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Imapact of Renewable Energy Consumption on Trade Openness in Nigeria: An Application of Autoregressive Distributed Lag Model

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Abstract: This study examined the impact of renewable energy consumption on trade openness in Nigeria covering the period of 1990 to 2021. The empirical date was analyzed using Augmented dickey fuller for stationary and autoregressive distributed lag model respectively. The result from Augmented dickey fuller for stationary indicate that all the series were stationary at first difference and were strongly cointegrated. The long run model result revealed that renewable energy consumption had a positive and significant impact on trade openness but it was negative and insignificant in the short run model. The speed of adjustment was estimated to be at 78 percent every year. The study recommends that government should support and encourage investments in the renewable energy sector in the country as well as providing a conducive business environment as this will make renewable energy affordable and accessible to the people as well as attract green foreign investment into the country through openness to trade.

Keywords: Renewable Energy, consumption on trade openness, Autoregressive Distributed Lag Model .

INTRODUCTION

Renewable energy consumption plays the most vital role to the Nigerian economic progress, and development, this is because energy consumption is always associated with industrialization and economic growth, but until recently renewable energy consumption in Nigeria did not constitute significantly to global increase in energy demand. The 1973 oil market crisis exposed the geopolitical implications of relying on unevenly distributed fossil based energy resources in the quest for economic development, his evidently led to calls towards diversification of energy sources in the country which obviously included renewables (Fubara, 2019). Uninterrupted renewable energy supply is a vital issue for all countries today including Nigeria, future economic growth crucially depends on the long-term availability of renewable energy sources that are affordable, accessible, and environmentally friendly. Climate change and public health are closely interrelated with energy. Energy is an important factor to all the sectors of the Nigeria's economy. The standard of living of a given country can be directly related to the per capita energy consumption. The recent world's energy crisis is due to two reasons, the rapid urbanization and the increase in the living standard of whole societies. Nigeria is the largest consumer of energy in Africa, but the largest source of energy for consumption is fossil fuels and biomass which is hazardous and vulnerable to world energy market unlike renewable energy sources (Onyebuchi, 2018).

Energy consumption plays a crucial role in socio-economic development, industrial breakthrough, health, education, employment and overall welfare of citizen. Sufficient amount of energy supply as well as its efficient utilization is needed for an economy to completely experience growth and development. The relationship between renewable energy consumption and trade openness is essential to examine because of the role they play in a country's economic success. As shown in the case of Nigeria, the country heavily depend on fossils fuel which means that, any increase in price of fuels is negatively affects the country's economic prosperity, as the two factors are directly related. This calls for the need to strengthen the effectiveness of renewable energy generation and supply agencies by providing them with proper and latest tools to replace the inadequate and obsolete ones to ensure Nigeria's economic growth and progress for years to come (Ogundipe, *et al*., 2013). One major way to increase access to renewable energy for consumption to ensure growth is to diversify the country's energy-generation and supply portfolio and to collaborate with the private sector within the context of public-private partnership to further exploit opportunities in the other energy generating sectors such as renewable energy sector. The influx of money and investments could stimulate the sector by helping them to replace the outdated and wane out engines to ensure high production and constant supply of the product to the energy market. This would not only benefit the investors, who would gain profit from their investments, but may also help Nigerian economy and its citizens because increase in renewables energy supply

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would decrease the costs of energy consumption in the country (Onakoya, *et al*., 2013).

Nigerian economy is open to trade with other economies around the world through international trade and integration, the country has been a member of the World trade organization (WTO) since 1 January 1995, having been a member of the General Agreement on Tariffs and Trade (GATT) since 18 November 1960, the country ratified the WTO Trade Facilitation Agreement on 20 January 2017 and the amended WTO Agreement on Trade-Related Aspects of Intellectual Property Rights 1994 (TRIPS) Agreement on 16 January 2017 (World trade organization, (WTO), 2020). The Nigerian Government is still committed through the National Office for Trade Negotiations (NOTN) to develop a Nigerian Schedule of Specific Commitments for Trade in Services, carried out through a consultative process. From this process, working in accordance with the agreed five priority sectors under the African continental free trade area (AfCFTA), among the important sectors are economic sector, transportation sector and agricultural sector. Furthermore, under the regional free trade agreement agenda, a regional instrument known as Economic community of West African State (ECOWAS) Trade Liberalization Scheme was established in 1990 to achieve an effective free trade area within the ECOWAS. All members of the ECOWAS, including Nigeria, have been implementing this scheme since 1990. Other ECOWAS-related schemes include the ECOWAS Protocol of Free Movement, which establishes the right of entry, residence and establishment of ECOWAS citizens in the region (WTO, 2020).

Nigeria is a member of the African continental free trade area (AfCFTA). This agreement is to establish a single market for goods and services across 54 counties, allow the free movement of business travelers and investments, and create a continental customs union to streamline trade and attract long-term investment. Full implementation of the agreement will take some time as negotiations covering trade, dispute settlement, investment, competition policy and intellectual property rights will have to be completed. The AfCFTA has been designed as a multi-stage process. The negotiated issues will be constituted into legal instruments. Phase one involved issues on origin, schedules of tariff concessions, and schedules of specific commitments on the five priority service sectors (business services, communications, finance, tourism, and transport). Phase 2 negotiations on intellectual property rights, investment, competition policy, and e-commerce and currently ongoing (WTO, 2020).

In terms of renewable energy consumption and trade openness nexus, energy consumption has been recognized to play a significant role towards the production of goods and services which improve country's international trade relations and economic activities. International trade motivates economic activities which call for more energy consumption (Kyophilavong, *et al*., 2015). Energy is seen as an important resource that each and every sector of the economy requires to add values to goods and services it produces. Since energy is viewed as an important element of modern life, its usage creates a strong base for economic development, because it would engender wealth creation, higher standard of living and a sustainable economic development. International trade motivates economic activities which call for more energy usage (Hasson and Masih, 2017). Moreover, Trade openness means that a nation relaxes the tax and other formalities to expand the international trade and helps to increase the international trade. In turn, trade openness is expected to have a positive contribution in the economic growth. Then, the earlier economic growth may increase the renewable energy demand due to higher commodity production and economic activities, which are higher consumption, production and government spending which is termed as scale effect. In the later phase of economic growth, the countries may grow enough to install the energy-efficient technologies or switch their production process from fuel driven energy-intensive industries to a more environmental friendly renewables energy service sector (Ibrahiem, 2018). Therefore, it is against this background that this paper seek to explore the relationship between renewable energy consumption and trade openness in Nigeria covering of the period of 1990 to 2021. The choice of the study period was influenced base on the availability of data. The remaining section of this paper include review of related literature, model specification, results and discussion, conclusion and recommendations.

REVIEW RELATED EMPIRICAL LITERATURE

Akinwale (2021) explored the link between energy consumption, trade openness and economic growth in Nigeria from 1971 to 2015 using Vector error correction model (VECM). The result of causality

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analysis in VECM shows that there is a long run causality from economic growth and trade openness to energy consumption as well as from economic growth and energy consumption to trade openness. Odhiambo (2021) investigates the causal relationship between trade openness and energy consumption in 20 sub-Saharan African (SSA) countries for the 1990–2019. Using a multivariate ECM-based panel Granger-causality test, the study found that there is a unidirectional causal flow from trade openness to energy consumption, but only when the exports are used as a proxy for trade openness. Mingming, *et al*. (2021) also investigates the effect of trade openness on renewable energy consumption in 35 OECD countries for the period of 1999 to 2018. A panel smooth transition regression model is built. The results demonstrate the existence of a strongly nonlinear relationship between trade openness and renewable energy consumption. Nepal, *et al*. (2021) examining whether FDI and trade openness play a role in the relationship between energy security, economic growth and environmental sustainability in India during the period 1978–2016 and found that energy use is caused by trade openness, among other variables.

Qamruzzaman and Jianguo (2020) examined the relationship between financial development, trade openness, and renewable energy consumption in low-income countries, middle-income countries and upper-middle-income panel. Using the panel NARDL, the authors found that there is a short-run causality from trade openness to renewable energy consumption demand in middle-income countries. Usman, *et al*. (2020) examined the dynamic effect of renewable energy consumption, economic growth, bio capacity and trade policy on environmental degradation in the United States during the period 1985Q1–2014Q4. Using the Toda–Yamamoto causality test, the authors found that there is a one-way causality running from trade policy to renewable energy consumption. Also, Satrovic (2019) conducted similar study for Turkey and observed that a unit growth in energy consumption improves GDP by 1.35 whereas a unit growth in trade openness reduces GDP by 0.13. Akinwale and Muzindutsi (2019) in their study in South Africa for the 1984–2015 using ARDL model confirmed the positive and significant influence of electricity consumption and trade openness on economic growth in the long run. Yusuf and Omar (2019) examined the effect of trade openness on GDP of Tanzania over the 1981-2017. While the result of VECM revealed a positive long run connection between them, the granger causality test indicated no causality between them. Liu, *et al*. (2018) examined the relationship between renewable energy, trade, and economic growth within 1994–2014. The result revaled that there is a long-run unidirectional Granger-causality from trade to renewable energy. Ohlan (2018) assessed the association between trade openness, electricity consumption and GDP in India from 1971 to 2016. The ARDL results showed that the variables are cointegrated and there exists a long-run causation running from electricity consumption and openness to economic growth. Akinwale (2018) explored the association between energy use, technology innovation and GDP in Saudi Arabia between 1980 and 2015 using ARDL. The findings established long run relationships between the series, with one-way causality from GDP to energy.

Lawal and Ezeuchenne (2017) analysed the connection between international trade and economic growth in Nigeria and the results revealed a long run connection them. The research conducted by Acaravci, *et al*. (2015) in Turkey indicated a long run connection among electricity consumption, trade openness, real GDP per capita and FDI. Zambrano-Monserrate, Troccoly-Quiroz & Pacheco-Borja (2016) examines the existence of an Environmental Kuznets Curve for Iceland from 1960 to 2010. The result conclude that there exists a correlation between CO_2 emissions, GDP per capita, energy consumption of fossil fuels and trade liberalisation. The study of Hu, *et al*. (2015) examined energy use and economic growth using panel data from different sectors in China between 1998 and 2010. The results indicated that there exist a positive relationship between energy use and economic growth. The panel study conducted by Nasreen and Anwar (2014) in 15 Asian countries showed the presence of long run association between energy consumption, trade openness and GDP, and there is a feedback effect between GDP and energy consumption, and also between energy consumption and trade openness. Shahbaz, *et al*. (2014) investigated the association between trade openness and energy consumption in 91 high, medium and low income nations for a data set from 1980 to 2010. Their results showed the presence of an inverted-U shaped association in high income nations and vice versa in middle and low income nations. Shakeel, *et al*. (2014) explored the link between GDP, energy consumption and international trade in five South

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Asian countries and their results revealed a feedback effects of the variables on one another in the short run. Shahbaz, *et al*. (2013) in their study conducted in China revealed an existence of a long run association among energy use, economic growth, trade, financial development and capital. The study of Chaudhry, *et al*. (2012) in Pakistan revealed one-way causality from energy use (of each variable electricity, oil, gas and coal) to GDP as well as from GDP to trade openness. In an article by Arouri, Youssef, M'henni & Rault (2012) they investigate the EKC curve in the Middle East and North Africa. Their results show that there is a strong positive correlation between energy consumption and CO_2 emissions.

Model Specification

The model for this study follows the framework in Ari (2020) in estimating the nexus between renewable energy consumption and trade openness equation. As a modification, this study incorporates foreign direct investment (*FDI*) and financial development (FD) into the model in addition to the standard regressor of renewable energy consumption (*REC*). The functional form of renewable energy consumption and trade openness is expressed as;

$$TOP = (REC, ECG, FDI, FD)$$

To achieve harmony in the units of measurement of the variables and express the coefficients as elasticities, the linear specification of the stochastic model is converted into log-log specification as it gives more appropriate and efficient results compared to linear-linear model (Iorember, Usaman & Jelilove, 2019). Therefore, the logarithmic form of the estimable model is specified as;

$$lnTOP_t = \beta_0 + \beta_1 lnREC_t + \beta_2 lnECG_t + \beta_3 lnFDI_t + \beta_4 lnFMD_t + \mu_t$$

Since the variables used in the econometric analysis are not stationary, there will be a regression fallacy problem, so it is necessary to examine the stationarity of the data before starting the analysis. Upon establishing that variables were stationary and the appropriate maximum lag determined, the next step involves performing a cointegration test to determine there is a long-term equilibrium connection among variables using the bounds test. The assumption that the bounds test is based that the series should be either *I(0)* or *I(1)*, and that is why only the lower and upper bounds critical values was compared with the estimated F-statistic value in the process determining the cointegration relationship (Handson, *et al*., 2016). However, the bounds testing approach to cointegration can be applied irrespective of *I(0)*, *I(1)* or a combination of *I(0)* & *I(1)*. However, the presence of *I(2)* variables invalided the computed F-statistics (Pesaran, *et al*., 2001).

The problem of endogeneity in the form of a model doesn't have a significant impact on the ARDL technique. This situation is supported by the fact that the ARDL technique is free from residual correlation, so this model makes it possible for variables to have a different maximum or optimum lag length, which is entirely impossible with the convection test for co-integration. According to Pesaran & Shin (1999), this statement is also supported by research, which states that a corresponding lag in the ARDL model will correct serial correlation and endogeneity problems. Based on the advantages of the ARDL method, this study developed an infinite error correction method (UECM) to capture the relationship between the variables, as shown in the equation below. It can be used to analyse co-integration through a bound F-test for co-integration in related research. The cointegration equation for the objective two of this study is given in the bounds equation below;

$$\Delta lnTOP_t = \delta_0 + \delta_1 lnTOP_{t-1} + \delta_2 lnREC_{t-1} + \delta_3 lnECG_{t-1} + \delta_4 lnFDI_{t-1} + \delta_5 lnFMD_{t-1}$$
$$+ \sum_{i=1}^{m} \gamma_{1i} \Delta lnTOP_{t-i} + \sum_{i=0}^{n} \gamma_{2i} \Delta lnREC_{t-i} + \sum_{i=0}^{p} \gamma_{3i} \Delta lnECG_{t-i} + \sum_{i=0}^{q} \gamma_{4i} \Delta lnFDI_{t-i} + \sum_{i=0}^{r} \gamma_{5i} \Delta lnFMD_{t-i} + \mu_t$$

Where all the variables remain as earlier defined, δ_0 and μ_t are the constant term and white noise stochastic term respectively. The *m*, *n*, *p*, *q* and *r* are the respective lag order.

The null hypothesis and alternative hypothesis of the bounds test are given as;

$$H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0$$
$$H_1 : \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq \delta_6 \neq 0$$

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he null hypothesis given as H_0 indicates the absence of cointegration relationship among the variables whereas the alternative hypothesis H_1 indicates the presence of cointegration relationship among the variables in the same equation. To determine the existence of cointegration relationship, the computed F-statistic will be compared with the lower and the upper bounds critical values as suggested by Pesaran, *et al*. (2001). If the computed F-statistic is greater than the lower and the upper bounds critical values then co-integration exist. But if the computed F-statistic is less than the lower and the upper bounds critical values, then there is no co-integration. However, when the computed F-statistic falls within the lower and the upper bounds critical values, then there is an inconclusive result (Pesaran, *et al*., 2001).

When the variables were tested for the cointegration relationship through the bounds test as shown in the equation above and established that the variables are cointegrated, the estimation process continuation with the test for the long-run coefficients through the ARDL long-run model as prescribed in the model below;

$$lnTOP_t = \delta_0 + \sum_{i=1}^{m} \delta_{1i} lnTOP_{t-i} + \sum_{i=0}^{n} \delta_{2i} lnREC_{t-i} + \sum_{i=0}^{p} \delta_{3i} lnECG_{t-i} + \sum_{i=0}^{q} \delta_{4i} lnFDI_{t-i} + \sum_{i=0}^{r} \delta_{5i} lnFMD_{t-i} + \mu_t$$

Where all the variables remain as earlier defined, δ_0 and μ_t are the constant term and white noise stochastic term respectively. The *k, m, n, p,* and *q* are the respective lag order. The script *t* stands for the time period and $\sum$ is the summation sign.

Following the establishment of long-run coefficients in equation above, the short-run and the error correction models will be estimated simultaneously. The error correction coefficient will serve as the confirmation to the bounds test as well as the speed of adjustment from the short run dynamic disequilibrium to equilibrium position. The equation for the two models is given as;

$$\Delta lnTOP_t = \gamma_0 + \sum_{i=1}^{m} \gamma_{1i} \Delta lnTOP_{t-i} + \sum_{i=0}^{n} \gamma_{2i} \Delta lnREC_{t-i} + \sum_{i=0}^{p} \gamma_{3i} \Delta lnECG_{t-i} + \sum_{i=0}^{q} \gamma_{4i} \Delta lnFDI_{t-i} + \sum_{i=0}^{r} \gamma_{5i} \Delta lnFMD_{t-i} + \vartheta ECT_{t-1} + \mu_t$$

Where all the variables remain as earlier defined, γ_1, γ_2, γ_3, γ_4, γ_5 & γ_6 are the short-run coefficients to be estimated. While γ_0 and μ_t are the constant term and white noise stochastic term respectively. Error correction coefficient is given as ϑ. The *m, n, p, q* and *r* are the respective lag order.

RESULTS AND DISCUSSIONS

Table 1 shows the descriptive statistics for the variables which include the mean, median, maximum, minimum, standard deviation, skewness, kurtosis and Jarque-bera respectively.

Table 1: Summary of Descriptive Statistics

	TOP	REC	ECG	FDI	FD
Mean	36.16016	84.85633	3.09E+11	1.628123	10.21454
Std. Dev.	9.393959	2.352052	1.40E+11	1.198091	3.498524
Skewness	-0.157258	-0.120397	0.255264	1.867129	0.877677
Kurtosis	2.465263	1.791349	1.436639	6.889065	3.548468
Jarque-Bera	0.513151	2.025091	3.606315	38.75935	4.509446
Probability	0.773696	0.363293	0.164778	0.000000	0.104903
Observations	32	32	32	32	32

Source: Author's Computation (2023)

Mean: The mean value for all the variables employed in the study which include trade openness, renewable energy consumption, economic growth, foreign direct investment and

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financial development all exhibit positive values of 36.16016, 84.85633, 3.09E+11, 1.628123 and 10.21454, respectively. The result simply shows the average value for each of the variables. **Standard Deviation:** Standard deviation captures the volatility in the series relative to the mean of the series. The result suggests that all the variables employed in the study exhibit a deviation below their mean value, which include trade openness, renewable energy consumption, economic growth, foreign direct investment and financial development. **Skewness:** The asymmetry of the distribution of series around its mean is being captured by the skewness. A negative skewness means that the series of distribution has a long left tail and a positive skewness simply means that distribution series has a long tail on the right. Distribution series is normal when it is zero (Murray and Larry**,** 2011). From the result, trade openness and renewable energy consumption are negatively skewed, while economic growth, foreign direct investment and financial development are positively skewed. **Kurtosis:** The peakedness and flatness of the distribution series was captured and explained by Kurtosis. According to Murray and Larry (2007) Kurtosis is neither peaked nor flat when it is equal to 3 (i.e. mesokurtic), a variable is peaked when its value it's greater than 3 (i.e. leptokurtic), a variable is flat when its value is less than 3 (i.e. platykurtic). The result showed that three variables were platykurtic (i.e. containing lower values in the distribution series) with the exemption of foreign direct investment and financial development which are leptokurtic. In other words, three series among the variables have flat sharps with the foreign direct investment and financial development which have peaked sharps. **Jarque Bera:** This measure the normal distribution of the series via the differences between the Skewness and Kurtosis. The result suggests that at 5 percent critical level, the probability of all the variables employed are greater than 0.05, with the exception of foreign direct investment, therefore, the null hypothesis of normal distribution of the series could not be rejected.

The unit root test is essential to ascertain the stationarity properties of the variables employed in the study. The unit root test is presented in the table 2 that follows.

Table 2: Unit Root Test Result

Variables	At Level		At First Difference	
lnECG	-0.6106	-1.7894	-4.8532***	-4.7882***
	(0.8538)	(0.6846)	(0.0030)	(0.0021)
lnREC	-1.6072	-2.5160	-5.4944***	-5.4101***
	(0.4670)	(0.3187)	(0.0001)	(0.0007)
lnTOP	-2.7160*	-3.3428*	-5.2231***	-5.2456***
	(0.0827)	(0.0781)	(0.0002)	(0.0011)
lnFDI	-2.4858	-3.1373	-6.6096***	-6.5071***
	(0.1285)	0.1157)	(0.0000)	(0.0000)
lnFD	-2.2944	-3.1608	-4.9838***	-4.8997***
	(0.1799)	(0.1113)	(0.0003)	(0.0026)

Source: Author's Computation (2023)

The result obtained from Augmented Dickey-Fuller (ADF) test showed that all variables were stationary at first difference, at 1 percent level of significant. Furthermore, all variables were found to be stationary at first difference at 1 percent level of significance. This means that the null hypothesis of unit root presence at levels could be rejected using of ADF test. To this end, the study concludes that all the variables were stationary at the first difference. Thus, provided none of the variables is of second-order of integration, the study proceeded to examine the existence of co-integration among the series using the Autoregressive Distributed Lag Bound. The likelihood of co-integration relationship between variables in time series is critical and needs to be examined, especially when the variables have unit root problem Gujarati (2004). Thus, the ARDL bound test's efficiency is not limited to only the mixed order of integration but single order, either at levels or first difference.

Also, ARDL Bound Test works efficiently with short time series (Gujarati, 2004). To this advantage, the study adopts the ARDL Bound test and the results obtained is reported in Table 3.

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Table 3: ARDL Bounds Test Result

Test Statistic	Value	K
F-statistic	5.8591***	4
Critical Value Bounds		
Significance	**I0 Bound**	**I1 Bound**
10%	2.45	3.52
5%	2.86	4.01
1%	3.74	5.06

Source: Author's Computation (2023)

The criteria for the presence of cointegration in ARDL Bound Test is that the estimated F-statistic must exceed the estimated upper bound or at least falls between the lower bound and the upper bound for the null hypothesis of no levels relationship to be rejected (Gujarati, 2004). From the result, the F-statistic obtained is 5.8591, which outweighs the upper bound at 1 percent critical level consequently, leading to the rejection of the null hypothesis. Towards this end, the study concludes the existence of long-run relationships (i.e. levels relationship) amongst the series. Thus, both the short-run and the long-run ARDL model will be estimated.

Following the satisfactory unit root and bounds tests results on the variables, they were employed to adequately provide answer to the research questions. The ARDL was employed to explain the dynamic effect of renewable energy consumption on economic growth in Nigeria. The following table shows the long-run and short-run ARDL results.

Table 4: ARDL Long-Run and Short-Run Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Short-run estimates				
D(lnREC)	-2.124922	2.599846	-0.817326	0.4221
D(lnECG)	2.727756**	1.148011	2.376070	0.0262
D(lnFDI)	-0.027500	0.062707	-0.438550	0.6651
D(lnFD)	-0.214673	0.209809	-1.023182	0.3169
ECT(-1)	-0.776147***	0.153424	-5.058833	0.0000
Long-run estimates				
lnREC	7.777145**	3.183141	2.443230	0.0226
lnECG	0.114830	0.255865	0.448791	0.6578
lnFDI	-0.035432	0.081652	-0.433935	0.6684
lnFD	-0.276588	0.277818	-0.995571	0.3298
C	-33.517922*	19.051512	-1.759331	0.0918
Goodness of fit Parameters				
R^2	0.6913	F-statistics	7.3593 (0.0000)	
Adjusted R^2	0.5974	DW-stat	2.5099	

Source: Author's Computation (2023)

The result from Table 4 showed the short-run and long-run ARDL results for the impact of renewable energy consumption on trade openness in Nigeria respectively. The result showed that in the short-run, renewable energy consumption has a negative but statistically insignificant impact on trade openness. But in the long-run, the coefficient of renewable energy consumption 7.777145 turns out to be positive and has a statistically significant impact at 5 percent level of significant on trade openness. This implies that 1 percent increases in renewable energy consumption will bring about 7.777145 percent increase in trade openness in the long-run period. The findings did not corroborates the findings of Gershon and Emekalam (2021) for the same country of study. However, it's consistent with the results of Omri, Daly and Nguyen (2015) for MENA region countries.

The coefficient of economic growth was found to be statistically significant and positive at the short-run but statistically insignificant long-run. This implies that in the short run, 2.7277 percent increase in trade openness is associated with 1 percent increase in economic growth at 5 percent level of significance. Therefore, economic growth has a positive effect on trade openness. This result

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of implies that, economic growth of Nigeria drive the country's openness to trade within the short-run period only but did not in the long-run period because the long run coefficient was statistically insignificant. The result is consistent with the findings of Yusuf and Omar (2019) and Lawal and Ezeuchenne (2017) who reported significant positive relationship between trade openness and economic growth in Tanzania and Nigeria respectively. This implies that significant relationship between trade openness to economic growth is an implication of growth hypothesis which encourages the continuous generation of eco-friendly energy in boosting economic growth in the future.

The coefficients of foreign direct investment and financial development were negative but statistical insignificant in explaining their effect on the dependent variable trade openness in both short-run and long-run periods in Nigeria within the study sample period. For the foreign direct investment and trade openness, the study did not follow the work of Zaman, *et al*. (2017) who reported a significant positive relationship between the variables in their comparative study of Asian countries for the relationship between trade openness and foreign direct investment. While Thuy and Trong (2021) reported no significant relationship between financial development and trade openness in their study for the impacts of trade openness on financial development in developing countries using a Bayesian model averaging approach. Therefore, this shows that there is no evidence to support the Rajan and Zingales hypothesis that the simultaneous openness to both trade and capital flows promotes financial development and it is an indication that a better institutions environment allows a developing economy to exploit the benefits of openness to financial development.

The error correction term is the speed of adjustment of a particular model from the short run to the long run. If the coefficient on the error term is negative and statistically significant, it is consistent (Wooldridge, 2012). From the table, the coefficient is negative (-0.78) and significant, meaning that the system corrects its previous period disequilibrium at speed of 78 percent and it indicates the higher speed of adjustment of disequilibrium correction for reaching long run equilibrium steady state position.

The R-squared is 0.6913, means that 69.13 percent variation of trade openness is attributed to renewable energy consumption, economic growth, foreign direct investment and financial development while the unexplained 30.87 percent is captured through the white noise term in the model. The Adjusted R-squared is 0.5974, means that 59.74 percent variation of trade openness is attributed to renewable energy consumption, economic growth, foreign direct investment and financial development while the unexplained 40.26 percent is captured through the white noise term in the model. F-test application is done in order to examine if a group of variables employed in the model are jointly significant Gujarati, (2004). From the table above, the probability value of the model is significant at 1 percent level of significant. Thus, the model's variables have a jointly significant. The DW statistic value of 2.50 implies that the model is free from first order serial correlation since the value is within the bench mark of 1.50 to 2.50.

Diagnostic Checks Results

Several post-estimation tests were implemented to authenticate the credibility of the estimation procedure. The best assessment for the ARDL modeling technique includes Serial Correlation (using the LM test), Heteroscedasticity test (using Breusch-Pagan-Godfrey), Error specification test (employing Ramsey RESET Test), Normality test (employing Jarque-Bera test) and Stability test (with CUSUM test).

Table 5: Diagnostic Checks Results

Tests	F-statistic	Obs*R-squared
Serial Correlation LM Test	1.388692 (0.2777)	13.19041 (0.1055)
Heteroskedasticity Test	1.523434 (0.2089)	9.820130 (0.1990)
Normality (Jarque-Bera)	1.379626 (0.5016)	NA
Ramsey RESET Test	1.872712 (0.1785)	NA
Stability	Normally distributed	

Source: Author's Computation (2023)

The most prominent autocorrelation test is Breusch-Godfrey LM. From table 5 the null hypothesis states that there is no autocorrelation. The F-statistic and the obs*R-squared p-values

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obtained were 0.5073 and 0.1055. This indicated that there was no presence of serial-correlation in the model estimated as the null hypothesis of no serial-correlation could not be rejected.

The essence of heteroscedasticity is to validate which the variance of the residuals is finite. Thus, the null hypothesis states that the residual has a constant variance (i.e. homoscedasticity). From table 4.5 the F-statistic and obs*R-squared probability values result for the model were 0.2089 and 0.1990 respectively which showed that the residuals had a constant variance as the null hypothesis of homoscedasticity cannot be declined.

From table 5, the probability value of the Jaque-Bera obtained is 0.5016, which is statistically insignificant at 5 percent critical value. Hence, the null hypothesis is not rejected and implies that the residuals are normally distributed in the model.

The Ramsey's Linearity test result shows that T-statistics value was 1.872712 with probability 0.1785. The essence of Ramsey test is validating if the models are properly specified and linear. The null hypothesis states that the models are linear (Ramsey, 1969). Thus, Ramsey Reset result was based on the probability value of t-statistics which showed that the model is linear and correctly specified. The purpose of CUSUM and CUSUMSQ testing rate validating how stable the model estimated and its appropriateness in making long-run decisions. The result obtained from figure 1 shows that the model parameters are structurally steady and fit in making a long-run decision i.e. all the coefficients in the ARDL regression are fit for determining long-run conclusions. Conclusively, none of the diagnostic test results expectation were violated. Thus, the model is reliable and suitable for policy recommendations.

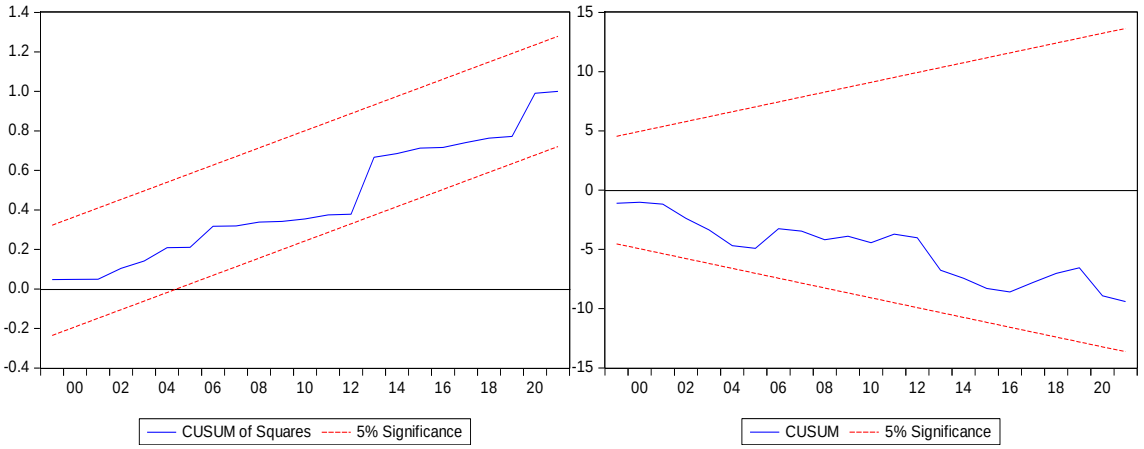

Figure 1: CUSUM and CUSUMSQ Stability Test Result

CONCLUSION

The impact of renewable energy consumption on trade openness in Nigeria was examined. The result from unit root showed that all the employed were stationary at first difference using ADF. The bounds test result revealed that there was strong cointegration relationship at 1 level of significance among the variables included in the estimated model.

The result from short-run and long-run ARDL showed that in the short-run, renewable energy consumption has a negative but statistically insignificant impact on trade openness. But in the long-run, the coefficient of renewable energy consumption turns out to be positive and was statistically significant at 5 percent level on trade openness. This means that renewable energy consumption leads to more openness to trade by the country as investors are looking for the cheaper and sustainable clean means of energy to fuel their machines as this will lead to cost reduction as well as profitable production process. The coefficient of error correction term is negative and statistically significant and it is consistent (Wooldridge, 2012). The coefficient suggested that the system will corrects its previous period disequilibrium at speed of 78 percent. Some post-estimation tests were implemented to authenticate the credibility of the estimation procedure. The best assessment for the ARDL modeling technique includes Serial Correlation (using the LM test), Heteroscedasticity test (using Breusch-Pagan-Godfrey), Error specification test (employing Ramsey RESET Test), Normality test (employing Jarque-Bera test) and Stability test (with CUSUM test). The most prominent autocorrelation test is Breusch-Godfrey LM. Result indicated that there was no presence of

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serial-correlation in the estimated model as the null hypothesis of no serial-correlation could not be rejected. The essence of heteroscedasticity is to validate which the variance of the residuals is finite. Thus, the null hypothesis states that the residual has a constant variance (i.e. homoscedasticity) and the result showed that the residuals had a constant variance as the null hypothesis of homoscedasticity cannot be declined. The probability value of the Jaque-Bera obtained was statistically insignificant at 5 percent critical value. Hence, the null hypothesis was not rejected and implies that the residuals are normally distributed in the model. The Ramsey's Linearity test result showed that the model is linear and correctly specified. The stability was validated using CUSUM and CUSUMSQ stable tests and the result showed that estimated model and its appropriateness were stable in making long-run decisions.

RECOMMENDATIONS

Based on the empirical findings and conclusion of this study, it is recommended that:

- Government should support and encourage investments in the renewable energy sector in the country as well as providing a conducive business environment for them. This will make renewable energy affordable and accessible to the people as well as attract green foreign investment into the country through openness to trade.
- Government should encourage the use of renewable energy in the country in order to reduce the domestic use of fossil fuel. This will help in the reduction of CO_2 emissions that causes environmental degradation, besides encouraging green economic growth as renewable energy consumption enhances growth. There is a need for the development of a robust waste management system in the country as waste has the potential for energy generation to drive the economy.

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