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Oil Price Volatility and Renewable Energy Consumption in Nigeria

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ABSTRACT

Oil price volatility is argued to be one of the incentives behind the rising prominence of renewable energy as a strategy to minimize oil dependence. Therefore, this study seeks to examine the impact of oil price volatility on renewable energy consumption in Nigeria from 1986-2017. A Vector Error Correction Model (VECM) was employed to achieve this objective. The variables were confirmed to exhibit a long run association. A unidirectional causality was also observed running from renewable energy consumption to oil price volatility. The impulse response function test shows that renewable energy consumption is positively influenced by oil price volatility in Nigeria. The variance decomposition result shows that real GDP causes the largest variation in renewable energy consumption amongst all the variables employed. The study recommends that public policies should be put in place to create awareness about the importance of the renewable energy sector and its potentials to lower health cost, mitigate climate change and helps Nigeria to attain energy security in the long run.

Keywords: Oil Price Volatility, Renewable Energy Consumption, Vector Error Correction Model, Nigeria
JEL Classifications: K32, P18, Q28

1. INTRODUCTION

Crude oil was discovered in the 1800s and ever since then, it has been a vital energy source to the global economy (Nwanna and Eyedayi, 2016). However, the market for Crude oil has a reputation of being extremely sensitive to various economic, political and sociological shocks and this has resulted in radical price changes from the beginning of the 1900s till date (Huber, 2011). The Nigerian economy is not exempted from this reality. The discovery of crude oil in 1958 has made the economy hugely dependent on oil for revenue generation. In 2017, over 70 per cent of government income and over 90 per cent of export earnings was accounted for by crude oil (National Bureau of Statistics, 2017).

Over the years, it has been difficult for the Nigerian economy to maintain steady growth. Nigeria benefited from the sustained increase in oil price from the year 2000 to 2008 because of her position as a major net exporter of oil. When crude oil price increased from $55.69 in 2005 to $101.43 in 2008, growth rate responded positively by increasing from 6.4 per cent in 2005 to 6.7 per cent in 2008. Nigeria was not affected by the global recession of 2008-2009 because of its accumulated foreign reserve during this period (Nwoba et al., 2017). However, there was an immense drop in the price of oil from $100.85 in 2014 to $52.95 in 2015 and further declined to $43.74 in 2016. Resultantly, the growth rate in Nigeria dropped from 6.3 per cent in 2014 to as low as 2.65 per cent in 2015. In 2016, growth further declined to -1.61 and the economy slid into recession (World development indicator, 2018). This depicts how the growth rate of the Nigerian economy oscillates with changes in crude oil price.

Oil price volatility is argued to be one of the incentives behind the rising prominence of renewable energy as a strategy to minimize oil dependence (Deniz, 2017; Rentschler, 2013; Alege et al., 2018). Besides, Climate change is caused by the increase in greenhouse gases which originates from continuous use of fossil fuel sources which includes oil. The release of carbon emissions or greenhouse gases has been said to be a leading source of global warming. Consequently, the energy sector is reshaping its core business to technological changes, decreasing costs of renewables and reaffirming its commitments made to reduce CO2 emissions (Ogutchu, 2017). The demand for crude oil has also been projected to begin declining by 2030 (World Oil Outlook, 2017). Therefore, it is imperative that Nigeria who is a major exporter of oil and solely depends on oil for running its economy begin to re-evaluate its priorities.

According to the theory of demand and supply, when two good are of comparable value or are substitute goods, when the price of one rises, simultaneously, the other good experiences a rise in its demand. In this study, energy is good under consideration and the different types of energy sources have different elasticities. For instance, crude oil has a higher degree of elasticity than renewable energy sources. This reality is caused by the multifaceted use of oil and gas ranging from transportation and electricity generation. Furthermore, oil is the most economical and reliable energy source today. On the contrary, renewable energy sources are mostly costly compared to oil and gas (Ogutchu, 2017). Consequently, the elasticity between these two sources is low and therefore, it is not easy to substitute. Nevertheless, the issues surrounding oil price volatility, climate change and technological change has influenced the search for alternatives to fossil fuel.

Empirically, there have been contentions that unfavourable consequence of oil price volatility should motivate the government and societies to hedge against this uncertainty and the adverse effect on the macroeconomy by transitioning into the consumption and production to renewables. This is important because it guarantees some degree of certainty while also reducing their reliance on oil import and vulnerability to international fluctuations (Sinha, 2015; Deniz, 2017; Shah et al., 2017; Sadorsky, 2009 and Rentschler, 2013). However, this study has majorly been examined in developed economies, but this nature of research is quite scarce in developing countries like Nigeria. Hence, this study attempts to fill this gap.

Therefore, the purpose of this study is to investigate the influence of oil price volatility renewable energy consumption in the Nigerian economy. The paper is segmented into five sections: this introductory segment is followed by the review of literatures. Section 2 presents the method of analysis; section 3 shows results and interpretations while section 4 discusses the findings and concludes the study with some recommendations.

2. LITERATURE REVIEW

There are four major energy hypotheses describing the association between economic growth and energy consumption. First, the Growth premise, which proposes that the higher the utilization of energy by an economy the more a nation will experience growth. Secondly, Conservation theory, which advocates a unidirectional causality moving from economic growth to energy utilization. Furthermore, the third is the Feedback premise states that energy utilization and economic growth can exhibit a two-way causal relationship. This implies that in an economy, energy utilization can stir up growth and growth can also stir up energy utilization. Lastly, the neutrality hypothesis this hypothesis states that neither energy utilization nor economic growth exhibit any influence on each other.

Most studies have addressed oil price volatility and renewable energy independently. However, empirical studies examining the relationship between these two is still very scarce. Some studies have however explored this relationship. Khan et al., (2018) employed the Johansen Cointegration technique to explore the effect of oil price on renewable energy consumption in Bangladesh from 1980- 2015. From the findings, the Johansen Cointegration technique found the two variables exhibiting a long run association and also discovered that renewable energy consumption is positively impacted by oil price volatility in the Bangladesh economy. Also, Apergis and Payne (2015) adopted South America as a case study and explored the link between renewable energy, carbon emission, output and oil price using a panel cointegration technique. Eleven countries were selected from Southern American countries and the findings show the existence of cointegration was observed between oil price, GDP, carbon emission and output. Also, the ECM shows that errors will converge over the long term horizon, this ascertains the importance of renewable energy to spur the growth of countries and also to aid the reduction of carbon emission.

In G7 and BRICT countries, Bashirov (2016) explored the link between carbon emission, renewable energy use and oil price from 1190 to 2013. The results obtained revealed that in both factions the use of renewable energy is positively influenced by an oil price increase. However, the results also show that renewable energy use is negatively affected by growth in G7 countries, but for BRICS countries the result showed growth and renewable energy utilization exhibit a positive association. Also, for G7 nations, carbon emission was shown to influence the utilization of renewable energy positively. However, this relationship proved negative for the BRICS countries, unlike the G7 countries.

Deniz, (2017) also established a corresponding result when the influence of oil price on the utilization of renewable energy was examined on a group of twelve countries that engage in oil importation and twelve countries that engage in oil exportation from 1995 to 2014. A panel analysis was employed and the result obtained revealed a diverse result for countries majorly importing oil and countries exporting. This study, however, differs from the previous as it employs not just oil price as a variable but also computed oil price volatility. For countries exporting oil, it was observed that oil price volatility exerts a negative influence on the utilization of renewable energy while for countries importing oil, a positive effect was observed. The study concludes that oil importers have an incentive to move towards renewable energy because oil price volatility affects them more. Oil exporters, however, would not usually have many incentives to move towards renewable energy.

Sinha (2015) also applied the Generalised Method of Moment technique to examine how irregularities in oil price movement affect renewable energy production. The author made an attempted to confirm whether the uncertainty caused by volatility in oil prices has been an incentive for countries to move towards the use of renewable energy. The result obtained revealed that the utilization of renewable energy in a country is influenced positively by volatility in oil price in the countries examined. Similarly, Ogutchu (2017) explored a comparative analysis of oil price and renewable energy utilization in EU countries between the periods of 2006-2014. The study employed both qualitative and quantitative analysis to carry out the objective of the study. From the result, it was evident that low oil prices impact renewable energy production positively and also that oil price volatility encourages investment in renewable energy technology. The qualitative analysis also revealed that low oil prices influence renewable energy in EU countries.

A study by Shah et al., (2017) employed the VAR methodology while selecting three countries (USA, UK and Norway) having a different relationship with the energy industry. Diverse findings were observed in the three countries. In the United Kingdom who is a major exporter of oil, no association was discovered between renewable energy and oil prices. While in Norway, an exporter also, the observable relationship was less significant and a major oil importer like the USA revealed a strong relationship. The reason for the strong relationship observed in the USA is attributed to the country is a major oil importer. The study recommends policies by the government that aid the use of renewables and also increase the support when the oil price is low and in periods of economic downturns.

Sarwar et al., (2017) explored 210 nations to ascertain the association connecting electricity utilization, oil price, and economic growth from 1960-2014. The study made use of cointegration for the Panel data and found all the variables employed to be cointegrated. The results also confirmed that there is a heavy reliance on oil for electricity consumption in developing countries although they also depend on oil prices for economic growth. Likewise, using a panel cointegration, the association between carbon emission and renewable energy consumption was explored by Nguyen and Kakinaka (2019) in one hundred and seven countries between the periods of 1990 to 2013. The results for the countries with low income, carbon emission and the utilization of renewable energy are positively related but negatively related to output. However, in the high-income countries, a negative association was discovered between renewable energy utilization and carbon emission while the use of renewable energy was found to influence output positively.

In twenty-four MENA nations, Charfeddine and Kahia (2019) used a Panel VAR to ascertain the response of Carbon emissions and GDP growth rate to financial expansion and renewable energy utilization from 1980 to 2015. Findings indicated that not much of the changes in carbon emission and economic growth can be explained by financial inclusion and utilization of renewable energy. Using the Panel ARDL methodology, Gozgor, Lau and Lu (2018) also studied the result of renewable and non-renewable energy use on growth in 29 OECD nations between 1990 and 2013. The result of the estimation showed economic growth can be improved in these countries by increasing the use of renewable energy.

Hanif (2018) attempted to analyse the factors causing environmental degradation in sub-Saharan African countries which includes Nigeria. The study explores the effect of renewable energy consumption, economic growth, fossil fuels and urban growth. It was established by the study that the use of solid fuel and fossil fuels contributes significantly to greenhouse gases causing carbon emission and also stimulating environmental pollution. Between per capita growth and carbon emission, an inverse relationship was observed. The validity of the environmental Kuznets Curve (EKC) was established in middle and low-income countries in sub-Saharan Africa. Zerbo (2017) using a multivariate analysis attempted to establish the correlation between energy consumption on economic growth in 13 sub-Saharan Africa. Interestingly, this study incorporates physical capital, trade openness, financial development and land. The study employed the use of Granger causality and the Autoregressive distributed lags. The study also observed that the growth hypothesis is evident in Kenya, Nigeria and Gabon. In Zambia and Sudan, the conversation hypothesis was observed, while in Cameroon, the feedback hypothesis was established. The neutrality hypothesis was observed in Ghana, Congo, South Africa, Togo, Cote d'Ivoire, Senegal and Benin.

Literature exploring the connection between renewable energy use and oil price volatility is scarce in Nigeria. However, studies have examined the response of economic growth to oil price volatility in Nigeria. Babalola (2018) carried out an empirical investigation into how the revenue obtained by the government is impacted by prices of crude oil. This research work used a VAR model to analyze both immediate as well as long term effect on the nation. The study observed that government revenue moved in the same direction as the oil price. However, the results show a decline in government revenue stems from crude oil shocks. It recommended that policies should be made towards the stabilization of the macroeconomic structure of the economy of Nigeria. Obi et al.. (2016) employed an annual data from the period of 1979 to 2014 in an attempt to analyze how the Nigerian economy reacts to shocks. Results show that changes in oil price will affect the behaviour of some important indicators in the economy, such as gross domestic product and interest rate. The recommendation that the government diversifies the economy to strengthen other sectors was proposed.

Nwoba et al., (2017) analysed how the Nigerian economy responds to declining oil prices. The results obtained revealed that declining oil price negatively influences the Nigerian economy and recommends diversification to curb the negative effect of fallen oil price. Nwanna and Eyedayi (2014) also assessed the response of economic growth to oscillations in oil price. The study employs secondary data and multiple regressions for analysis from 1980 to 2014. Results revealed that the fluctuations in the price of oil have a significant consequence on the growth achievable by an economy. From findings, the study recommends diversification of the export base and minimal reliance on petroleum products, fiscal prudence, accountability and corporate governance.

3. DATA AND METHODOLOGY

3.1. Model Specification

This study employs a VECM model to realize the objective of this research. The model follows the specification of (Shah et al., 2015) however; this study extends this model to include carbon emission and oil price volatility. The inclusion of RGDP and CO_2 emanates from the conservation hypothesis which suggests that when economic growth increases, energy needs will also increase. According to the Environmental Kuznets curve (EKC) hypothesis, higher economic growth will boost economic activities and in turn, increase environmental pollution. Carbon emission is one of the major reasons most economies are advocating for renewable energy consumption in an attempt to combat climate change (Shah et al., 2017).

The model in its implicit form can be stated as follows;

$$REC_t = f(OPV_t)\ RGDP_t\ CO_{2t}) \quad (1)$$

Where REC represents renewable energy consumption, OPV denotes oil price volatility (OPV), $RGDP$ is gross domestic product and CO_2 represent carbon emission.

The dependent and explanatory variables are assumed to exhibit a non-linear relationship. This is stated below as;

$$REC_t = A.OPV_t^{\alpha 1}.RGDP_t^{\alpha 2}.CO_{2t}^{\alpha 3}.\mu_t \quad (2)$$

A log-linearised form of equation (2) is stated as:

$$REC_t = \alpha_0 + \alpha_1\ LnOPV_t + \alpha_2\ LnRGDP_t + \alpha_3\ LnCO_{2t} + \mu_t \quad (3)$$

$LnREC_t$ represents the logarithm function of renewable energy consumption. Also, OPV_t symbolizes the logarithm function of oil price volatility while $LnRGDP_t$ and $LnCO_{2t}$ signify the logarithm function of real gross domestic product and Carbon emission respectively. These variables are put in their logarithm form because it allows the variables to be transformed into a uniform unit of measurement while also reduce the possibility of heteroscedasticity in the model (Gujarati, 2005).

3.2. Technique of Estimation

Vector autoregressions (VARs) have become the workhorse model for macroeconomic forecasting and have been extensively used in economic time series. The Vector autoregressions can be described as a multi-equation system in which the entire variables in the VAR system are endogenous. The Autoregressive element of the VAR shows how each variable are represented as a function of their past values. A VAR system can either be estimated restricted or unrestricted. The process of deciding which of the VAR dimensions to used will involve ascertaining the order of integration of the variables in the system through a stationarity check. When the variables are established to be level stationary, then the VAR model can be analysed as unrestricted. Conversely, when the stationarity check establishes that the variables are first-difference stationary, then a cointegration analysis becomes necessary. Upon the confirmation of cointegration, the VAR will then be estimated as restricted (Adeniran and Igbatayo, 2016). The restricted dimension of VAR is called the Vector Error Correction Model (VECM). Furthermore, since every equation specified in a VAR model is an autoregressive model, it is easy to obtain the error correction model (ECM) from the VAR. The implication of this is that when there is any divergence from equilibrium, the error correction model can enforce a convergence in the long run. This connotes that the VECM can restrict the long run performance of the endogenous variables to return to their cointegrating association if there is any discrepancy in the current period.

Therefore, the VECM can observe both immediate and long term relationship amongst the variables and can evaluate the specific impacts through impulse response functions and variance decomposition (Oladeji et al., 2018). The VAR method either restricted of unrestricted has some desirable properties. First, it is easy to implement because of the flexibility in its estimation. Secondly, it can trace how a variable reacts to shocks in another variable in the VAR system through the impulse response functions. For instance, it can examine how renewable energy consumption can be influenced by a shock to oil price volatility. Furthermore, the VAR model is also desirable because it can be used for forecasting (Adeniran and Igbatayo, 2016). However, the VAR methodology is not without its lapses. Over time, it has been observed that because of the large number of parameters and lack of prior information, there is a possibility of overfitting of data (Ciccarelli and Rebucci, 2003).

The VECM will, however, be employed because the variables are cointegrated (Table 7). Thus, following the work of (Oladeji et al., 2018) a typical VECM model is given as:

$$\Delta REC_t = \varnothing_1 + \alpha_{11}ECT_{t-1} + \sum_{i=1}^{k-1}\beta_{11i}\Delta REC_{t-i} + \sum_{j=1}^{k-1}\beta_{12j}\ \Delta OPV_{t-j} + \sum_{k=1}^{k-1}\beta_{13k}\ \Delta RGDP_{t-k} + \sum_{m=1}^{k-1}\beta_{14m}\ \Delta CO2_{t-m} + \mu_{1t} \quad (4)$$

$$\Delta OPV_t = \varnothing_2 + \alpha_{21}ECT_{t-1} + \sum_{i=1}^{k-1}\beta_{21i}\Delta REC_{t-i} + \sum_{j=1}^{k-1}\beta_{22j}\ \Delta OPV_{t-j} + \sum_{k=1}^{k-1}\beta_{23k}\ \Delta RGDP_{t-k} + \sum_{m=1}^{k-1}\beta_{24m}\Delta CO2_{t-m} + \mu_{2t} \quad (5)$$

$$\Delta RGDP_t = \varnothing_3 + \alpha_{31}ECT_{t-1} + \sum_{i=1}^{k-1}\beta_{31i}\ \Delta REC_{t-i} + \sum_{j=1}^{k-1}\beta_{32j}\ \Delta OPV_{t-j} + \sum_{k=1}^{k-1}\beta_{33k}\ \Delta RGDP_{t-k} + \sum_{m=1}^{k-1}\beta_{34m}\ \Delta CO2_{t-m} + \mu_{3t} \quad (6)$$

$$\Delta CO2_t = \varnothing_4 + \alpha_{41}ECT_{t-1} + \sum_{i=1}^{k-1}\beta_{41i}\Delta REC_{t-i} + \sum_{j=1}^{k-1}\beta_{42j}\ \Delta OPV_{t-j} + \sum_{k=1}^{k-1}\beta_{43k}\ \Delta RGDP_{t-k} + \sum_{m=1}^{k-1}\beta_{44m}\ \Delta CO2_{t-m} + \mu_{4t}$$

Table 1: Data description

DATA	Identifier	Description	Data source	Measurement
Renewable energy consumption	REC	Renewable energy consumption as a proportion of total energy utilization	World Development Indicator (2018)	Percentage
Real Gross Domestic Product	RGDP	Real Gross Domestic Product measured at 2010 constant prices in US dollars	World Development Indicator (2018)	Billion (Naira)
Crude Oil Price	OILP	Crude oil, the average spot price of Brent, Dubai and West Texas Intermediate measured at 2010 US dollars.	World Bank Commodity Price	US Dollars
Carbon Emissions	CO_2	Total Carbon emission from fossil fuel	World Development Indicator (2018)	Metric ton

Where ECT_{t-1} is the error correction term lagged 1 year, ∅ denotes the constant term, Δ represents the first difference of the variables, β represents the coefficients of the variables and μ is the disturbance term. Other notations have been earlier defined.

Table 1 shows the data description, sources and measurement used in this research. The study period was chosen covers a period of 1986 to 2017. Through the GARCH (1, 1) methodology, the conditional variance was used to compute oil price volatility from the oil price data.

4. ESTIMATION AND RESULTS

To achieve the objective of this study, the study conducts a preliminary analysis to estimate the VECM model using the impulse response and the variance decomposition.

4.1. Preliminary Analysis

The preliminary analysis is conducted to assess the data set in general as well as the variables specifically. This analysis will give a detailed summary of the content in the data set. The preliminary analysis will include descriptive statistics, a stationarity test and a VAR stability test.

4.1.1. Descriptive statistics

The descriptive statistics is important as it helps to give a detailed description of the data set. From Table 2, the skewness statistics show a positive value for (RGDP, CO_2 and OPV) while REC is negatively skewed. The kurtosis is appropriate when the value of the statistics is greater than 3. From the table, REC and CO_2 are less than 3 while the kurtosis value of RGDP and OPV is greater than 3 depicting a normal distribution while only OPV is less than 3.

Table 2: Descriptive statistics

	REC	RGDP	CO_2	OPV
Mean	86.28470	5.216713	0.540060	3493.209
Median	86.44863	5.917685	0.571338	729.2881
Maximum	88.83185	15.32916	0.770794	14167.20
Minimum	82.95602	–2.035119	0.325560	234.6389
Std. Dev.	1.486974	3.988284	0.151490	4702.538
Skewness	–0.443640	0.218412	0.009661	1.361827
Kurtosis	2.604349	3.400838	1.694771	3.361816
Jarque-Bera	0.983131	0.366132	1.774995	7.863748
Probability	0.611668	0.832713	0.411685	0.019607
Sum	2157.117	130.4178	13.50149	87330.22
Sum Sq. Dev.	53.06620	381.7538	0.550782	5.31E+08
Observations	25	25	25	25

Source: Authors' compilation Eviews 9

4.1.2. Correlation analysis

This analysis allows the strength of association between variables to be observed. The correlation analysis also helps to test for the presence of multicollinearity among the explanatory variables. From Table 3, it was observed that REC has a positive correlation with OPV and negative correlation with RGDP and CO_2. RGDP also shows a positive correlation with CO_2 and OPV. CO_2 was also found to exhibit a positive correlation with OPV. Also, none of the independent variables was found to exhibit high correlation showing the absence of multicollinearity amongst the variables.

Table 3: Correlation analysis

	REC	RGDP	CO_2	OPV
REC	1.000000			
RGDP	–0.336477	1.000000		
CO_2	–0.674008	0.632893	1.000000	
OPV	0.287462	0.190253	0.191949	1.000000

Source: Authors' compilation Eviews 9

4.1.3. Stationarity test

Stationarity occurs when the mean and variance are constant over time, having a long-run horizon to which they can always return to when there is a deviation (Prajitno, 2011). Therefore, the Augmented dickey fuller test is carried out to ascertain that the variables do not have a unit root or exhibit a non-stationary trend. From Table 4, based on a 5% probability value, all the variables are first-difference stationary.

4.1.4. Var stability test

The Autoregressive (AR) roots analysis is used to determine whether the VAR model is stable or not. The stability of the model implies that it is stationary and affirms the validity of results. On the contrary, the instability of the model can lead to invalid conclusions. When modulus of the AR roots is less than one and lies inside the unit then the model is stable. Figure 1 presents that AR roots graph which also reveals that the variables satisfy the condition and all point lies within the circle.

4.1.5. Residual diagnostic tests

This study conducts a residual diagnostic test to ascertain the efficiency of the model. This means testing for violations of any of the BLU (best, linear, unbiased estimator) properties. This includes the test for autocorrelation, heteroscedasticity and the normality test. The null hypothesis that the assumptions are violated will be assumed. Therefore, if the probability value is greater than 0.05, we can reject the null hypothesis and conclude that the assumptions are not violated. From Table 5, the probability values of the serial correlation test, heteroscedasticity test and normality test are above 0.05, therefore we conclude that the model is efficient and does not violate any of the BLU properties. Put differently, there is absence of autocorrelation and heteroscedasticity; also, the variables are normally distributed.

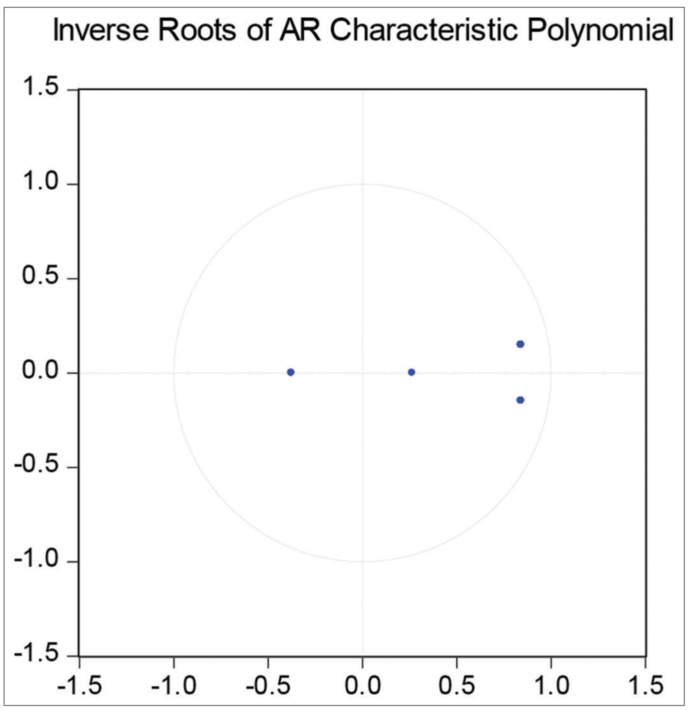
4.2. Lag Length Selection

The lag selection process is very crucial to the VAR estimation. It helps to choose the select the best lag that suits the model. All the information criteria suggest that lag 1 best fits the model as shown in Table 6. Therefore, Lag 1 will be used for the estimation.

4.3. Johanson Cointegration Test

Cointegration test becomes essential when the variables are observed to be first-difference stationary or I(1). When the Trace and Max Eigen statistics exceeds the critical value at 5% level of significance then there is the presence of cointegration. From the result in Table 7, both tests reveal the presence of one (1) cointegrating equation(s) each. Therefore, this confirms the presence of a long-run relationship among the variables.

Figure 1: VAR stability testf



Source: Authors' compilation Eviews 9

Table 4: Summary of stationarity test

Variable	T-stat	Probability-value	Order of integration
LnREC	–5.1326	0.0004	1(1)
LnRGDP	–9.9200	0.0000	1(1)
$LnCO_2$	–5.6645	0.0001	1(1)
LnOPV	–5.3633	0.0001	1(1)

Source: Authors' compilation Eviews 9

Table 5: Residual diagnostic tests

Test	P-value
Serial correlation lm test	0.4683
Heteroskedasticity test	0.3213
Normality test	0.8245

Source: Authors' compilation Eviews 9

4.4. VAR Granger Causality/Block Exogeneity Wald Tests

The Granger causality is utilized to check for causality amongst the variables. Table 8 shows the existence of a one-way causality moving from REC to OPV. The test further reveals a one-way causality from REC to CO_2. Furthermore, the result shows that RGDP Granger causes CO_2. This result conforms to the environmental Kuznets curve (EKC) hypothesis which states that as economic growth increases, it will boost economic activities and therefore, increasing environmental pollution. Additionally, CO_2 Granger causes OPV at 5% level of significance.

4.5. Vector Error-correction Model (VECM)

The error correction model (ECM) which examines the speed of adjustment indicates that there is convergence of errors that is, about 10% of errors generated in one period will be correct in the subsequent periods. However, Sims (1980) contends that it is quite complex to interpret the individual coefficient of the ECM. Therefore, the impulse response functions (IRF) and the variance decompositions (VDs) can be used to analyse the dynamic properties of the model. This was also adopted by (Oladeji., 2018).

The IRF and VD are employed in the Vector Autoregression analysis to give more information about the dynamic relationship amongst the variables. The VD helps to establish what fraction of forecast variance of a variable is determined by the variation in other variables. That is, it helps in the identification of the amount of variation each variable contributes to other variables in the dynamic economic system. The IRF takes into account the sensitivity of a variable to unanticipated adjustments in other variables within the VAR model (Boheman and Maxén, 2015). Put differently, the IRF reveals how and for how many successive periods a variable reacts to a standard deviation shock in other variables.

4.6. Impulse Response Functions

The generalized IRF will be used to analyse how renewable energy consumption (REC) reacts to shocks in oil price volatility (OPV), carbon emission (CO2) and real GDP (GDP). This is indicated in Figure 2. From the first row, it was observed that a standard deviation shock to REC will have a positive response on REC throughout the ten periods. The effect declines from the 1st year until the fourth period initially, resumes an upward trend till the fifth period, declines till the eighth period and rises steadily till the 10th year. Also, a shock to OPV positively influences REC. The impact rises steadily and peaked in the 3rd year, waned till the 5th year and remains steady till the 10th year. REC responds negatively to a shock to RGDP. The impact declines from the 1st year till the 2nd year, rises and peaks in the 4th year and declines steadily till the 10th year. A shock to CO_2 negatively influences REC from the 1st year until the 10th year. The impact throughout the periods is similar to that of RGDP. The impact waned from the 1st year until the 2nd year, increases and peaks in the 4th year and declines and increases steadily till the 10th year. The response of each variable to shocks in other variables is also presented below.

This is indicated in Figure 2.

Table 6: Lag selection table

Lag	LogL	LR	FPE	AIC	SC	HQ
0	13.29441	NA	4.64e-06	–0.929441	–0.730295	–0.890566
1	55.58464	63.43534*	3.50e–07*	–3.558464*	–2.562732*	–3.364087*

Source: Authors' compilation Eviews 9

Table 7: Johanson cointegration test

Hypothesized No. of CE(s)	Eigenvalue (5%)	Trace stat (5%)	0.05 Critical Value	Eigenvalue (5%)	Max Eigen (5%)	0.05 Critical value
None *	0.797672	56.00581	47.85613	0.797672	28.76159	27.58434
At most 1	0.656734	27.24422	29.79707	0.656734	19.24648	21.13162
At most 2	0.334285	7.997739	15.49471	0.334285	7.324090	14.26460
At most 3	0.036733	0.673649	3.841466	0.036733	0.673649	3.841466

Source: Authors' compilation Eviews 9

Table 8: VAR granger causality/block exogeneity wald

Null Hypothesis	Chi-Squ	Prob	Results
REC does not Granger cause OPV	4.146	0.00	REC Granger causes oil price volatility
REC does not Granger cause CO_2	8.023	0.05	REC Granger causes carbon emission
RGDP does not Granger cause CO_2	236.7	0.01	OILPV Granger causes oil price
CO_2 does not Granger cause OPV	9.451	0.05	CO_2 Granger causes Oil price volatility

Source: Authors' compilation Eviews 9

Table 9: Variance decomposition of renewable energy consumption

Period	S.E.	REC	OPV	RGDP	CO_2
1	0.015585	100.0000	0.000000	0.000000	0.000000
2	0.020700	88.86974	0.107752	4.315569	6.706941
5	0.031015	90.80247	1.204942	4.015924	3.976666
8	0.039078	91.21848	1.369903	4.199239	3.212379
10	0.043813	91.61483	1.369775	4.167352	2.848038
Variance decomposition of oil price volatility					
Period	**S.E.**	**REC**	**OPV**	**RGDP**	**CO_2**
1	0.476451	58.76780	41.23220	0.000000	0.000000
2	0.608475	46.03344	44.74057	4.142868	5.083115
5	1.028268	51.27258	33.49307	5.179279	10.05507
8	1.298699	51.36226	32.52410	5.462292	10.65135
10	1.444554	51.47058	32.57190	5.406645	10.55087

Source: Authors' compilation Eviews 9

4.7. Variance Decomposition

The VD helps to establish what portion of forecast variance of a variable is determined by the variation in other variables. For REC, the largest source of shock was as a result of variations in REC itself which contributed 100 per cent in the 1st year, declining to about 90 per cent in the 5th year, rising again to 91 per cent by the 10th year. The contribution of OPV shock to variations in REC is about 10 per cent in the 2nd year and rising to about 1.20 per cent in the 5th year and 1.36 per cent in the long run. Shocks in real GDP also contributed to about 4.31 per cent variation in REC in the 2nd year, with an increasing effect of about 4.19 per cent in the 8th year and declines to 4.16 per cent variation in REC by the 10th year. The contribution of CO_2 shocks to variations in REC is about 6.7 per cent in the 2nd year, rising to 3.97 per cent in the 5th year. However, the impact begins to decline from the 8th year, it declines from 3.21 per cent to 2.84 per cent in the eight and tenth period respectively.

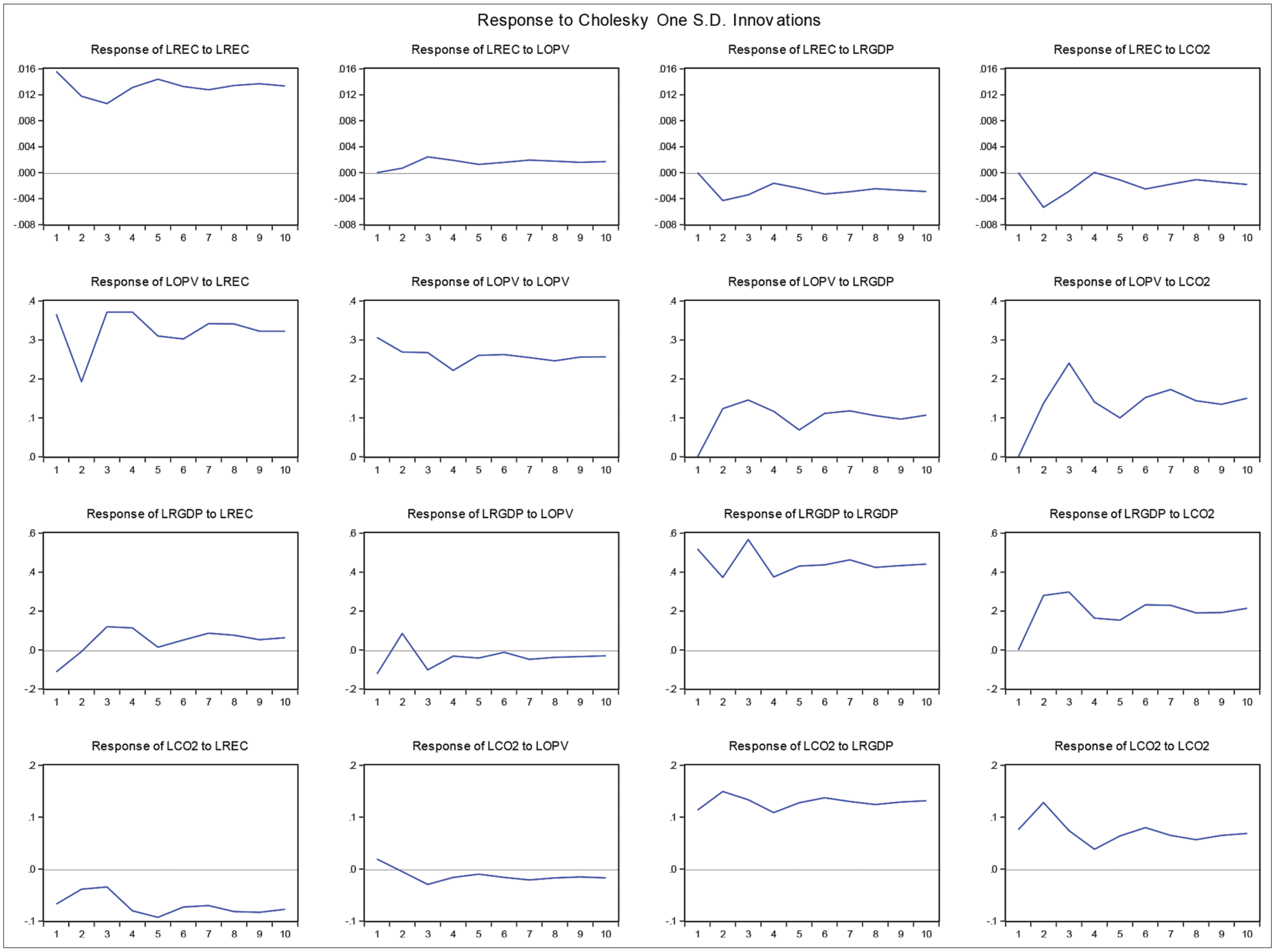
The variance decomposition of oil price volatility was also examined. In the 1st year, about 41 per cent of variations oil price volatility is explained by own innovations, declining to 33 per cent in the 5th year and declining further to 32 per cent in the long run. It was also established that renewable energy causes the highest variation to OPV amongst the other variables. REC explains about 58.7 per cent of the variation in OPV in the first period. However, this effect declines to 46 per cent in the second period, rising to 51.2 per cent in the fifth period and 51.4 per cent in the long run. This is shown in Table 9.

5. DISCUSSION OF RESULTS

Following the analysis, the impulse response reveals in the long run and shocks to OPV produces a positive impact on renewable energy consumption in Nigeria. This implies that oil price volatility will lead to an increase in the consumption of renewable energy in the long run. This is contrary to the results of (Sinha, 2015; Deniz, 2017; Shah et al., 2017) who in their studies have observed that it is unusual for countries who export oil majorly to commit to the development of renewable energy. This is because oil-exporting country benefits from the proceeds of crude oil sales for revenue generation and therefore might be reluctant in transitioning to renewable energy sources. However the contrary result could be Nigeria is a major net-oil exporter, who relies heavily on oil proceeds for its revenue and also imports petroleum products because of the absence of efficient refineries. Therefore, when uncertainty increases as a result of oil price volatility, the revenue generation capacity of the economy will be affected and the price of petroleum products will also be volatile. If the Nigerian economy will be stable, it must begin to look into other energy sources such as renewable energy in the long run. This result was also found by Khan et al., (2017) who carried out the same analysis in Bangladesh.

Also from the result, renewable energy consumption responds negatively to shocks in real GDP. The conservation hypothesis states that an increase in RGDP will increase energy consumption. Also, the richer a country gets, the more they can afford cleaner energy sources. However, the RGDP in Nigeria has not maintained a steady increase over the years because of fluctuation in the oil price which constitutes the bulk of government revenue. Therefore, if dependence on oil is not reduced and strategies put in place to

Figure 2: Impulse response function



Source: Authors' compilation Eviews 9

improve the growth of real GDP, it will not influence renewable energy consumption positively in the long run.

Furthermore, renewable energy responds negatively to shocks in carbon emission. Empirically, an increase in the use of fossil fuel increases the emission of greenhouse gases referred to as carbon emission. Therefore his means the more carbon emission increases, the more they need for renewable energy consumption to prevent climate change (Zoundi, 2017). However, a negative relationship was established between these two variables. This implies that in the long run, when there is a shock to carbon emission, it will not influence renewable energy positively.

Variance decomposition result shows that real GDP causes the largest variation in renewable energy consumption asides its own shock. This suggests that real GDP is a vital variable in determining the consumption of renewable energy in Nigeria. Oil price volatility is also an important driver of renewable energy in the long run. The impact of carbon emission on renewable energy consumption increases in the short run but declines in the long run.

6. CONCLUSION AND RECOMMENDATIONS

The study examines the impact of oil price volatility on renewable energy consumption in Nigeria. The study period chosen was from 1986 to 2017. The study employs a VECM technique and carried out the impulse response function and variance decomposition. All the variables used for the analysis were confirmed to be integrated into the order one after the stationarity check was performed. The Johansen cointegration test provided evidence of a long run relationship amongst the variable used. A one-way causality was found running from REC and oil price volatility when the Granger causality was performed. It was also revealed that RGDP Granger causes carbon emission. This validates the Environment Kuznets Curve (EKC) hypothesis which advocates that when economic growth keeps rising, environmental pollution also increases in Nigeria.

The impulse response function result shows that REC is positively impacted by oil price volatility all through the ten periods observed.

Renewable energy responds negatively to shocks in real GDP and carbon emission all through periods examined. The variance decomposition shows that real GDP and oil price volatility causes the most variation to renewable energy consumption. This means that Nigeria must ensure the growth rate of the economy is stable over time if renewable energy use will increase. Therefore, the Nigerian economy must reduce its dependence on oil so that the growth rate is less susceptible to oil price volatility.

It is widely known that oil price volatility affects developing countries the most and Nigeria who is majorly dependent on oil will continue to experience the adverse effect from oil price fluctuations until dependence on oil is reduced. This study hence recommends that policies should be put in place to create awareness of the advantages of renewable energy consumption over fossil fuel sources. Also, the renewable energy sector should be prioritized; this will give room for more annual budgetary allocation towards its development. In conclusion, the development of renewable energy will go a long way to mitigate climate change and also create energy security for the Nigerian economy.

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