

EFFECT OF OIL PRICE SHOCKS AD EXCHANGE RATE VOLATILITY ON ECONOMIC GROWTH: EVIDENCE FROM NIGERIA

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Abstract

The paper investigated the effect of Oil Price Shocks and Exchange Rate Volatility on economic growth in Nigeria. The study utilized both symmetric Linear Autoregressive Distributed Lag (ARDL) and asymmetric Nonlinear Autoregressive Distributed Lag (NARDL) Models of co-integration to capture oil price shocks and Generalised Autoregressive Conditional Heteroscedasticity (GARCH) Model to capture exchange rate volatility covering the period 1980 to 2019. The findings of NARDL model revealed that in the long-run, positive oil price has a negative but insignificant effect on GDP while negative oil price has a positive and significant impact on GDP. This suggests that, over the period of the study, oil price increase hampers economic growth in Nigeria while oil price decrease is growth enhancing for Nigeria. However, the result of the GARCH model shows that the sum of the ARCH and GARCH coefficients is greater than one, suggesting a high volatility in exchange rate over the period of the study. Based on the findings, the study recommends greater diversification of the economy through investments in key productive sectors of the economy to guard against the regular occurrence of oil price shocks and exchange rate volatility. Furthermore, the monetary authority should focus on policies that minimize the magnitude of exchange rate volatility in order to encourage foreign investment in the economy.

Keywords: Oil Price, Exchange Rate, Economic Growth, NARDL, GARCH

Introduction

Among the numerous global traded commodities, crude oil stands unique as every country, in one way or another, depends on it either as an exporter or importer. Crude oil, like many other primary commodities, is a major input in the production process of an economy. Consequently, oscillations in its price ultimately have impact on the global economy. Oil price shocks are unexpected changes in the prices of oil, which are capable of affecting the economy either positively or negatively. Over the last few decades, researchers have found oil price shocks to be responsible for economic recessions, inflation, trade imbalances, and low equity values. At the same time, oil price changes have been considered a key factor in the exchange rate fluctuations experienced by oil importers and exporters. This has driven many researchers to investigate the relationship between oil prices and exchange rates (Akram, 2009; Basher, Haug, and Sadorsky, 2016; Ding and Vol, 2012; Reboredo, 2012; Tiwari, Mutascu, and Albulescu, 2013).

In the case of Nigeria, an oil dependent nation or put differently, a mono cultural country the oil-supply glut sounds unlike as it poses strong signal, to revenue generation and thriving economic activities. The recent dramatic decrease in the prices of oil and the subsequent reduction in the value of the currencies of several oil exporting countries should once again revive an interest in the interdependence between major commodity prices and exchange rates. Given these developments, Nigeria has lost track in meeting spending commitments in many areas. It has put upward pressures on government borrowing (both local and foreign) as the government seeks to fund additional deficit situations (Sulaiman 2012).

Oil revenues are the main source of financing government expenditures and imports of products in Nigeria. The unique role of oil revenues in the structure of government budgets is a special characteristic of the developing and less developed oil export economies like Nigeria. Since on average 90% of government revenues come from oil and gas, the budget is especially affected by sudden negative or positive shocks in oil prices. The oil rich developing economies are hard hit recently by the burst of the crude oil price bubble at the international market. This has created agitation on how the countries who are key players would respond economically to the shocks in the short and long-run. Nigeria is one of the countries heavily affected by the sharp decline in the revenue vis-à-vis the fall in the price of crude oil. It is recalled that, over the years, oil revenues are the main source of financing government expenditures and for importation of products to the country. Specifically, on average, 75% of government revenues come from oil export (Nweze & Edame, 2016). As such, the budget is usually affected by sudden negative or positive shocks to the oil prices. Exchange rate is one of the most influential macroeconomic variables in terms of its widespread effects on the economy. Right from its impact on external competitiveness, trade balance and balance of payment position to the general price level, exchange rate poses a great concern to monetary authorities with macroeconomic policy management responsibilities. Exchange rate as the price of the foreign currency in terms of the domestic counterpart is determined by forces of demand and supply at the international market for foreign exchange. The Naira/Dollar (₦/\$1) rate is determined by interaction between domestic demand for United State Dollar (USD) and its supply on the Foreign Exchange (FOREX) market in Nigeria. The demand for United State Dollar (USD) derives from import demand as United State Dollar (USD) is required to import products from abroad; the supply of United State Dollar (USD) on the Foreign Exchange (FOREX) comes from United State Dollar (USD)-denominated proceeds from export. As the Nigeria is virtually mono-resourceful with 80% of the exports and foreign exchange earnings dominated by oil, oil export plays a very important role in the determination of exchange rate in Nigeria (Nweze & Edame, 2016).

Oil price shocks can be held responsible for changes in monetary policy, labor market adjustments, and for changes in economic growth, energy technologies, maintaining that the fluctuations in the real price of oil since 2003 have led to a resurgence of research on the oil market and its consequential effects on global economies (Kilian and Murphy, 2014). Despite higher oil prices and revenues in recent years, the Nigerian government budget deficits are still challenging issues, in part due to the huge amount of state subsidies on energy and comestible goods. This is similar to spending the oil revenues directly and has strong inflationary effects through increasing money supply in the economy. Moreover, the most recent challenge the Nigerian economy is facing consists of the increase in the Foreign Exchange Rate (FOREX) of Naira versus Dollar, lack of sustainable power supply and lack of effective and efficient refineries for Nigerian crude oil. It is likely that the factors will exacerbate the amount of oil revenues and consequently the budget deficit. This shows a dilemma to the policymakers who are trying to keep up the momentum into the economy by injecting more government expenditure into domestic

economy while at the same time the oil revenues are uncertain and expected to decrease (Van Marrewijk and Van Bergeijk, 1993).

Oil revenues in most oil-exporting countries are paid directly to the government as the guardian of the natural resources. Hence, the government becomes the conduit for the oil revenues into the economy. If the revenue is unstable and/or transitory, then the other macroeconomic variables will be unstable and the natural resource blessing could become a curse (Devlin and Lewin, 2005). The study by Hamilton (1983) detailed the trail of research on the influence of oil price shocks and exchange rate on economic growth. The study tried to empirically provided explanations about this phenomenon in various jurisdictions. He observed that early studies concentrated on the oil price-macroeconomic relationship in the developed economies of the US, UK, Australia, Canada, and China, with very limited contributions from emerging economies. On the issue of oil price shocks and exchange rate volatility, earlier works (Yin and Ma (2018), Jin *et al.* (2019), Dovert *et al.* (2017); Ghosh (2011); Wasseh & Lin, (2018); Ghassan & AlHajhoj, (2016); Volkov & Hyang, (2016); Iwayemi & Fowowe, 2011) have revealed essentially two ways by which oil price shocks may ultimately affect exchange rate on economic growth; direct and indirect effects. This appears conceivable in the light of the weak exchange rate hypotheses, exhibiting informational inefficiency by displaying the capabilities to lock away some information, of which abrupt fluctuations in oil prices is one. However, none examined the cumulative direct and indirect effects of oil price shocks and exchange rate volatility on economic growth in Nigeria. In the light of the foregoing, this study seeks to examine the effect of oil price shocks on economic growth in Nigeria by highlighting its impact on exchange rate and analyse its impact on the country's economy, covering the period 1980-2019. The rest of the study is organized as follows. Section 2 discussed the theoretical and empirical literature on the issues of oil price and exchange rate volatility and its effects on economic growth. Section 3 outlined the empirical model and the method of estimation while section 4 presented the empirical results. Section 5 is conclusion which summarized the main findings and policy implications

Literature Review

Theoretical Frameworks

The theoretical literature adopted two major theories relevant to the study which include "*the neoclassical model of economic growth by Solow - Swan*:" Robert Solow proposed a long term economic growth model in response to the unsatisfactory results derived from the model of the Harrod Domar (Solow 1956). In the same year, American economist Trevor Swan presented a similar model (Swan 1956), which is why the discussed model is called the Solow – Swan model. Its main aim was to show that in the long run, an economy achieved sustainable growth. Then, the growth rate of income *per capita* was equal to rate of population growth. The two problems identified by the Harrod Domar model instability of the economy and the impossibility of full use of the labor were solved in the Solow – Swan model by introducing the assumption of substitution of factors of production, which in turn removed the assumption of a constant ratio of capital/production. However, "*Robert Lucas*" proposed a model of endogenous growth according to which there are two sectors. According to Lucas, there are two types of capital too – physical capital used in the production process and human capital that affects the growth in productivity of both labor and physical capital. Another theoretical framework adopted in the study is the "*Purchasing Power Parity (PPP) Theory*" the purchasing power parity (PPP) is such an important element in seeking to explain exchange-rate movements; we ought to say rather more about it. Basically it comes in two versions: '*Absolute*' purchasing power parity (PPP) suggests that price

levels expressed in a common currency will be equalized throughout the world. 'Relative' (PPP), on the other hand, argues merely that nominal exchange rates will alter in such a way as to maintain equilibrium real exchange rates in the light of differential inflation.

Empirical Review

On the aspect of oil price shocks, Alley (2018) analysed monthly data on Nigeria from 2008 to 2015 in the ARDL, VAR and VEC models to determine the potential of economic diversification/non-oil export performance in halting the fall of Naira on the FOREX market. The study affirms the findings of many previous studies on the nexus between oil price and exchange rate, and between exchange rate and non-oil export performance. The findings established that positive changes in oil price led to appreciation of naira while oil price fall depressed the exchange rate; Exchange rate appreciation discouraged non-oil export while the depreciation encouraged it; Increase in import was also found to depreciate the naira.

Olayungbo and Olayemi (2018) investigated the dynamic relationships among non-oil revenue, government spending and economic growth in an oil producing country evidenced from Nigeria for the period of 1981 to 2015. The study employed the endogenous growth model which can be shown in Aghion and Howitt (1998) and Romer (1990) production function known as AK model. Also, the variables used in this study are gross domestic product (GDP), non-oil revenue and government spending. The findings of both the short run and long run results showed negative effects of government spending on economic growth while non-oil revenue showed positive effect on economic growth. We also found non-oil revenue to have negative shocks on economic growth while the government spending shock was positive. The Granger causality revealed that government spending granger caused both non-oil revenue and economic growth supporting the Keynesian and spend-tax hypothesis in Nigeria over the period of the study. The Study recommends that the economy of Nigeria should be diversified into non-oil sector rather than relying solely on revenue from oil export.

Raheem (2017) examined the relationship between oil price change and other key macroeconomic variables which includes import, export, and total openness on some selected countries which include China and Germany (high trading), U.S. and India (oil importing) and Russia and Canada (oil exporting). The estimation is based on both symmetric (linear) ARDL and asymmetric (nonlinear) ARDL models using a monthly dataset from 01/1992 to 06/2016 The findings revealed that there is the existence of an asymmetric (indirect) effect on the export component of the high trading economies in the long run, import of the oil importing countries in the short run and import of the oil exporting countries in the long run. The findings concluded that oil price has a significant effect on economic growth.

With regards to the studies on exchange rate volatility, Ehikioya (2019) employed the time series data covering a time span from 1980 to 2017 to examine the exchange rate volatility and its effect on economic growth in Nigeria using the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model and the system Generalized Method of Moments (GMM) technique based on a deducted endogenous growth model. Using inflation, credit to private sector, trade openness, money supply, human capital development, government expenditure, crude oil prices and dummy variable for exchange rate regimes as key variables, he established significant negative relationship between exchange rate volatility and economic growth. His findings are in agreement with Ozata (2020) who utilised GDP, export, investment, import and exchange rate as key variables to conclude that real effective exchange rate volatility in particular has a significant negative relationship with economic growth. Relatively,

Using a time series data covering a span of 35 years (1981-2015), Ebele *et al* (2017) investigated exchange rate volatility in Nigeria and its effect on economic growth. The variables used comprised of Exchange Rate, Gross Domestic Product, Government Expenditure, External Reserve, and Foreign Direct Investment which the study employed GARCH (1,1) model. The key variables exhibit a negative but significant relationship between exchange rate volatility on the growth of the Nigerian economy for the period under consideration.

Ajao (2013) examined the determinants of real exchange rate volatility in Nigeria from 1981 to 2008 using the Generalized Autoregressive Conditional Heteroscedasticity GARCH (1,1) model. Utilizing openness of the economy, government expenditures, interest rate movements as well as the lagged exchange rate are among the major significant variables that influence real exchange rate volatility during the period. The findings revealed that there was presence of a long term equilibrium relationship between real exchange rate volatility and its various determinants.

Danson et al (2012) examined Real Exchange Rate volatility by using Generalized Autoregressive Condition of Heteroscedasticity (GARCH) and computation of the unconditional standard deviation of the changes covering a time span 1993 to 2009 they found that real exchange rate volatility exerts negative effect on host country's economic growth. Mahmood *et al* (2011) has established mixed results showing a positive and negative relationship between the variables used on the relationship between exchange rate volatility and economic growth on the host country's economic growth.

Gap in the Literature

The review reveals the need for this study based on the shortcomings of the related empirical literature. One of the shortcomings of the previous studies is that the studies have reported inconsistent effect of macroeconomic variables on the economic growth. The studies did not consider investigating the moderating effect of exchange rate on the relationship between oil price shocks and economic growth. Hence, the findings may not be applicable given the recent micro and macroeconomic developments in Nigeria. None amongst such studies examine the direct and indirect effect of oil price shocks on economic growth contingent on exchange rate volatility in Nigeria. The present study, therefore, represent a unique contribution to knowledge because it attempts to examine whether exchange rate moderates the relationship between oil price shocks and economic growth.

Data and Methodology

Sources Data

The variables on which the data were collected were oil price, exchange rate, labour force, physical capital, interest rate, trade openness, inflation, government expenditure and GDP. Data on GDP was collected from World Bank Development Indicators (WDI) (2019) while Data on oil price was collected from West Texas Intermediate (WTI) (2019) and Data on exchange rate, labour force, physical capital, inflation were collected from World Bank Development Indicators (WDI) (2019). Data for all the variables covers a period of forty years from 1980 – 2019 adopting two econometric models which are: The Non-linear Autoregressive Distributed Lag Model (NARDL) approach to cointegration technique and the Generalised Autoregressive Conditional Heteroscedasticity Model (GARCH).

Measurement of Data

Gross Domestic Product (GDP) was used as dependent variable while oil price (OP), exchange rate (EXR), interest rate (INTR), labour force (LF), physical capital (K), inflation (INFL), trade openness

(TO) money supply (MS) and government expenditure (GE) were the independent variables. GDPC was measured in 2010 constant prices, exchange rate was measured as price of Naira versus Dollar and oil price was measured in dollar per Barrel, physical capital proxy by Gross fixed capital formation, labour force was measured as (labour force, total), government expenditure was measured as general government final consumption expenditure on goods and services (% of GDP), inflation was measured as consumer prices (annual %), interest rate (real interest rate (%), trade openness was measured as (Trade % of GDP) and money supply was measured as Broad money (% of GDP).

Model Specification

Symmetric (Direct) Linear-ARDL Effect

To examine the effect of oil price shocks on economic growth in Nigeria; the empirical model in this study follows the endogenous growth theory by Romer (1986) and Lucas (1988). The theory is considered to be more relevant and appropriate to provide the theoretical framework for this study because first it tries to underscore the key determinants of economic growth and secondly it can appropriately be applied to an aggregate production function with more than two variables or components. The functional and the econometric representations of the relationship among the variables of the study are given in equation (1) and (2).

$$GDP = F(OP, K, L, EXR, INF) \dots \dots \dots (1)$$

$$GDP_t = \beta_0 + \beta_1 OP_t + \beta_2 K_t + \beta_3 LF_t + \beta_4 EXR_t + \beta_5 INF_t + \varepsilon_t \dots \dots \dots (2)$$

Where GDP was measured in 2010 constant prices; exchange rate was measured as price of Naira versus dollar; oil price was measured in Dollar per barrel; physical capital proxy by Gross fixed capital formation; labour force was proxy by (labour force, total), and inflation proxy by consumer prices (annual %).

The empirical symmetric (linear) ARDL model is specified as follows:

Based on the bounds-testing approach proposed by Pesaran and Smith (1998), Pesaran et al. (2001) and Narayan (2005) any long-run relationship may be given by the equation as follows:

$$GDP_t = \beta_0 + \sum_{i=0}^n \beta_1 GDP_{t-1} + \sum_{i=0}^n \beta_2 OP_{t-1} + \sum_{i=0}^n \beta_3 K_{t-1} + \sum_{i=0}^n \beta_4 LF_{t-1} + \sum_{i=0}^n \beta_5 EXR_{t-1} + \sum_{i=0}^n \beta_6 INF_{t-1} + \beta_{7i} \ln GDP_{t-1} + \beta_{8i} \ln OP_{t-1} + \beta_{9i} \ln K_{t-1} + \beta_{10i} \ln LF_{t-1} + \beta_{11i} \ln EXR_{t-1} + \beta_{12i} \ln INF_{t-1} + \varepsilon_t \dots \dots \dots (3)$$

Where n represents the optimal lag length, t is time.

By using the coefficient of this error correction model (ECM), the speed of the adjustment will be calculated. This will explain how much time the system will take to return to the long term equilibrium after a random shock and the expected sign will be negative to ensure the convergence. The error correction model (unrestricted) for the ARDL model is specified in the equation below:

$$\Delta \ln GDP_t = \pi_0 + \sum_{i=0}^n \pi_{1i} \Delta \ln GDP_{t-1} + \sum_{i=0}^n \pi_{2i} \Delta \ln OP_{t-1} + \sum_{i=0}^n \pi_{3i} \Delta \ln K_{t-1} + \sum_{i=0}^n \pi_{4i} \Delta \ln LF_{t-1} + \sum_{i=0}^n \pi_{5i} \Delta \ln EXR_{t-1} + \sum_{i=0}^n \pi_{6i} \Delta \ln INF_{t-1} + \gamma ECM + \varepsilon_t \dots \dots \dots (4)$$

Where the speed of adjustment will be γ and **ECM** is the residuals which were obtained through the application of the cointegration model. In addition, the coefficient will give the information about the long run relationship among the variables.

Asymmetric (Indirect) Nonlinear-ARDL Effect

In order to capture the inherent asymmetry in the oil price dynamics, we decomposed the oil price into positive and negative changes. The decision to decompose oil price is based on the understanding that economic agents might react differently to oil price changes. The NARDL is specified as:

$$\Delta GDP_t = \alpha_0 + \alpha_1 GDP_{t-1} + \alpha_2 K_{t-1} + \alpha_3 LF_{t-1} + \alpha_4 EXR_{t-1} + \alpha_5 INF_{t-1} + \alpha_6 OP_t^+ + \alpha_7 OP_t^- + \sum_{i=0}^{N1} (\gamma_i^+ \Delta OP_{t-i}^+ + \gamma_i^- \Delta OP_{t-i}^-) + \varepsilon_t \dots (5)$$

In Equation (3), the oil price (OP_t) variable has now been decomposed into OP_t^+ and OP_t^- denoting positive and negative changes of oil price respectively. These decomposed prices are defined theoretically as:

$$OP_t^+ = \sum_{i=1}^t \Delta OP_j^+ = \sum_{i=1}^t \max(\Delta OP_i, 0) \dots (6)$$

$$OP_t^- = \sum_{i=1}^t \Delta OP_j^- = \sum_{i=1}^t \min(\Delta OP_i, 0) \dots (7)$$

Equation (5) can be re-specified to include an error correction term (ECT) thus:

$$\Delta GDP_t = \lambda ECT_{t-1} + \sum_{i=1}^{N1} \lambda_i \Delta GDP_{t-i} + \sum_{i=1}^{N2} \lambda_i \Delta K_{t-i} + \sum_{i=1}^{N3} \lambda_i \Delta LF_{t-i} + \sum_{i=1}^{N4} \lambda_i \Delta EXR_{t-i} + \sum_{i=1}^{N5} \lambda_i \Delta INF_{t-i} + \sum_{j=0}^{N6} (\gamma_j^+ \Delta OP_{t-j}^+ + \gamma_j^- \Delta OP_{t-j}^-) + \varepsilon_t \dots (8)$$

Where λECT_{t-1} is the Error Correction Term (ECT) that captures the long-run equilibrium in the NARDL, while the speed of adjustment λ measures the time frame it would take the system to adjust to its long-run when there is a shock. The ECT term is expressed as

$$\lambda_{t-1} = 1 - \phi_0 - \phi_1 K_{t-1} - \phi_2 LF_{t-1} - \phi_3 EXR_{t-1} - \phi_4 INF_{t-1} - \phi_5 OP_{t-1}^+ - \phi_6 OP_{t-1}^-$$

wherein the parameters $\phi_{1-4} \left(= -\frac{\alpha_{2-5}}{\alpha_1} \right)$ and $\phi_{1-4} \left(= -\frac{\alpha_{2-5}}{\alpha_1} \right)$ represent the long-run parameters

for positive and negative changes in oil price respectively while short run parameters are γ_j^+ and γ_j^- . The NARDL would only work in a situation where there is Cointegration in the system. To ensure the existence of the Cointegration, the study would adopt some pre-estimation, such as the Bounds testing that is F-distributed. Also, employ the Wald test for testing restrictions to ascertain whether the asymmetries matter both in the long run and short run.

The empirical GARCH model for this study is specified as follows:

$$\ln RGDPI_t = \alpha_0 + \alpha_1 \ln EXR_t + \alpha_2 \ln TO_t + \alpha_3 \ln GE_t + \alpha_4 \ln INTR_t + \alpha_5 \ln INF_t + \alpha_6 \ln MSI_t + \varepsilon_t \dots (9)$$

Where RGDP represents the real GDP represents the productivity index, government expenditure measured was as general government final consumption expenditure on goods and services (% of GDP); exchange rate was measured as price of Naira versus dollar; TO indicates trade openness was measured as (% of GDP); INTR indicates the interest rate real interest rate (%); INFL consumer prices (annual %) while e_t is the stochastic error term. Statistically, volatility is often measured as the sample standard deviation:

$$\sigma = \sqrt{\frac{1}{r-1} \sum_{t=1}^r (r_t - \mu)^2} \dots\dots\dots (10)$$

In presenting the model, there are two distinct specifications, the first for the conditional mean and the other for the conditional variance. The model will be estimated using maximum likelihood method under the assumption of Gaussian normal error distribution. The log likelihood function is maximized using Marquardt numerical iterative algorithm to search for optimal parameters.

Having generated the real exchange rate from the nominal exchange rate, this will derive the real exchange rate volatility (REXRVOL) with the aid of the Generalised Autogressive Conditional Heteroskedasticity (GARCH 1, 1) which belongs to the family of ARCH 'as introduced by Engle (1982) and Bollersley (1986). The jointly estimated GARCH (1,1) model is given as:

$$\alpha_t^2 = \alpha_0 + \alpha_1 \sum_{t=1}^2 + \beta_{t=1}^2 + \mu_t \dots\dots\dots (11)$$

Which says that, the conditional variance (σ^2) of Σ at time t depends not only on the squared error term in the previous time period (as in, ARCH (1) but also on its conditional variance in the previous time period.

Method of Estimation

The Autoregressive Distributed Lag (ARDL) technique was utilized because of its advantages: it can be applied to the variables irrespective of whether the time series data are purely 1 (0), purely 1 (1), or fractionally cointegrated (Pesaran *et al* 2001). Furthermore, both the short-run and the long-run coefficients could be obtained simultaneously although the sample observation is limited (Chindo *et al*, 2015). However, The Nonlinear Autoregressive Distributed Lag (NARDL) model developed by Shin *et al.* (2014) would examine both the long-run and short-run asymmetrical effects of oil price shocks on exchange rate and economic growth. The NARDL model is an asymmetric expansion of the linear ARDL model of Pesaran *et al.* (2001), which is a single cointegration and error correction approach. The advantages of using the NARDL approach are well documented in the works of Van Hoang *et al.* (2016) and Nusair (2016). First, it allows modeling the cointegration relation that could exist between the endogenous and exogenous variables. Second, it allows testing both the linear and nonlinear cointegration. Third, it differentiates between the short- and long-run effects of the independent variable to the dependent variable. Fourth, unlike other error correction models where the order of integration of the considered time series should be the same, the NARDL model relaxes this restriction and permits combining data series having different integration orders.

The GARCH model was used to test for the existence of volatility in exchange rate variable. The model has several advantages which includes simplicity, generates volatility clustering and heavy tails (high kurtosis); It also aim to minimize errors in forecasting by accounting for errors in prior forecasting and enhancing the accuracy of ongoing predictions; GARCH model is also presented in the estimation of the volatility in time series analysis. Furthermore, GARCH models describe

financial markets, in which volatility can change, becoming more volatile during periods of financial crises or world events and less volatile during periods of relative calm and steady economic growth.

Pre-Estimation Diagnostics

Unit Root Test

Since the data used in this study are time series, there is need to check the stationarity of the data. The stationarity properties of the data were checked using the Augmented Dickey Fuller (ADF) test (Dickey and Fuller 1979, 1981) and the Phillips Perron (PP) test (Phillips and Perron, 1988). It also provided an indication to use or not to use a constant as a plot of time series, a trend with a constant, or none. Therefore, estimation was made to test equation that includes both constant and time trend for testing unit roots for all the variables. The general form of these tests is estimated in the following forms:

$$\Delta Y_t = b_0 + \beta Y_{t-1} + \mu_1 \Delta Y_{t-1} + \mu_2 \Delta Y_{t-2} + \dots + \mu_p \Delta Y_{t-p} + \varepsilon_t \dots \dots \dots (12)$$

Where, Y_t represents time series to be tested, b_0 is the intercept term, β is the coefficient of interest in the unit root test, μ is the parameter of the augmented lagged first difference of Y_t to represent the p^{th} order autoregressive process and ε_t is the white noise error term.

Post-Estimation Diagnostics

Testing for Heteroscedasticity

One of the most important issues before applying the generalized autoregressive conditional heteroscedasticity (GARCH) methodology is to first examine the residuals of the returns series of exchange rate for evidence of heteroscedasticity. To test for this heteroscedasticity, the Lagrange Multiplier (LM) test proposed by Engle (1982) was applied. After obtaining the residuals e_t , the next step is to regress the squared residuals on a constant and q lags as in the following equation:

$$e_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 e_{t-2}^2 + \dots + \alpha_q e_{t-q}^2 + v_t \dots \dots \dots (13)$$

The null hypothesis that there is no ARCH effect up to order q can be formulated as:

$H_0 : \alpha_1 = \alpha_2 \dots = \alpha_q = 0$ Against the alternative: $H_1 : \alpha_i > 0$ for at least one $i = 1, 2, \dots, q$. The autoregressive moving average ARMA (1,1) model for the conditional mean in the series is employed as an initial regression, then, test the null hypothesis that there are no ARCH effects in the residual series.

Result and Discussion

Table 1: Result of Unit Root Test of Stationarity

Variables	ADF at Level	ADF at First difference	PP at Level	PP at First difference	Order of Integration
OP	-2.282	-1.196	-6.622	-6.523	I(1)
EXR	-4.298	-4.281	-4.256	-5.058	I(1)
GDP	-4.472	-4.132	-4.582	-4.137	I(1)
K	-1.994	-5.333	-3.417	-4.220	I(1)
LF	-4.953	-5.546	-2.434	-2.334	I(1)
INF	-16.811	-17.412	-14.143	-14.614	I(1)
GE	-3.455	-3.562	-1.471	-3.949	I(1)
TO	-4.496	-7.486	-4.493	-8.791	I(1)
MS	-1.102	-6.875	-2.494	-6.920	I(1)
INTR	-4.810	-4.662	-4.443	-4.244	I(1)
ADF Critical Values (5%) = 2.94			PP Critical Values (5%) = 2.9		

Source: Computed by the researcher using EViews 9

The results of the unit root tests presented in table 4.1 employed by the Augmented Dickey and Fuller (ADF) (1979) and Phillips and Perron (PP) (1988) shows that all the variables are stationary at first difference which indicates that all the series are, integrated at the same order I(1). This indicates the existence of the order of integration of each of the variables. This is the reason why the study qualifies to use both the Nonlinear Autoregressive Distributed Lag (NARDL) Model and Generalised Autoregressive Conditional Heteroscedasticity (GARCH) Model.

Table 2: The Bounds Test Results for the ARDL and NARDL

	F Statistic	Level of Significance	Bounds test critical values	
			I (0)	I (1)
ARDL	8.078[0.000]^a	1%	3.41	4.68
		5%	2.62	3.79
		10%	2.26	3.35
NARDL	6.234[0.000]^a	1%	1.83	2.94
		5%	2.06	3.24
		10%	2.54	3.86

Note: Based on Narayan Table Case III (Narayan, 2005)

^aDenote Model's cointegrated F-statistic with the corresponding critical bond values, respectively.

Source: Computed by the researcher using EViews 9

The cointegration result presented in Table 2 shows that the ARDL and NARDL are cointegrated as the calculated F-statistics values (8.078 and 6.234) based on the optimum lags selected exceed

the upper bound of the critical bounds table developed by Narayan (2005) at 1% for both the models respectively. Therefore, the results agree to the long run relationship between the variables in the two models. This allows for the estimation of the short-run error correction model and the long run coefficients.

Table 3: The estimated Long-Run and Short-Run Coefficients Based on Akaike Info Criterion (AIC) for Symmetric (Direct) Linear-ARDL

Regressors	Coefficients	T-Ratio[Prob]
The long-run results		
LOP	0.280	4.549 [0.000]***
LK	0.025	0.323 [0.749]
LLF	0.624	0.194 [0.847]
LEXR	-0.167	-2.259[0.032]**
LINF	-0.169	-3.995[0.000]***
Constant	5.175	0.416[0.681]
The short-run results		
dLOP	0.072	3.168 [0.004]**
dLK	0.007	0.310 [0.759]
dLLF	0.161	0.194 [0.848]
dLEXR	0.005	0.234 [0.817]
dLINF	-0.018	-2.433 [0.022]**
ECM (-1)	-0.259	-4.804 [0.000]**
Adjusted R ²	0.990	
Durbin-Watson statistics	2.030	

Note: LR GDP = Dependent Variable: Lag lengths are 1, 0, 0, 0, 2, 2 selected based on AIC

Note: *Significant at 10% level. ** Significant at 5% level. ***Significant at 1% level.

Source: Computed by the researcher using EViews 9

Table 3 presents the long-run and short-run equations estimated for (linear) ARDL symmetric effect. The long-run result discloses that oil price is positive and significant at 1% level. The result clearly indicates that oil price has direct positive impact on growth in Nigeria. To be specific, a 1% increase in oil price would lead to a 0.280% impact on economic growth. This finding confirmed that of Olayungbo and Olayemi (2018); Alley (2018) for the same sample country. The direct symmetric effect of oil price on economic growth in Nigeria in the short-run is also positive and significant at the 1% level. Among the other variables, real effective exchange rate is negative and significant in the long run, inflation rate is also negative and significant on growth both in the long-run and short-run. The Error Correction Model (ECM) with the coefficient (-0.259) corroborates the long-run relationship among the variables and donates the speed of adjustment of the variables convergence from short-run to long-run equilibrium is 25.9%. This shows that in the event of any shock the speed of adjustment is moderate. The reported F-statistics values, Adjusted R-squared, and the Durbin-Watson statistic suggest that the model is a good fit.

Table 4: The estimated Long-Run and Short-Run Coefficients Based on Akaike Info Criterion (AIC) for Asymmetric (Indirect) NARDL

Regressors	Coefficients	T-Ratio[Prob]
The long-run results		
LOP_POS	-0.073	-1.097[0.289]
LOP_NEG	0.110	2.255[0.039]*
LK_POS	0.037	0.791[0.440]
LK_NEG	-0.066	-0.990[0.337]
LLF_POS	19.547	4.919[0.000]***
LLF_NEG	-8.141	-2.199[0.043]**
LREER_POS	-0.206	-4.677[0.000]***
LREER_NEG	-0.044	1.589[0.132]***
LINF_POS	-0.002	-0.112[0.912]
LINF_NEG	-0.058	-2.502[0.024]**
Constant	6.982	97.036[0.000]***
The short-run results		
dLOP_POS	0.035	0.764[0.456]
dLOP_NEG	0.010	0.225[0.825]
dLK_POS	0.031	0.748[0.465]
dLK_NEG	-0.055	-1.020[0.323]
dLLF_POS	1.261	0.179[0.860]
dLLF_NEG	-6.910	-1.384[0.185]
dLREER_POS	-0.108	-2.299[0.035]**
dLREER_NEG	0.037	1.508[0.151]
dLINF_POS	-0.002	-0.113[0.912]
dLINF_NEG	-0.027	-2.172[0.045]**
ECM(-1)	-0.828	-5.963[0.000]***
Adjusted R ²	0.991	
Durbin-Watson statistics	2.603	

Note: LR GDP = Dependent Variable: Lag lengths are 1, 1, 1, 0, 0, 2, 2, 2, 0, 0, 1 selected based on AIC

Note: *Significant at 10% level. ** Significant at 5% level. ***Significant at 1% level.

Source: Computed by the researcher using EViews 9

Table 4 presents the long-run and short-run results for (Nonlinear) ARDL asymmetric effect. The long-run result discloses that positive oil price is negative but insignificant while negative oil price is positive and significant. This clearly indicates that lower oil price have a significant impact on growth in Nigeria. To be specific, 1% oil price decrease would lead to 0.110% increase in economic growth. The result is consistent with the findings advanced by Raheem (2017) who reported similar results that oil price is an important precondition for positive and negative effects of oil price shocks. The impact of oil price in Nigeria in the short-run is positive but insignificant. Labour is positive and significant and capital is also positive but insignificant which is in accordance with the endogenous growth theory.

Among the other variables, the results in Table 4 reveal that both in the long-run and short run positive real effective exchange rate is negative and significant while negative real effective

exchange rate is positive but insignificant. This also suggests that higher exchange rate has a negatively significant impact on economic growth. Positive inflation rate both in the long-run and short-run is negative but insignificant while negative inflation rate is positive and significant at 5% significance level. The Error Correction Term (ECT) coefficient (-0.828) substantiates the long-run relationship among the variables and donates the speed of adjustment of the variables' convergence from short-run to long-run equilibrium is 82.8%. This shows that in the event of any shock the speed of adjustment is high. The Adjusted R², Durbin-Watson statistic, and F-statistic indicate that the model is also a good fit.

Table 5: Wald Test for NARDL

Test Statistic	Value	Df	Probability
NARDL 10			
F-statistic	16.72278	(10, 16)	0.0000
Chi-square	167.2278	10	0.0000

Source: Computed by the researcher using EViews 9

Table 5 presents the results of the joint asymmetries. The null hypothesis of the test is that the addition of the partial sums of the decomposition of oil price change into both positive and negative oil price shocks is not important; while the other side of the coin is that the decomposition of oil price changes matter. The Wald test F-statistic and P-values are positive and significant. This means that null hypothesis will be rejected. The Wald statistics indicates that there is existence of asymmetry effect on Nigeria's economic growth both in the short-run and long-run.

Table 6: ARDL and NARDL Diagnostic Tests

Test-Statistics	LM Version	F Version
Model 1 (ARDL)		
Serial Correlation	CHSQ(2) = 0.877[0.645]	F(2, 25) 0.295[0.747]
Heteroskedasticity	CHSQ(1) = 0.069[0.792]	F(1, 35) 0.066[0.799]
Model 2 (NARDL)		
Serial Correlation	CHSQ(2) = 8.052[0.018]	F(2, 14) 1.947[0.180]
Heteroskedasticity	CHSQ(1) = 0.202[0.653]	F(1, 34) 0.192[0.664]

Source: Computed by the researcher using EViews 9

Like any other time series analysis, diagnostic tests are imperative in assessing the validity, efficiency and consistency of the estimated model. Table 6 shows that the ARDL and NARDL have passed all the diagnostic tests. The result is free from autocorrelation. The Jacque Bera statistics confirmed that the model is stable because the normality tests favour the alternative hypothesis. The functional form results reveal that the model is correctly specified. The results of the heteroscedasticity show that the residual is constant over time since the null of the presence of heteroscedasticity is rejected.

Table 7: The estimated ARCH/GARCH equation coefficients based on ML ARCH – Normal distribution

Variables	Coefficients	z-Statistics	P-Value
Real Exchange Rate (<i>LREER</i>)	-0.020	-1.936	0.053**
Interest Rate (<i>LINTR</i>)	0.005	0.247	0.805
Trade Openness (<i>LTO</i>)	0.038	0.907	0.364
Government Expenditure (<i>LGE</i>)	0.109	17.069	0.000***
Inflation Rate (<i>INFL</i>)	0.008	0.493	0.622
Money Supply (<i>MS</i>)	-0.010	-15.293	0.000***
Constant	5.043	98.394	0.000***

Variance Equation estimate of GARCH Model

	Coefficients	z-Statistics	P-Value
Constant	0.000	0.950	0.342
RESID(-1)^2	1.453	1.159	0.247
GARCH(-1)	-0.073	-0.232	0.817

Note: *, **, and *** denote statistical significance at 1%, 5%, and 10% levels, respectively.

Source: Computed by the researcher using EViews 9

As shown in Table 7, the results of the GARCH (1,1) model discloses that real effective exchange rate volatility is negative and significant. The result clearly offered evidence that real effective exchange rate volatility persists throughout the study period, and has a negative and highly statistically significant effect on economic growth of the Nigeria economy. The results of the GARCH model shows that the sum of the ARCH and GARCH coefficients is greater than one, suggesting a high volatility in exchange rate over the period of the study. The coefficient of the ARCH term is greater than that of GARCH term indicating that volatility in the exchange rate tends to be more extreme. The result indicates that exchange rate volatility exerts a negative impact on economic growth in Nigeria. This result is statistically significant at 5% level and suggests that 1% increase in the volatility of the exchange rate will lead to -0.020% decrease in the economic growth of Nigeria. The finding confirmed that of Ehikioya (2019) who reported similar result and have discovered that exchange rate volatility has significant negative effect on economic growth. The result also substantiates the findings of Ozata (2020) among others, reported similar results in Turkey and have discovered that real exchange rate volatility has significant negative effect on economic growth. Among all the other explanatory variables; government expenditure (GE) demonstrates a positive and statistically significant determinant of economic growth in explaining the fluctuations of exchange rate volatility in Nigeria. Money supply (MS) was found to have a significant negative effect on economic growth. However, interest rate (INTR), inflation rate (INFL) and trade openness (TO) exerts a positive but insignificant effect on economic growth over the sampled period.

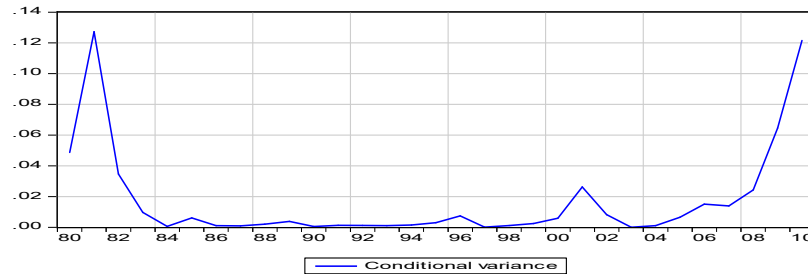


Figure 1: Conditional Variance from GARCH (1,1) Model

Source: Computed by the researcher using EViews 9

Figure 1 shows that increase in the volatility during the years can easily be seen from the conditional variance from GARCH(1,1) model.

Conclusion and Policy Recommendations

The findings of the long-run and short-run relationship of symmetric (direct) Linear-ARDL revealed that oil price have a direct positive effect on the growth of the Nigerian economy. The asymmetric (Indirect) Nonlinear-ARDL long-run relationship revealed that lower oil price has a significant positive effect on the growth of the Nigerian economy over the sampled period. This indicates that oil price decrease has a direct positive and significant impact on economic in growth. In effect, oil price by itself has strong economic potential to motivate growth; while in the short-run oil price changes have been found to be positive but insignificant. The ECMs for the two models have confirmed the long-run relationship and indicated a moderate and high speed of adjustments of the variables' convergence to equilibrium in the long run. The Wald test showed that there is existence of asymmetric (indirect) effect for the Nonlinear-ARDL. With regards to exchange rate volatility, its effect on economic growth in Nigeria, the result revealed the existence of time-varying conditional volatility of the real exchange rate; that is, there is the existence of ARCH effect and volatility clustering in the real exchange rate data which makes the exchange rate to be volatile. The study offered evidence that exchange rate volatility persists throughout the study period, which suggests that periods of high (low) exchange rate shocks tend to be followed by periods of high (low) exchange rate shocks for a prolonged period. The result of the empirical analysis shows that exchange rate volatility negatively and significantly influences the economic growth of Nigeria.

Based on the findings, the following recommendations are proffered to guide policy and decision making: The authorities in Nigeria would need to work on policy frameworks that should be cautious and resist the temptation of taking advantage of "revenue effect" because, in the short run, oil price change has meaningful impact. This assertion is coming from the fact that the negative consequence of oil price rise might be overwhelming; also, the state should focus more on diversifying the economy by invigorating its non-oil sector for increased and diversified exports. This could be achieved through various production-stimulating policies such as monetary policies (e.g. interest rate reduction), fiscal policies (e.g. tax incentives) and infrastructure-development polices; The government needs to monitor the foreign exchange market at regular intervals and make policies that will prevent fluctuations of its currency; also, it is necessary to strengthen the fiscal and financial structure and institute policies that will minimize the magnitude of exchange rate volatility and control of viable macroeconomic variables; government should diversify the economy away from crude oil and natural gas to non-oil revenue generating sectors

such as agriculture, mining, services, and spend more on non-oil sector and thus improve economic growth of Nigeria.

References

- Aghion, P., Howitt, P., Howitt, P. W., Brant-Collett, M., & García-Peñalosa, C. (1998). *Endogenous growth theory*. MIT press.
- Ajao, M. G., & Igbekoyi, O. E. (2013). The determinants of real exchange rate volatility in Nigeria. *Academic Journal of Interdisciplinary Studies*, 2(1), 459-471.
- Akram, Q. F. (2009). Commodity prices, interest rates and the dollar. *Energy economics*, 31(6), 838-851.
- Alley, I. (2018). Oil price and USD-Naira exchange rate crash: Can economic diversification save the Naira?. *Energy Policy*, 118, 245-256.
- Basher, S. A., Haug, A. A., & Sadorsky, P. (2016). The impact of oil shocks on exchange rates: A Markov-switching approach. *Energy Economics*, 54, 11-23.
- Bollerslev, T., Engle, R. F., & Nelson, D. B. (1994). ARCH models. *Handbook of econometrics*, 4, 2959-3038.
- Cassel, G. (1918). Abnormal deviations in international exchanges. *The Economic Journal*, 28(112), 413-415.
- Devlin, J., & Lewin, M. (2005). Managing oil booms and busts in developing countries. *Managing economic volatility and crises: a practitioner's guide*, 186-209.
- Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American statistical association*, 74(366a), 427-431.
- Dickey, D. A., & Fuller, W. A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica: journal of the Econometric Society*, 1057-1072.
- Ding, L., & Vo, M. (2012). Exchange rates and oil prices: A multivariate stochastic volatility analysis. *The Quarterly Review of Economics and Finance*, 52(1), 15-37.
- Domar, E. D. (1946). Capital expansion, rate of growth, and employment. *Econometrica, Journal of the Econometric Society*, 137-147.
- Dornbusch, R., Krugman, P., & Cooper, R. N. (1976). Flexible exchange rates in the short run. *Brookings Papers on Economic Activity*, 1976(3), 537-584.
- Dovern, J., & Kenny, G. (2017). The long-term distribution of expected inflation in the euro area: what has changed since the great recession?.
- Ebele, N., Samuel, T., & Sebastine, U. (2017). *Modeling Exchange Rate Volatility and Economic Growth in*. 02(06), 88-97.
- Ehikioya, B. I. (2019). *The impact of exchange rate volatility on the Nigerian economic growth : An empirical investigation*. 37(3), 45-68.
- Engle, R. F. (1982). A general approach to Lagrange multiplier model diagnostics. *Journal of Econometrics*, 20(1), 83-104.
- Engle, R. F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica: Journal of the Econometric Society*, 987-1007.
- Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: representation, estimation, and testing. *Econometrica: journal of the Econometric Society*, 251-276.

- Erkan, B., Şentürk, M., Akbaş, Y. E., & Bayat, T. (2011). The Effect on the Indicators of Unemployment of International Crude Oil Price Volatility: Empirical Findings on the Case of Turkey. *Gaziantep University Journal of Social Sciences*, 10(2), 715-730.
- Ghassan, H. B., & AlHajhoj, H. R. (2016). Long run dynamic volatilities between OPEC and non-OPEC crude oil prices. *Applied Energy*, 169, 384–394.
- Ghosh, S. (2011). Examining crude oil price–Exchange rate nexus for India during the period of extreme oil price volatility. *Applied Energy*, 88(5), 1886-1889.
- Hamilton, J. D. (1988, March). Are the macroeconomic effects of oil-price changes symmetric?: A comment. In *Carnegie-Rochester Conference Series on Public Policy* (Vol. 28, pp. 369-378). North-Holland.
- Hamilton, J. D. (1996). This is what happened to the oil price-macroeconomy relationship. *Journal of Monetary Economics*, 38(2), 215-220.
- Hamilton, J. D. (2008). Oil and the Macroeconomy. *The new Palgrave dictionary of economics*, 2.
- Harold, R. F., & Domar, E. D. (1946). Capital Expansion, Rate of Growth and Employment. *Econometrica*, 14.
- Holmes, J. M. (1967). The purchasing-power-parity theory: in defense of Gustav Cassel as a modern theorist. *Journal of Political Economy*, 75(5), 686-695.
- Iwayemi, A., & Fowowe, B. (2011). Impact of oil price shocks on selected macroeconomic variables in Nigeria. *Energy Policy*, 39(2), 603–612.
- Iwayemi, A., & Fowowe, B. (2011). *Impact of oil price shocks on selected macroeconomic variables in Nigeria. Energy Policy*, 39(2), 603–612.
- Jin, X. (2019). The role of market expectations in commodity price dynamics: Evidence from oil data. *Journal of International Money and Finance*, 90, 1-18.
- Krugman, P. R. (1978). Purchasing power parity and exchange rates: Another look at the evidence. *Journal of international economics*, 8(3), 397-407.
- Lucas, R. E. (1988). *On the mechanics of economic development. Journal of monetary economics*, 22(1), 3-42.
- Lucas, R. E. (1988). *On the mechanics of economic development. Journal of monetary economics*, 22(1), 3-42.
- Mahmood, I., Ehsanullah, M., & Ahmed, H. (2011). *Exchange Rate Volatility & Macroeconomic Variables in Pakistan © Society for Business and Management Dynamics © Society for Business and Management Dynamics*. 1(2), 11–22.
- Narayan, P. K. (2005). *The saving and investment nexus for China: evidence from cointegration tests. Applied economics*, 37(17), 1979-1990.
- Nusair, S. A. (2016). The effects of oil price shock s on the economies of the Gulf Co-operation Council countries: Nonlinear analysis. *Energy Policy*, 91, 256–267.
- Nweze, N. P., & Edame, G. E. (2016). An empirical investigation of oil revenue and economic growth in Nigeria. *European Scientific Journal*, 12(25).

- Olayungbo, D. O., & Olayemi, O. F. (2018). *Dynamic relationships among non-oil revenue , government spending and economic growth in an oil producing country : Evidence from Nigeria*. *Future Business Journal*, 4(2), 246–260.
- Ozata, E. (2020). *The effect of exchange rate volatility on economic growth in turkey*. 9, 42–51.
- Pesaran, H. H., & Shin, Y. (1998). Generalized impulse response analysis in linear multivariate models. *Economics letters*, 58(1), 17-29.
- Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). *Bounds testing approaches to the analysis of level (D, 2013)relationships*. *Journal of applied econometrics*, 16(3), 289-326.
- Philips, P. C. (1988). B\& Perron. P., *Testing for a Unit Root in Time Series Regression*, *Eioneria*, 75, 335-46.
- Raheem, I. D. (2017). Asymmetry and break effects of oil price-macroeconomic fundamentals dynamics: The trade effect channel. *The Journal of Economic Asymmetries*, 16, 12-25.
- Reboredo, J. C., Rivera-Castro, M. A., & Zebende, G. F. (2014). Oil and US dollar exchange rate dependence: A detrended cross-correlation approach. *Energy Economics*, 42, 132-139.
- Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of political economy*, 94(5), 1002-1037.
- Romer, P. M. (1994). The origins of endogenous growth. *Journal of Economic perspectives*, 8(1), 3-22.
- Sulaiman, C., Bala, U., Tijani, B. A., Waziri, S. I., & Maji, I. K. (2015). Human capital, technology, and economic growth: Evidence from Nigeria. *Sage Open*, 5(4).
- Sulaiman, L. A. (2012). Does restructuring improve performance? An industry analysis of Nigerian oil & gas sector. *Research Journal of Finance and Accounting*, 3(6), 55-62.
- Tiwari, A. K., Mutascu, M. I., & Albulescu, C. T. (2013). The influence of the international oil prices on the real effective exchange rate in Romania in a wavelet transform framework. *Energy Economics*, 40, 714-733.
- Van Hoang, T. H., Lahiani, A., & Heller, D. (2016). Is gold a hedge against inflation? New evidence from a nonlinear ARDL approach. *Economic Modelling*, 54, 54–66.
- Van Hoang, T. H., Lahiani, A., & Heller, D. (2016). Is gold a hedge against inflation? New evidence from a nonlinear ARDL approach. *Economic Modelling*, 54, 54–66.
- Volkov, N. I., & Yuhn, K. (2016). *Oil price shocks and exchange rate movements*. *Global Finance Journal*, 1–13.
- Wesseh, P. K., & Lin, B. (2018). *Exchange rate fluctuations, oil price shocks and economic growth in a small net-importing economy*. *Energy*.
- Yin, L., & Ma, X. (2018). Causality between oil shocks and exchange rate: A Bayesian, graph-based VAR approach. *Physica A: Statistical Mechanic*.