 'green mentality' in the articulation of policy relating to fiscal, energy, and environmental issues. The Green bond initiative launched in 2017 by the federal government should be expanded to strengthen the capital market to adequately cater to renewable energy projects and funding. Financial sector institutions can aid renewable energy growth by initiating funding avenues through innovative green business-friendly packages while existing green loans and insurance should be invigorated (Dimnwobi et al., 2021; Shobande and Ogbeifun, 2021)

Second, given the huge investment requirements of renewable energy projects, borrowing from Nigeria's financial sector to support the transition to clean energy utilisation is unavoidable; hence the Central Bank of Nigeria should consider providing a preferential lending rate for renewable energy investors. Additionally, given the low credit access in Nigeria, the Central Bank of Nigeria should deepen its financial inclusion program to improve credit access, particularly for firms and households who are interested in green goods. Third, the Nigerian government should take deliberate actions to considerably reduce fossil fuel consumption. One such measure could be actualised by removing fossil fuel subsidies alongside a gradual introduction of an environmental or carbon tax on the utilization of non-renewable energy.

Fourth, there is a need for sound, sustainable, and committed macroeconomic interventions to address the growth rate of per capita GDP and FDI which were both found to be inconsequential to renewable energy consumption in Nigeria. Recent national economic plans namely, the 2017 recession recovery plan (The Economic Recovery and Growth Plan - ERGP) and the 2020 post-COVID resurgence plan, need to be effectively synchronised and efficiently executed to meet growth rate projections and quickly get the economy on track. This will expectedly pave the way for the much-desired improvement in inclusive growth and better per capita GDP figures. Also, the Nigerian Investment Promotion Commission (NIPC) can leverage a solid financial sector and expected growth in economic performance to lure more international investors into the economy and specifically aim to boost the renewable energy share of FDI in the country. Finally, the combined efforts of concerned stakeholders should be geared towards policies that not only improve renewable electricity share but those that equally grow renewable energy quota in overall energy consumption.

Future studies can improve on this by focusing on the role of governance quality in the financial development-renewable energy consumption nexus in developing nations. Besides, where data permits, further studies could ascertain the implication of financial development on various renewable energy sources since most developing nations are blessed with diverse renewable sources. The study analysis utilizes a few variables that could influence renewable energy consumption; further studies should incorporate other variables that could have an implication on renewable energy consumption.

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