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# Renewable Energy Consumption, Oil Price and Level of Economic Growth in Nigeria: A Non-Linear Autoregressive Distributed Lag Approach

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## Abstract
*This paper analyze the causal relationship between renewable energy consumption, oil price and level of economic growth, using a non-linear auto regressive distributed lag approach for the period 1988–2020. The study revealed that renewable energy is by far the cleanest source of energy available. Findings of the study showed that oil price has significant and positive impact on economic growth in Nigeria, in the short-run and long run. Furthermore, results from the study showed that in the short and long run, renewable energy consumption has a positive but insignificant impact on the primary and tertiary sectors, whereas it has a negative and significant impact on the secondary sector. The study revealed that a percentage increase in oil price, all else constant, will significantly bring about 0.0697, 0.0887 and 0.0363 percentage increase in the short-run and 0.2283, 0.9610 and 0.7084 percentage increase in the long-run for the primary, secondary and tertiary sectors, respectively. Result of the study further revealed that in the long-run, a percentage rise in renewable energy consumption will bring about 1.0587, 0.2360 and 0.9365 percentage increase in the primary, secondary and tertiary sectors, respectively ceteris paribus. The study therefore recommends that the Nigerian government subsidizes renewable energy to enable it promote all levels of economic growth. Likewise, diversification policies should be adhered to in order to prevent the negative impact of fall in oil price on economic growth in Nigeria.*

**Keywords: Renewable, Energy, Consumption, Oil Price, Economic Growth**

## 1. Introduction

Attaining a higher and sustainable level of economic growth and development is one of the principal objectives of macroeconomic analysis, and by extension the goal of every economy. Therefore, a country's ability to achieve this enviable goal depends on among other things, its capacity to explore energy resources available to it. Theoretically, energy use is an essential indicator of economic growth and development as countries with higher per capita energy consumption are more developed than those with low per capita energy consumption. However, the classical perspective of economic growth, chiefly represented by Smith (1776), Malthus (1798); Ricardo (1817) focused mainly on capital accumulation, population growth and labour productivity, arguing in favour of free trade as the drive to economic growth (Gizo, 2019). Whether renewable or non-renewable energy, consumption of energy resource is important to the global economy including Nigeria and has been universally recognized as one of the most important inputs necessary for a productive economy and economic growth. Oil and natural gas alone are predicted to contribute almost 60 percent of global energy supplies in 2030 (Ghoble, 2012).

Nigeria is a mono-cultural economy which depends heavily on oil for revenue and foreign exchange earnings. Over the years, Nigeria's budget and other economic growth are hinged majorly on oil revenue. The product accounts for 80 percent of government revenue and 95 percent of foreign exchange earnings (Iwu, 2008). Oil price which is determined exogenously has been unstable over time due to changes in global demand for and supply of oil. Thus, making the Nigerian economy vulnerable to external shocks. Dwindling global economic growth affects global oil price negatively; thereby, declining oil revenue generated by oil exporting countries like Nigeria. For instance, the global financial meltdown of 2008 brought a decline of 39 percent in oil revenue in Nigeria (Budget, 2014). Lately, fluctuations in energy (particularly oil) prices, exhaustible nature of conventional energies and global warming have drawn the attention of different countries to the need for Renewable Energy (RE) sources.

Currently, Nigeria is blessed with great renewable energy resources. It lies within a high sunshine belt and therefore has sufficient solar radiation to generate electricity. For example, solar radiation per day in the Northern and Southern parts of the country is as high as 7000 W h/m$^2$ and 4000 W h/m$^2$ respectively (Mohammed, Mustapha, Bashir & Mokhtar, 2013). The country's wind energy reserve is at 10m height, with an annual average wind speed ranging from 8 MWh in Yola to 51 MWh in the area of Jos and may reach as high as 97MWhin Sokoto (Sambo, 2009). Nigeria is also blessed with great biomass resources which are predicted at 8 x 10$^2$MJ (Sambo, 2015), while the hydropower potential in the country is estimated at 14,750 MW (Shaaban & Petinrin, 2014). Besides, the country is endowed with large rivers and some natural falls which are responsible for the high hydropower potentials.

The use of energy in the modern world is highly essential in promoting economic growth, improving living standards, curbing unemployment and reducing poverty. This suggests that countries that are endowed with abundant energy resources should have high living standards, low unemployment and poverty rates. More so, economic growth in these countries should witness a boom. However, Nigeria, despite having enormous non-renewable energy resources as well as huge potentials for generating renewable energies, does not seem to have a better level of economic growth. This is evident by the recent naming of the country the world headquarters of poverty in 2018 by Brookings International. It is therefore on these bases that this research work empirically investigates the impact oil price and renewable energy consumption has on the level of economic growth in Nigeria.

## 2. Literature Review and Theoretical Framework

This study reviewed a number of studies, findings of these studies vary, for instance, in order to establish the links between oil prices and various macroeconomic and financial variables for 36 countries, OPEC member included Lescaroux and Mignon (2008) employed Vector Autoregressive (VAR) to annual data from 1960-2005 and found unidirectional causality from oil price to GDP. However, Wang, Tao and Lobont (2019) revealed a time-varying positive bidirectional causality between oil and agricultural prices over certain sub-periods. They explored the causalities between oil and agricultural commodity prices to examine whether the vertical market integration model holds for global market applying VAR and Granger causality to monthly data from January 1990 to February 2017.

To examine the impact of oil price shocks on the Nigerian economy Mobolaji and Adeniran (2014) utilized General Method of Moments (GMM) and annual data from 1981-2012. They found that oil price shocks insignificantly retard economic growth while oil price itself significantly improves the economy. Similarly, Dong *et al* (2018) confirmed an evidence of a significant and positive relationship between global economic activity and oil price with dynamic lead-lag relationships across time. They applied Wavelet analysis approach to monthly data from May 1985 to February 2018 to examine the dynamic relationship between global economic activity and crude oil prices in both time and frequency domains. In the same vein, Nwoba, Nwonu and Agbaeze (2017) examined the impact of fallen oil prices on the Nigeria economy for the period 2011-2015 using OLS for this period and found that a fallen oil price has a significant effect on the Nigerian economy and has impacted negatively on it.

To analyse the casual relationship between renewable energy consumption, oil prices, and economic activity in the United States, Troster, Shahbaz and Uddin (2018) applied Granger causality to monthly data from July 1989 to July 2016. Their study established an evidence of bi-directional causality between renewable energy consumption and economic growth. These findings corroborate with Naminse and Zhuang (2015) study who applied ARDL and Granger causality to annual data for the period 1952-2012 mainly to investigate the relationship among renewable energy, carbon emissions and economic growth in China. They revealed that GDP has bi-directional relationship with coal, gas and electricity consumption.

Conversely, findings from study by Belaid and Youssef (2017) revealed that there exists a unidirectional causality from GDP to non-renewable electricity consumption after applying VECM and Granger causality to annual data from 1980-2012 to explore the dynamic causal relationship between $CO_2$ emissions, renewable electricity consumption, non-renewable electricity consumption and economic growth in Algeria. Their findings aligns with Alam, Ahmed and Begun (2017) who also found a unidirectional causality that runs from economic growth to energy demand in the case of Bangladesh. They analysed the causal relationship between energy demand and economic growth by utilizing Maximum Entropy Bootstrap (MEBOOT), VAR and annual data for the period 1980-2011. In contrast, Empirical results of Vlahinic-Dizdarevic and Zikpvic (2010) provided clear support of causality that runs from real GDP growth to energy consumption in industry and households, oil consumption, primary energy production and net energy imports. Their study applied Error Correction Model (ECM) to annual data that spanned from 1993-2006 in Croatia, Bloch, Rafiq and Salim (2015) revealed that Chinese' economic growth is led by coal, oil and renewable energy consumption after employing ARDL and VECM to annual data from 1965-2013 to investigate the relationship between aggregate output and energy consumption in the form of coal, oil and renewable energy.

Although literature is replete with studies on renewable energy, economic growth and environmental sustainability, there is no consensus view. None of these studies reviewed evaluated the impact of renewable energy expansion on both macroeconomic aggregates and environmental quality either in Nigeria or elsewhere. Most of the studies on renewable energy deployment either focused on economic growth or on carbon emission separately. Rather than focusing mainly on economic growth as a measure of macroeconomic aggregate as done by most of the studies in literature. This study wills in addition; incorporate other macroeconomic aggregates to address the welfare of the people.

## 2.1 Theoretical Review

### 2.1.1 Robert Solow's Growth Theory

Solow's growth theory is an extension of the Cobb-Douglas production function and an expansion of the Harrod-Domar model by adding a second factor, labour and introducing a third independent variable and technology to the growth equation. This growth theory explains that output depends on the technology, number of employees, amount of physical capital, the amount of human capital as well as the amount of natural resources (Soejoto, Cahyono & Slikhah, 2017).

The growth theory assumes that labour force grows exogenously at the constant rate and technological progress is exogenous. Furthermore, the theory assumes diminishing marginal productivity of labour and capital, constant returns to scale, full employment of labour and capital, flexible prices and wages and constant saving ratio. The Solow's neoclassical growth theory uses a standard aggregate production function in which a single good (Y) is produced using two factors of production, labour (L) and capital (K) in an aggregate production function which imply that the elasticity of substitution must be asymptotically equal to one. This relationship is given by Equation below.

$$Y(t) = K(t)\alpha\ (A(t)\ L(t)1 - \alpha \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where Y in the above equation is Gross Domestic Product (GDP), K is the stock of capital (which may include human capital as well as physical capital), L is labour, and A represents the productivity of labour or labour-augmenting technology, which grows at an exogenous rate, t denotes time and $0<\alpha< 1$. Output is taken as a whole and the only commodity in the economy. Equation 12 suggests that the output of an economy depends on two factors; labour (L) and capital (K).

The growth model assumes that the quantity of output produced is determined by the quantity of labour and capital available. That is to say, if a society has more of labour and capital, the society will produce more and vice versa. According to the Solow's growth model, at the initial stage of production, all factors of production are fully employed and their initial values A(0), K(0) and L(0) are given. Labour and technology grow exogenously at rates n and g respectively given by the below Equations.

$$L(t) = L(0)en\, t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

$$A(t) = A(0)egt \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

Where L(t) and A(t) are the respective values of labour and capital at a particular time t. Equation (1) suggests that the stock of labour which a society can have at a particular time is determined by the initial value of labour (L(0) and its growth rate at a particular time (nt). Similarly, Equation (2) indicates that the technology available in an economy at a particular time is determined by the initial available technology (A(0)) and its growth rate at given time (gt). If L (0) and A(0) and their respective growth rates nt and gt are high, in addition to K(0), then the GDP will be high and vice versa.

## 2.1.2 Two-Sector Model (Economic Growth and Useful Work)

The two-sector model is based on the neoclassical theory of growth originated by Solow. The neoclassical growth theory has been developed over the years with important contributions to questions related to energy, the environment, and economic growth, as well as natural resource extraction, environmental quality and income levels (Santos, 2013). This model is a framework that was developed to explain the proximate causes and mechanisms behind economic growth, under the assumption that energy (or an energy-related proxy) is an essential factor of production.

Based on this model, the economy is described as a two-stage process with a separation between the energy-related activities and the remaining economic growth. It is assumed that this is a closed economy, running in continuous time and populated only by consumers (households, government and Non-Profitable Institutions Serving Households, (NPISH) and firms. Factors as imports/exports, taxes and subsidies, as well as capital transfers and net lending/borrowing are disregarded in this simple analysis. Markets are assumed as perfectly competitive, so that economic agents take prices as given. The Energy Sector (E-Sector) is responsible for supplying the economic system with useful work (energy) which can act as an intermediate or be directly consumed by households, government and NPISH. The Non-Energy Sector (NE-Sector) produces all kinds of final investment and non-energy related consumption goods and services in the economy.

This theoretical model holds that energy enters the economy through the E-sector as primary energy inputs from the environment $B^P(t)$. Here, energy is converted into useful work ($B^U(t)$) in function of the physical capital invested in this sector ($K^E(t)$). A constant fraction of this useful work ($0<\gamma<1$) will be used as a factor of production for the NE-Sector, while the rest will be directly consumed by households, government, and NPISH ($C^E(t)$). The NE-Sector will use the outputs of the E-Sector not attributed to direct consumption, as well as its own capital inputs ($K^{NE}(t)$) and labour inputs (L(t) to produce non-energy related consumption goods ($C^{NE}(t)$ and investment for both sectors (L(t)) through a neoclassical production function ($Y^{NE}(t)$).

## 3. Methodology

The study will employ Linear Autoregressive Distributed Lag (ARDL) and the Toda and Yamamoto test in Nigeria. The justification for the choice of this model is shown in the model specification.

### 3.1 Model Specification

This study examined the impact of renewable energy consumption and oil price of the level of economic growth in Nigeria. The symmetric ARDL model developed by Pesaran, Shin and Smith (2001) was used to achieve this objective. This model used a sufficient number of lags to capture the data generating process in a general-to-specific modeling framework (Laurenceson & Chai, 2003). Equations 4, 5 and 6 specify the standard log-log symmetric ARDL models for the primary, secondary and tertiary sectors.

$$\Delta InPEC_t = \alpha_0 \sum_{i=1}^{n} \alpha \Delta InPEC_{t-i} + \sum_{i=0}^{n} \alpha_3 \Delta REC_{t-i} + \sum_{i=0}^{n} \alpha_3 \Delta InOIP_{t-i} + \sum_{i=0}^{n} \alpha_4 \Delta InEXR_{t-i} +$$

$$\sum_{i=0}^{n} \alpha_5 \Delta InINTRO + \lambda InPEC_{t-i} + \lambda_2 InnREC_{t-i} + \lambda_3 InOIP_{t-i} + \lambda_4 InEXR_{t-i} + W_5 InTRO_{t-i} + \mathcal{E}t \ldots\ldots 4$$

$$\Delta InSEC_t = \alpha_0 \sum_{i=1}^{n} \alpha \Delta InPEC_{t-i} + \sum_{i=0}^{n} \alpha_3 \Delta REC_{t-i} + \sum_{i=0}^{n} \alpha_3 \Delta InOIP_{t-i} + \sum_{i=0}^{n} \alpha_4 \Delta InEXR_{t-i} + \sum_{i=0}^{n} \alpha_5 \Delta InINTRO + \lambda InPEC_{t-i} + \lambda_2 InnREC_{t-i} + \lambda_3 InOIP_{t-i} + \lambda_4 InEXR_{t-i} + W_5 InTRO_{t-i} + \mathcal{E}t \ldots\ldots 5$$

$$\Delta InTET_t = \delta_0 \sum_{i=1}^{m} \delta_1 \Delta InTET_{t-i} + \sum_{i=0}^{m} \delta_2 \Delta REC_{t-i} + \sum_{i=0}^{m} \delta_3 \Delta InOIP_{t-i} + \sum_{i=0}^{m} \delta_4 \Delta InEXR_{t-i} + \sum_{i=0}^{m} \delta_5 \Delta InINTRO + w_1 InPEC_{t-i} + \phi_2 InnREC_{t-i} + \phi_3 InOIP_{t-i} + \phi_4 InEXR_{t-i} + \phi_5 InTRO_{t-i} + \mathcal{E}t \ldots\ldots 6$$

Where, Δ and t in Equations 4, 5 and 6 denote the first difference operator of the respective variables and time respectively, $\mathcal{E}_t$ is the white noise stochastic disturbance term assumed to be normally distributed, $\alpha_i$ $\beta_i$ and $\delta_i$ are the short run coefficients while λi wi and ϕi are the corresponding long run multiplier of the underlying ARDL model, $PRI_t$, $SEC_t$ and $TET_t$ denote primary, secondary and tertiary sectors, correspondingly and REC, *OIP, EXRANDTRO* denotes renewable energy consumption, oil price, exchange rate and trade openness, respectively. Optimal lag lengths included in the estimation of the equation are denoted by *n, m* and *w* and can assume any positive value.

Error Correction Model (ECM) can be derived from ARDL through a simple linear transformation (Benerjee, Dolado, Galbraith & Hendry, 1993). ECM integrates short-run adjustments with long-run equilibrium without losing long-run information (Pesaran & Shin, 1999). The ECM result indicates the speed of adjustment back to long-run equilibrium after a short-run shock. Equations 4, 5 and 6 are re-specified to capture the Error Correction Term (ECT), thus, we have Equations 7, 8 and 9.

$$\Delta InPEC_t = \alpha_0 \sum_{i=1}^{n} \alpha \Delta InPEC_{t-i} + \sum_{i=0}^{n} \alpha_3 \Delta REC_{t-i} + \sum_{i=0}^{n} \alpha_3 \Delta InOIP_{t-i} + \sum_{i=0}^{n} \alpha_4 \Delta InEXR_{t-i} + \sum_{i=0}^{n} \alpha_5 \Delta Intro_{t-i} + \varphi ECT_{t-i} + \varepsilon_t \ldots\ldots 7$$

$$\Delta InSEC_t = \beta_0 \sum_{i=1}^{m} \alpha \Delta InSEC_{t-i} + \sum_{i=0}^{m} \beta_3 \Delta SEC_{t-i} + \sum_{i=0}^{m} \beta_3 \Delta InOIP_{t-i} + \sum_{i=0}^{m} \beta_4 \Delta InEXR_{t-i} + \sum_{i=0}^{m} \beta_5 \Delta InTRO_{t-i} + \Phi ECT_{t-i} + \varepsilon_t \ldots\ldots 8$$

$$\Delta InTET_t = \delta_0 \sum_{i=1}^{w} \alpha \Delta InTET_{t-i} + \sum_{i=0}^{w} \delta_3 \Delta SEC_{t-i} + \sum_{i=0}^{w} \delta_3 \Delta InOIP_{t-i} + \sum_{i=0}^{w} \delta_4 \Delta InEXR_{t-i} + \sum_{i=0}^{w} \beta_5 \Delta InTRO_{t-i} + \gamma ECT_{t-i} + \varepsilon_t \quad \ldots\ldots 9$$

The parameter of the term $ECT_{t-1}$ is the speed of or the feedback effect. It is derived as the error term from the ARD L-models (Equations 4, 5 and 6). Coefficient of the $ECT_{t-1}$ shows how much of the disequilibrium is corrected, i.e., the extent to which any disequilibrium in the previous period is adjusted towards the long run equilibrium in the $PEC_t$, $SEC_t$ and $TET_t$ models. A positive coefficient indicates a divergence, while a negative coefficient indicates convergence. If the estimate of $ECT_{t-1} = 1$, than 100 percent of the adjustment takes place within the period, or the adjustment is instantaneous and full, if the estimate of $ECT_{t-1} = 0$, it shows that there is no adjustment.

Renewable Energy Consumption (REC), Oil Price (OIP), Naira/US Dollar Exchange Rate (EXR), Trade Openness (TRO) and the Primary (PRI), Secondary (SEC) and Tertiary (TET) sector activities were employed for this study.

**A Priori Expectation**

In this study the short and long run a priori expectation for the primary, secondary and tertiary sectors are stated below.

Primary sector:

$\alpha_2, \alpha_3, \lambda_2, \lambda_3 > 0$ and $\beta_4, \beta_5, \lambda_4, \lambda_5 < 0$

Secondary sector:

$\beta_2, \beta_3, w_2, w_3 > 0$ and $\beta_4, \beta_5, w_4, w_5 < 0$

Tertiary sector:

$\delta_2, \delta_3, \phi_2, \phi_3 > 0$ and $\delta_4, \delta_5, \phi_4, \phi_5 < 0$

This suggests that the coefficients of renewable energy consumption and oil price in Equations 1-3 should be positive and greater that zero and the coefficients of trade openness and the Naira/US Dollar exchange rate in all the models be negative and less than zero. It implies that a positive relationship is expected between economic growth (primary, secondary and tertiary sector activities) and renewable energy consumption and oil price. With regard to trade openness and the Naira/US Dollar exchange rate, the a priori expectation proposes that there is a negative relationship between economic growth (primary, secondary and tertiary sectors activities), trade openness and the Naira/US Dollar exchange rate.

## 4. Results and Discussion

Descriptive analysis of the primary, secondary and tertiary sectors activities, renewable energy consumption, oil price, exchange rate and trade openness is carried out in order to describe the main attributes of these variables.

The summary of the descriptive statistics for these variables are presented in Table 1.

**Table 1: Descriptive Statistics**

| Vari. | Mean | Median | Max. | Min. | Std.dev. | Skewness | Kurtosis | J. Berra | OBS |
|---|---|---|---|---|---|---|---|---|---|
| *InPRI* | 9.5837 | 9.6201 | 10.0710 | 8.9397 | 0.3843 | -0.1592 | 1.4806 | 3.3139 | 33 |
| *InSEC* | 8.1254 | 7.8548 | 9.1342 | 7.4439 | 0.5775 | 0.6888 | 1.9353 | 4.1684 | 33 |
| *InTET* | 9.5237 | 9.3339 | 10.5334 | 8.6449 | 0.6687 | 0.3172 | 1.5278 | 3.5334 | 33 |
| *InREC* | 4.3835 | 4.3894 | 4.4280 | 4.3366 | 0.0203 | -0.5062 | 2.9240 | 1.4173 | 33 |
| *InOIP* | 3.5592 | 3.3555 | 4.7152 | 2.5463 | 0.7059 | 0.3303 | 1.6156 | 3.2354 | 33 |
| *InEXR* | 3.9831 | 4.7753 | 5.7239 | 0.5622 | 1.4166 | -0.7716 | 2.4032 | 3.7638 | 33 |
| *InTRO* | -1.1762 | -1.0576 | -0.5290 | -2.6088 | 0.4062 | -1.3941 | 5.8363 | 21.7521*** | 33 |

Note: *** denotes statistically significant at 1 percent level of significance.
**Source: Authors Computation using Eviews 10.**

Table 1: The descriptive statistics of primary, secondary and tertiary sector, renewable energy consumption, oil price, exchange rate and trade openness. Primary sector has the highest average value of 9.5837 followed by the tertiary and secondary sectors with respective average values of 9.5237 and 98.1254. The kurtosis confirms that only trade openness is leptokurtic, i.e., highly peaked whereas, primary, secondary and tertiary sectors, renewable energy consumption, oil price and exchange rate are less peaked-platikurtic.

## 4.1 Unit Root Test Result

The Augmented Dickey-Fuller (ADF) and the Philips-Perron (PP) unit root tests were employed to test for the stationarity status of renewable energy consumption, oil price, exchange rule, trade openness and primary, secondary and tertiary sectors. Table 6 reports summary of the unit root test results for these variables.

**Table 2: Unit Root Test Result**

| Variables | Augmented Dickey Fuller (ADF) | | | Philips Perron (PP) | | |
|---|---|---|---|---|---|---|
| | Levels | First differences | 1(d) | Levels | First difference | 1(d) |
| InPRI | $-1.4866^{m}$ | $-4.4028^{***m}$ | I(1) | $-1.2119^{n}$ | $0.0015^{***n}$ | I(1) |
| InSEC | $-1.6325^{n}$ | $-2.112639^{**o}$ | I(1) | $3.0487^{o}$ | $-2.2319^{**o}$ | I(1) |
| InTET | $-4.5658^{***n}$ | | I(0) | $-1.8075^{n}$ | $-3.1900^{**m}$ | I(1) |
| InREC | $-2.7857^{n}$ | $-5.310666^{***m}$ | I(1) | $-2.1610^{m}$ | $-6.0863^{***m}$ | I(1) |
| InOIP | $-2.0075^{n}$ | $-4.779323^{***m}$ | I(1) | $-2.0787^{n}$ | $-4.7101^{***m}$ | I(1) |
| InEXR | $-2.7417^{*m}$ | - | I(0) | $-2.9164^{*m}$ | - | I(0) |
| InTRO | $-4.6182^{***m}$ | - | I(0) | $-4.6592^{***m}$ | - | I(0) |

**Note:** ***,** and * signify statistically significant at 1 percent, 5 percent and 10 percent respectively, while $^{m}$,$^{n}$ and $^{o}$ denote model with intercept only, model with intercept and trend and model with none respectively.

**Source: Authors Computation using Eviews 10.**

The Stationarity test on the variables was carried out at intercept only, at intercept and trend and at none. Table 2 reveals that the null hypothesis of both the ADF and PP unit root tests for exchange rate and trade openness were rejected at level suggesting that they are stationary at level. From Table 6, the ADF unit root test for the tertiary sector is stationary at level, while the null hypothesis of non-stationarity using the PP unit root test for the tertiary sector is accepted at level- implying that there is unit root in the variable. Nevertheless, the variable was differenced on time and found to be stationary at 5 percent level of significance. With regard to primary and secondary sectors, renewable energy consumption and oil price, the null hypothesis of non-stationarity of both the ADF and PP unit root tests were accepted at levels, i.e., the series are not stationary at level. However, the series were put to stationarity test at their first difference and were found to be significant at 1 percent level of significance for both the ADF and PP tests; implying the absence of unit root in the series. Rejecting the null hypothesis of non stationarity at either level or first difference for all the series under study suggests that results obtained from the study are reliable (not spurious) and can be used for policy.

### 4.2 Symmetric Short-and Long-Run Autoregressive Distributed Lag (ARDL) Models Estimates

To determine the short-and long-run relationship between renewable energy consumption, oil price, exchange rate, trade openness and economic growth, the ARDL model for the primary, secondary and tertiary sectors models were estimated and summarized below

**Table 3: Summary of the ARDL estimates.**

| **Var.** | **Primary Sector** | | **Secondary Sector** | | **Tertiary Sector** | |
|---|---|---|---|---|---|---|
| | **Short run Coefficient** | **Long-run Coefficient** | **Short-run Coefficient** | **Long-run Coefficient** | **Short-run Coefficient** | **Long-run Coefficient** |
| Constant | 1.4651 | 3.5155 | 0.6269 | 3.2982 | 0.4353 | 2.2882 |
| | (2.4442) | (5.4633) | (1.5030) | (7.9058) | (1.2622) | (6.6644) |
| InREC | 0.7886 | 1.0587 | -1.2487*** | 0.2360 | 0.1781 | 0.9365 |
| | (0.6653) | (1.2581) | (0.4336) | (1.8219) | (0.2962) | (1.5303) |
| InOIP | 0.0697* | 0.2283*** | 0.0887*** | 0.9610*** | 0.0363*** | 0.7084*** |
| | (0.0370) | (0.0492) | (0.0271) | (0.1081) | (0.0100) | (0.0720) |
| InEXR | -0.0356 | 0.1627*** | 0.0037 | 0.019561 | -0.0204 | 0.1906*** |

| | | | | | | |
|---|---|---|---|---|---|---|
| | (0.0318) | (0.0236) | (0.0087) | (0.0444) | (0.0235) | (0.0376) |
| InTRO | 0.0697 | -0.0313 | -0.1028*** | -0.5408*** | 0.0576** | -0.1071 |
| | (0.0507) | (0.0776) | (0.0278) | (0.1092) | (0.0258) | (0.1171) |
| $ECT_{t-1}$ | -0.4168*** | | -0.1901*** | | -0.1902*** | |
| | (0.1185) | | (0.0317) | | (0.0351) | |
| R2 | 0.9887 | | 0.9969 | | 0.9984 | |

**Note:** ***,** and * denote statistically significant at 1 percent, 5 percent and 10 percent significant levels respectively, (.) is standard error.

**Source: Authors Computation using Eviews 10.**

The ARDL estimates of primary, secondary and tertiary sectors models are reported. In the short-run, while oil price is positively and significantly related to the primary sector, renewable energy consumption and trade openness are positively and insignificantly related to the primary sector. With regard to the Naira/US Dollars exchange rate, it is negatively but insignificantly associated with the primary sector in the short-run. Furthermore, the short-run estimates reveal that, all else constant, if renewable energy consumption increases by 1 percent, primary sector will rise by 0.7886 percent. Similarly, a percentage rise in oil price will significantly raise primary sector activity by 0.0697 percent. All other things equal, a percentage increase in trade openness will bring about 0.697 percent increase in primary sector activity, but this is not significant.

On the other hand, a percentage increase in units of the Naira exchanged for a US Dollar will bring about 0.0356 percentage decrease in the value of primary sector in the short-run, *ceteris paribus.* The coefficient of the Error Correction Term ($ECT_{t-1}$), for the primary sector model. The correct sign and probability value (-0.4168); this indicates the evidence of a long-run relationship between the primary sector and its repressors. This suggests that nearly 41.68 percent of the disequilibria in renewable energy consumption, oil price, exchange rate, trade openness and primary sector of the previous year's shock adjust back to the long-run equilibrium in the current year. The Adjusted R-Squared ($\bar{R}^2$) value (0.9887) indicates that the estimated model has a reasonable good fit. About 98.87 percent of variations in the primary sector is attributable to renewable energy consumption, oil price, exchange rate and trade openness.

The long-run estimates of the primary sector confirm that renewable energy consumption, oil price and the Naira/US Dollar exchange rate are positively connected to primary sector. *Ceteris Paribus,* if oil price and the Naira/US Dollar exchange rise by 1% primary sector will increase by 0.2283% and 0.1627 percent, respectively and are both statistically significant at 1%; implying that they are highly important in contributing to the activities of the primary sector. The results further reveal that a percentage increase in renewable energy consumption will insignificantly increase primary sector activity by 1.0587 percent all else constant. With regard to trade openness, it shows that it negatively and insignificantly linked to primary sector activity. A percentage increase in trade openness, all other things constant will decrease primary sector activity by 0.3400 percent in the long-run.

For the secondary sector, is positively linked to oil price and the Naira/US Dollar exchange rate whereas renewable energy consumption and trade openness are negatively and significantly associated with secondary sector in the short-run. More precisely, a percentage surge in renewable energy consumption and trade openness significantly runs down secondary sector activity by 1.2487 percent and 0.1028 percent respectively, *ceteris paribus.* On the other hand, all other things equal, a percentage rise in oil price significantly boosts secondary sector by 0.0887 percent while a percentage rise in exchange rate improves secondary sector activity by 0.0037 percent but insignificantly in the short-run. In addition, the negative and statistically significant coefficient of the lagged Error Correction Term ($ECT_{t-1}$) for the secondary sector model validates the existence of a long-run relationship between renewable energy consumption, oil price, exchange rate, trade openness and secondary sector. The coefficient on $ECT_{t-1}$ also implies that deviations from the long-run equilibrium are corrected by 19.01 percent in each year. Furthermore, the goodness of fit of the specification ($R^2$ = 0.9968) is very close to one that is preferred in econometric analysis and confirms the joint significance of explanatory variables in the ARDL model.

The long-run estimates of the secondary sector reveals that the coefficients of renewable energy consumption, oil price and exchange rate are positively associated to secondary sector but trade openness is negatively and significantly related to secondary sector. Specifically, a percentage upswing in renewable energy consumption and exchange rate will bring about 0.2360 percent and 0.020 percent increase, respectively in secondary sector both insignificantly *ceteris paribus.* Furthermore, a percentage rise in oil price significantly (at 1 percent) brings about 0.9620 percentage increase in secondary sector in the long-run all else constant. With regard to trade openness, all other things equal, a percentage increase in trade openness causes secondary sector to decline by 0.5408 percent and is statistically significant at 1 percent level in the long-run.

The tertiary sector discloses that in the short-run, trade openness is positively and significantly linked to tertiary sector. Similarly, the table reveals that renewable energy consumption is positively connected to tertiary sector however, it is insignificant. The estimates further confirm that every other thing constant, if renewable energy consumption and trade openness increases by 1 percent, tertiary sector activity will increased by 0.1781 percent (insignificant) and 0.05760 percent (at 1 percent significance level), respectively. The coefficient of the $ECT_{t-1}$(-0.1902) is statistically significant at 1 percent significance level. This indicates that around 19.02 percent of instabilities in renewable energy consumption, oil price, exchange rate, trade openness and tertiary sector of the shock of previous year will adjust back to the long-run equilibrium in the current year. The $\bar{R}^2$ value of 0.9984 indicates a strong explanatory power of the tertiary sector model. About 99.84 percent variations in tertiary sector activity are attributable to renewable energy consumption, oil price, Naira/US Dollar exchange rate and trade openness.

The impact of oil price and Naira/US Dollar exchange rate on the tertiary sector activity is positive and both statistically significant (at 1 percent level) in the long-run. The table also shows that renewable energy consumption and tertiary sector are positively but insignificantly related in the long-run. On the other hand, the table reports that trade openness is negatively but insignificantly related to tertiary sector in the long-run. Explicitly, a percentage increase in oil price and the Naira/US Dollar exchange rate will all else constant, significantly boost tertiary sector by 0.7084 percent and 0.1906 percent, respectively.

Meanwhile, a percentage rise in renewable energy consumption translates into 0.9365 percentage increase in tertiary sector in the long-run *ceteris paribus.* With respect to trade openness, a percentage surge in trade openness will every other thing equal cause tertiary sector to weaken by 0.1071 percent, but insignificantly in the long-run.

### 4.3 Post-Estimation Tests Results

In order to validate the estimates of the ARDL model for the primary, secondary and tertiary sectors, Table 4 shows the post-estimation tests results of normality, homoscedasticity, functional form (linearity) and serial correlation.

**Table 4: Post-Estimation Tests Result**

| | **Primary** | **Secondary** | **Tertiary** |
|---|---|---|---|
| Normally (X2) | 0.8171 (0.6646) | 0.0700 (0.9656) | 20.6559 (0.0000) |
| ARCH (X2) | 0.6321 (0.4333) | 0.0362 (0.8504) | 0.3929 (0.5359) |
| RESET (X2) | 1.7044 (0.2828) | 2.9482 (0.1368) | 1.7951 (0.1907) |
| Serial (X2) | 0.5989 (0.5613) | 0.1301 (0.8788) | 0.0641 (0.9380) |

**Note:** [.] is P-value.
**Source: Authors Computation using Eviews 10.**

The primary and secondary sectors, the Jarque-Berra statistics indicate that the residuals of the series are normally distributed as their p-values are greater than the 10 percent level of significance, thus, the acceptance of the null hypothesis of normally distributed residuals and the rejection of the alternative hypothesis which states that they are not normally distributed. This implies that the study does not violate one of the classical linear regression assumptions of a normally distributed error term or residual for the primary and secondary sector. The above results confirm that the estimates of the primary, secondary and tertiary sectors models do not violate the classical linear regression model assumption of homoscedasticity of the variance of the error term. The results of the Autoregressive Conditional Heteroskedasticity (ARCH) LM test reveal that the null hypothesis of no existing ARCH up to order in the residuals is not rejected since the p-values of the F-statistics of the tests are not statistically significant at 1, 5 or 10 percent level of significance. This means that the variances of the error terms of Equations 1-3 are not heteroskedastic, i.e., they are constant. The p-values of the F-statistics for the Ramsey reset tests (functional form tests) for the primary, secondary and tertiary sectors are not statistically significant at 1, 5 and 10 percent level of significance, this entails that the null hypothesis that there are no omitted variables or the models are correctly specified is accepted. Therefore, the ARDL models which state the relationship among renewable energy consumption, oil price, exchange rate, trade openness and the level of economic growth are correctly specified and the underlying assumptions of the classical linear regression are satisfied.

## 4.4 Discussion of Findings

Based on the *a priori* expectation of this study, the relationship between renewable energy consumption, oil price and economic growth (primary, secondary and tertiary sectors) is expected to be positive. The results conform to the *a priori* expectation of a positive relationship between economic growth and oil price for all the sectors. This finding agrees with that of Dong, Chang, Gong & Chu (2018) who found an evidence of a positive and statistically significant relationship between global economic growth and oil price. However, the results contradict that of Leifao (2014) whose result reveals a negative relationship between oil price and economic growth for the case of Greece. In the same way, the relationship between economic growth and renewable energy consumption for the primary and tertiary sectors in the short-and long-run and for secondary sector in the long-run follows the *a priori* expectation. However, the short-run relationship between the secondary sector and renewable energy consumption is negative which violates the *a priori* expectation. This short-run negative relationship between renewable energy consumption and secondary sector could be justified considering that the initial cost of renewable energy installation (apart from the grid) in Nigeria is very expensive. As a result, renewable energy contributes less to output of secondary sector than its initial cost of installation leading to reduction in the output of the secondary sector.

The relationship between exchange rate, trade openness and economic growth is expected to be negative. From the ARDL estimates reported in Table 8, only the short-run estimates of the primary and tertiary sectors conform to the *a priori* expectation of a negative relationship between exchange rate and economic growth. The long-run estimates of both the primary and tertiary sectors and the short-and long-run estimates of the secondary sector show a positive relationship between exchange rate and economic growth. This implies that if the Naira depreciates against the US Dollar, Nigerian products become more competitive in the international market, this leads to increased exportation and thus boost in economic growth *ceteris paribus*. With respect to trade openness and economic growth, all the estimates follow the *a priori* expectation except for the short-run estimates of the primary and tertiary sectors.

The short-and long-run estimates of the primary sector model show that renewable energy consumption and trade openness do not significantly influence the primary sector. This implies that renewable energy consumption and trade openness are inconsequential in determining the primary sector activities in Nigeria in the short-run. Results further disclose that oil price is a key variable that influences activities in the primary sector in both short-and long-run. Since Nigeria is an oil producing and exporting country, an increase in oil price will all else constant increase government revenue, increase in government revenue leads to an increase in economic growth as a result of increased government expenditure. With regard to the Naira/US Dollar exchange rate, appreciation of the US Dollar against the Naira immaterially boosts the primary sector in the short-run whereas, in the long-run, when the Naira becomes weak in relation to the US Dollar, primary sector significantly witnesses a boost. This is because, all else constant, Naira depreciation will make the Nigerian product more competitive in the international market and thus increased production as a result of increased export.

The coefficients of renewable energy consumption with respect to secondary sector show positive significant and negative not significant in the short- and long-run, respectively. This is because generating power from renewable sources requires high capital investment and so, the expected benefits are way too less especially when compared with the aggregate cost in the short-run whereas, benefits of renewable energy are reaped over some period of time (long-run). Just as the primary sector, oil price plays a vital role in determining activities in the secondary sector in both the short-and long-run. The exchange rate is positively but insignificantly related to secondary sector activities in both the short-and long-run. This implies that a fall in the value of the Naira against the US Dollar has a weak impact in promoting secondary sector activities. Conversely, trade openness proves to be an important variable that weakens secondary sector activities. The negative and significant relationship between trade openness and secondary sector activities could be as a result of unfavourable competition the manufacturing and construction industries in Nigeria face from foreign industries as a result of open trade.

The renewable energy consumption is an unimportant determinant of activities in the tertiary sector of the Nigerian economy in both the short-and long-run. However, the table shows that oil price is a key variable that encourages activities in this sector. This suggests that, an increase in oil price creates an impetus for economic growth in the tertiary sector. This could be due to the fact that Nigeria being an oil producing and exporting country, an increase in oil price will being about an increase in government revenue which in turn increases government spending and thus economic growth through a multiplier effect. Similar to the primary sector, depreciation of the Naira against the US Dollar insignificantly run down tertiary sector in the short-run. Conversely, Naira depreciation considerably stimulates tertiary sector activities in the long-run. In the short-run, trade openness is vital in determining the tertiary sector activities. This suggests that open trade significantly promotes tertiary sector activities in the short-run. In the long run however, trade openness has negative but negligible impact on activities in the tertiary sector.

## 5. Conclusion and Recommendations

Global oil price considerably influences the level of economic growth (primary, secondary and tertiary sectors) both in the short-and long-run in Nigeria; the primary and tertiary sectors respond weakly to renewable energy consumption in both the short-and long-run, while the secondary sector significantly contracts in the short-run and insignificantly increase in the long-run as a result of increase in the consumption of renewable energy; the Naira/US Dollar exchange rate depreciation significantly boosts the primary and tertiary sectors in the long-run, insignificantly improves the secondary sector in both the short-and long-run and insignificantly decreases the primary and tertiary sectors in the short-run. trade openness substantially dampens the secondary sector in both the short-and long-run, slightly weakens the primary and tertiary sectors in the long-run, immaterially appreciates the primary sector in the short-run and extensively boosts the tertiary sector in the short-run. The study recommends that renewable energy is the cleanest source of energy available and is said to be the backbone of modern economies, therefore, the Nigerian government should subsidize renewable energy to enable it promote all levels of economic growth. In addition, since oil price is critical in determining economic growth in Nigeria and it is exogenously determined, diversification policies should be adhered to in order to prevent its negative impact on economic growth when there is a drop in its price.

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