Growth and Oil Price Fluctuation in Nigeria: A Variance Decomposition Evidence

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Abstract: This study examines the impact of oil price shocks on economic growth rate in Nigeria using the impulse response functions and forecast error variance decomposition on quarterly data from 2000 to 2016. This study finds that fluctuations in oil prices cause swings in GDP growth rate in Nigeria. The fluctuation in oil prices also depreciates Naira exchange rate. The country should branch out its revenue sources to shield the dangle effect of the fluctuation in prices of oil.

Keywords: Growth Rate, Shocks, Oil Price

1. Introduction

The research problem is explained on the basis of Nigeria's high susceptibility to fluctuations in international oil market given the intense reliance on crude oil proceeds (Akpan, 2009). Basically, the crux of the problem lies in the fact that since the country is oil driven, the economy is exceedingly exposed to oil price shocks.

The recent case in point is that in 2008 when oil price fell from a peak of US$147 to about US$37.81 per barrel, the economy plummeted into a recession. Okonju (2009) observed that during the oil boom era, GDP grew positively by 6.2% annually, but the growth rate turned negative in period preceding economic recession. Even when copious studies exists on impact of erratic movement of oil prices on output growth in Nigeria, most of these studies relied on samples that are far backward in time. Hence, the significance of this study using most recent periodical data from 2000 to 2016.

The study thus aimed to ascertain effect of shocks in oil prices on GDP growth rate in Nigeria. Subsequent to this introduction, are literature review, theoretical framework, discussion of empirical estimates and the conclusion.

2. Literature Review

Fluctuation in oil price and its attendant cost on growth have persistently generated controversies. Some of the studies that advocated the positive effects include Akpan (2009), Aliyu (2009), Olomola (2006), Alley, Asekomeh, Mobalaji and Adeniran (2014), Oriakhi and Osazee (2013) etc . For example, Olomola (2006) has found that oil price instability is statistically different from zero in explaining GNP growth in Nigeria. Conversely, the study by Cerralo (2005) upholds that volatility in oil price impact negatively on growth.

In the study by Rodriguez and Sanchez (2003), the empirics had it that oil shocks have negative impact on economic growth on oil-importing economies. Similarly, Elder *et al.*, (2009) opines that negative oil shocks may not be expansionary for oil-importing countries in the short-run, if the oil shock creates uncertainty about prices.

3. Theoretical Framework

In this study the channel of transmission of oil price fluctuation on the economy is rooted on both the demand and supply channels (Jin, 2008). The supply side is made evident on the ground that crude oil is a basic input to production, and increased fluctuation in oil price leads to a rise in uncertainty in production costs that induces lower output of firms.

Demand side effect is made evident on the ground that variation in oil prices affects mutually consumption and investment decisions. Theory provides other channels of transmission which include real balance channel, income transfer channel, endogenous monetary policy response and sectoral shifts hypothesis, Dutch-Disease channel, Hotelling rule and irreversibility and uncertainty channel (Adeniyi, 2010).

The irreversibility and uncertainty channel maintains that oil price fluctuation raises uncertainty about future oil prices, hence delays in business investment (Guo and Kliesen, 2005). In effect, uncertainty about energy prices will induce optimizing firms to postpone irreversible investment decisions as long as the expected value of additional information surpasses the expected short-run return to current investment (Elder et al., 2009).

3.1 Model Specification

The model specification is.

$$Rgdp(t) = \sum_{j=1}^{p} A_{11j} Rgdp(t-j) + \sum_{j=1}^{p} A_{12j} Oilpv(t-j) + \sum_{j=1}^{p} A_{13j} Gexpd(t-j) + \sum_{j=1}^{p} A_{14j} Nexch(t-j) + E_1(t)$$

$$Oilpv(t) = \sum_{j=1}^{p} A_{21j} Oilpv(t-j) + \sum_{j=1}^{p} A_{22j} Rgdp(t-j) + \sum_{j=1}^{p} A_{23j} Gexpd(t-j) + \sum_{j=1}^{p} A_{24j} Nexch(t-j) + E_2(t)$$

$$Gexpd(t) = \sum_{j=1}^{p} A_{31j} Gexpd(t-j) + \sum_{j=1}^{p} A_{32j} Oilpv(t-j) + \sum_{j=1}^{p} A_{33j} Rgdp(t-j) + \sum_{j=1}^{p} A_{34j} Nexch(t-j) + E_3(t)$$

$$Nexch(t) = \sum_{j=1}^{p} A_{41j} Oilpv(t-j) + \sum_{j=1}^{p} A_{42j} Nexch(t-j) + \sum_{j=1}^{p} A_{43j} Rgdp(t-j) + \sum_{j=1}^{p} A_{44j} Gexpd(t-j) + E_4(t)$$

Where *GDP* is gross domestic product, *Oilpv* is fluctuation in crude oil prices, *Nexch* is the nominal exchange rate of the Naira vis-vis the US dollar, *Gexpd* is government expenditure, *p* is the maximum number of lagged observations included in the VAR equation, *A* is the matrix of coefficients of the respective variables, E_1, E_2, E_3 and E_4 are residuals (prediction errors) for each time series.

4. Method of Data Analysis

The vector auto regression method of analysis is adopted in the paper. The study mainly relied on the variance decomposition of the forecast error and the impulse response functions to aid in the interpretation of a vector auto regression (VAR) model when fitted. For the VAR (p) of form,

$$y(t) = w + A_1 y(t-1) + \ldots + A_p y(t-p) + \mu_t$$

The VAR(1) model is thus specified using the general matrix notation of a VAR(p) as:

$$Y(t) = W + AY(t-1) + E(t)$$

where

$$A=\begin{bmatrix} A_1 & A_2 & . & . & . & A_{p-1} & A_p \\ I_k & 0 & . & . & . & 0 & 0 \\ 0 & I_k & . & . & . & 0 & 0 \\ . & & & & & . & . \\ . & & & & & . & . \\ . & & & & & . & . \\ 0 & 0 & . & . & . & I_k & 0 \end{bmatrix}$$

$$Y=\begin{bmatrix} y_1 \\ . \\ . \\ . \\ y_p \end{bmatrix},\ W=\begin{bmatrix} w \\ 0 \\ . \\ . \\ . \\ 0 \end{bmatrix}\ and\ \ E(t)=\begin{bmatrix} \mu_t \\ 0 \\ . \\ . \\ . \\ 0 \end{bmatrix}$$

where y, w *and* μ_t *are* k, are dimensional column vectors, A *is* $(kp \times kp)$ is by dimensional matrix and Y, W *and* E *are* kp are dimensional column vectors. The mean squared error of the *f-step forecas*t of variable *j* is derived thus:

$$MSE[y_{j,t}(f)]=\sum_{i=0}^{f-1}\sum_{k=1}^{K}(\varepsilon_j^{'}\Theta_i\varepsilon_k)^2$$

$$=\left(\sum_{i=0}^{f-1}(\Theta_i\Theta_i^{'})\right)_{jj}=\left(\sum_{i=0}^{f-1}\Phi_i\sum\nolimits_{\mu}\Phi_i^{'})\right)_{jj}$$

where $\varepsilon_j^{'}$ is the j[th] column of I_K and the subscript jj refers to that element of the matrix, $\Theta_i=\Phi_i P$ where P is a lower triangular matrix achieved by a Cholesky decomposition of $\sum_{\mu}$ such that $\sum_{\mu}=PP'$, where $\sum_{\mu}$ is the covariance matrix of the errors μ_t, $\Phi_i=JA^iJ'$, where $J=[I_k\ \ 0\ \ ...\ \ 0]$, so that J *is a* $(k \times kp)$ by dimensional matrix. The amount of forecast error variance of variable j accounted for by exogenous shocks to variable k is given by $\omega(jk, f)$.

$$\omega(jk,f)=\frac{\sum_{i=0}^{f-1}(\varepsilon_j^{'}\Theta_i\varepsilon_k)^2}{\sum_{i=0}^{f-1}\sum_{k=1}^{K}(\varepsilon_j^{'}\Theta_i\varepsilon_k)^2=\left(\sum_{i=0}^{f-1}(\Theta_i\Theta_i^{'})\right)_{jj}=\left(\sum_{i=0}^{f-1}\Phi_i\sum\nolimits_{\mu}\Phi_i^{'})\right)_{jj}}$$

Whereas the variance decomposition determines how much of the forecast error variance of the growth rate of the Nigerian economy can be explained by exogenous shocks to the oil prices, government expenditure and the nominal exchange rate of the Naira, impulse response determines the reaction of the growth function in response to some external change in oil prices, government expenditure and the nominal exchange rate and hence describes the reaction of the growth system as a function of time and the aforementioned variables that parameterizes the dynamic behavior of the growth rate of the Nigerian economy.

The study conducted stationarity test and co-integration test to guarantee valid statistical inference. The time series data were sourced from the CBN statistical bulletin. The data covers from 1990 through to 2016.

5. Empirical Analysis

5.1 Trend Analysis/Analysis of Stationarity Test Results

Graphical plot of the variables are as represented below in Figure 4.1. As shown, fluctuation in the residuals of oil prices along with nominal exchange rate are found stationary at level as they both crossed the zero-line and devoid of excessive divergence from zero. Conversely, the residuals of growth rate and government spending show evidence of unit root as the line graph of the series exhibited huge divergence from the equilibrium line following a perturbation. The stationarity condition is satisfied; hence any shock to the series will lead to a subsequent time-path that has a bounded mean and variance. The process is stationary and subsequent to such a shock, the time-path for the series will eventually reconcile to what it was up to that time and the shock will be absorbed.

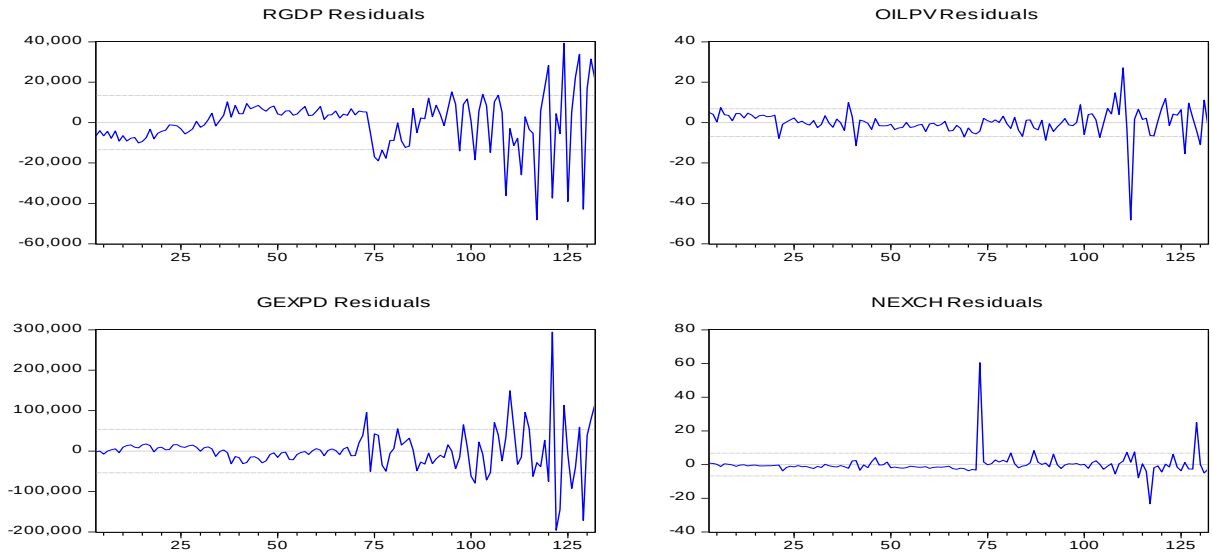

Figure 1: Stationarity Graphs

The study performed stationarity test on the time series to series and found a statistical robust evidence of stationarity of all the variables in the study. Hence, first difference of the variables was hereafter adopted for estimation.

5.2 Analysis of Co-integration Results

Given that all the variables in the study are I(I), we ran the Johansen co-integration test, found one co-integrating relation (for the trace and maximum eigen-value) with the graphical plot detailed in Figure 4.2 below. The analysis is that series are (I(1)) but some co-integrating vector of coefficients exists to form a stationary linear combination of them.

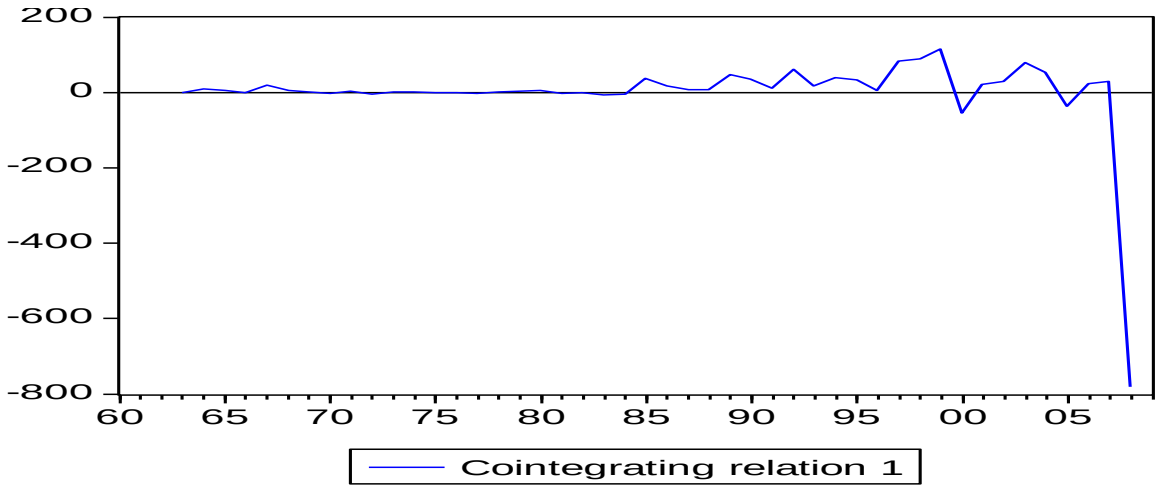

Figure 2: Co-integration Graph

The co-integration graph above suggests long-run relationship of linear combination of oil price fluctuation, government expenditure, exchange rate and growth rate in Nigeria at the 5% level.

5.3 Analysis of Granger Causality Results

The empirical analysis of the Granger-causality test results of Table 4.2 is as follows:

i. Unidirectional Granger-causality from oil price fluctuation to economic growth. Here, fluctuation in oil price increases the prediction of GDP growth rate but not vice versa. Given an F-statistic of 10.3266 and a probability value of 0.0000, we reject that fluctuation in oil prices does not cause predictions in GDP growth rate in Nigeria and accept the hypothesis that economic growth does not Granger cause oil price volatility in Nigeria.
ii. Bidirectional Granger-causality from government spending to GDP growth rate and vice versa. Here, economic growth increases government spending. Also, government spending predicts the variation in economic growth.
iii. Bidirectional causality from the nominal exchange rate to economic growth and not vice versa. More decisively, the fluctuation exchange rate causes variation in economic growth only as shown by a significant F-statistic of 14.5826 and a probability value of 0.0000.

iv. Unidirectional Granger causality from government spending to fluctuation in oil prices in view of the F-statistics 1.0084 and 33.5671 together with probability values of 2.1345 and 0.0000 respectively.
v. Zero causality between the nominal exchange rate and government expenditure. This goes to show that the variation in government spending does not induce changes in the nominal exchange rate and conversely, the variation in the nominal exchange rate do not stimulate variation in government expenditure. In effect, there is independence between the nominal exchange rate and government spending in recent time.

Table 1: Pairwise Granger Causality Test

Null Hypothesis:	F-Statistic	Prob
Oilpv does not Granger Cause Rgdp	10.3266	0.0000
rgdp does not Granger Cause oilpv	0.0866	1.2673
Gexpd does not Granger Cause Rgdp	35.8780	0.0000
RGDP does not Granger Cause GEXPD	40.2904	0.0000
Nexch does not Granger Cause Rgdp	14.5826	0.0000
Rgdp does not Granger Cause Nexch	0.61270	2.5436
Gexpd does not Granger Cause Oilpv	1.0084	2.1345
Oilpv does not Granger Cause Gexpd	33.5671	0.0000
Nexch does not Granger Cause Oilpv	40.1646	0.0000
Oilpv does not Granger Cause Nexch	25.3897	0.0007
Nexch does not Granger Cause Gexpd	32.0368	0.0000
Gexpd does not Granger Cause Nexch	0.8495	0.4301

5.4 Analysis of the Variance Decomposition of Forecast Errors

The variance decomposition for the volatility in oil price, government expenditure, exchange rate and the growth rate of the Nigerian economy is shown in Figure 4.1 below. As shown, oil price fluctuation plays significant function in causing variation in economic growth in Nigeria economy within the quarterly periods of the various years analyzed in the study.

Fluctuation in prices of oil also contributed to the variation in government expenditure in Nigeria and to the variation in the nominal exchange rate of the Naira. This is made empirically evident in the drift pattern of the forecast error variance of nominal exchange rate and government spending given the exogenous shocks to oil prices within the period of study.

In effect, the volatility of oil prices leads to about 0.57 percent decline in the growth of the Nigerian economy and after two years, it results to 3.1 percent decline. Similar results are obtained for the nominal exchange rate. The variance decomposition of the forecast error in the volatility in oil price to itself shows that disequilibrium in oil price can be persistent over time. Yet, the series would adjust to eliminate any deviation from the long-run equilibrium target given the first-order integration principle. This goes to show the existence of a linear relationship between oil price shocks, government

expenditure, nominal exchange rate and growth rate of the Nigerian economy. On the whole, both shocks in oil prices significantly induce swings in GDP growth in Nigeria.

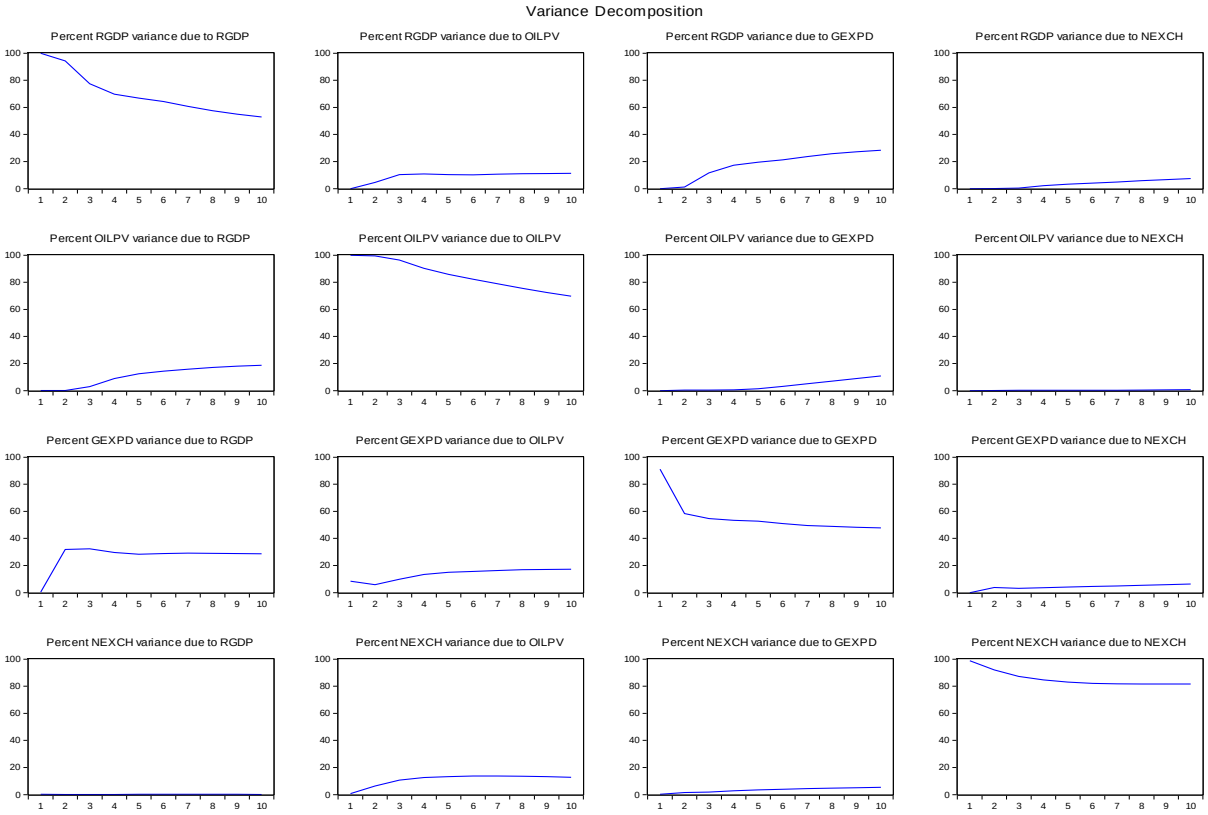

Figure 3: Variance Decomposition Results

5.5 Analysis of the Impulse Response Functions

The results of the impulse response functions shown in Figure 4.3 demonstrate the direction of travels government expenditure, exchange rate and the growth rate of the Nigerian economy indulged in subsequent to a standard error shock in oil price. The shocks in oil prices are seen to contract the growth rate of the Nigerian economy within the period of the analysis. The shock in oil prices also depreciates the nominal exchange rate of the Naira and causes deep swings in the growth rate of real GDP in Nigeria.

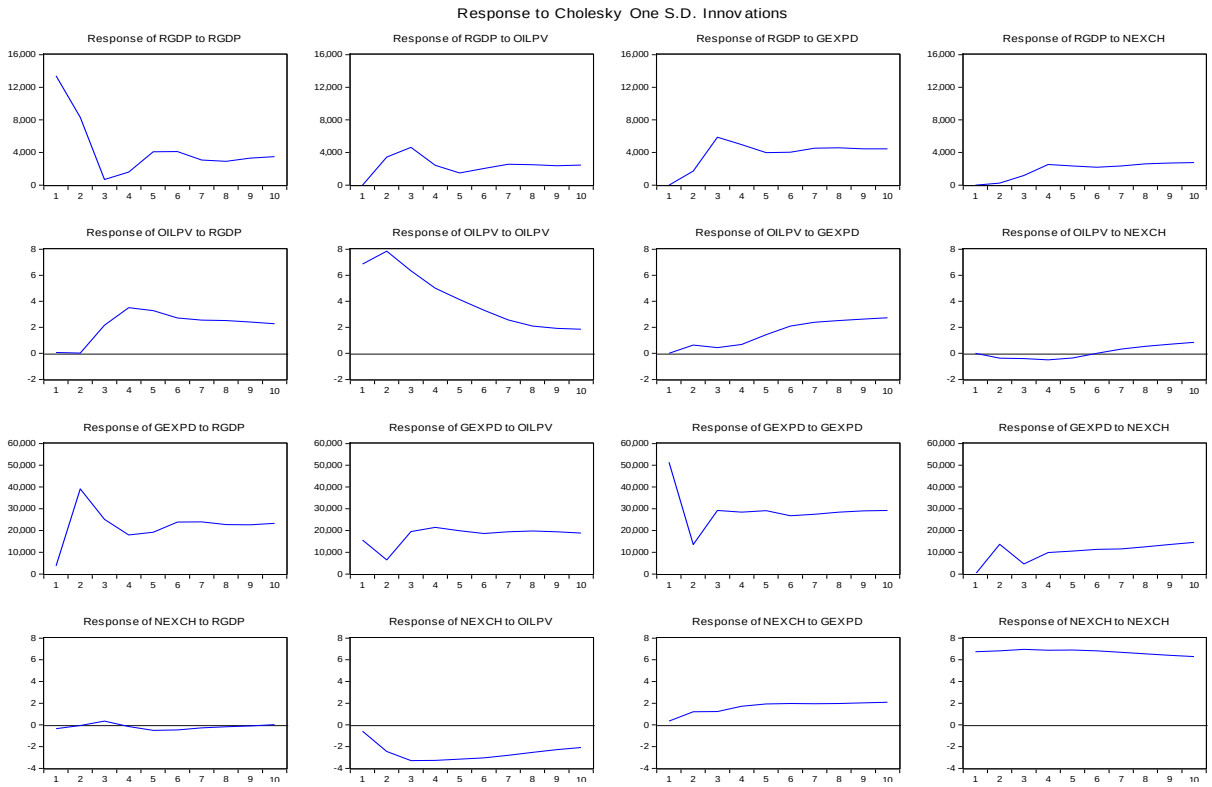

Figure 4: Impulse Response Functions

The diagnostic statistics were analyzed based on the inverse roots of AR characteristic of the model residual series. Figure 4.3 shows graphical report of the inverse roots of the characteristic AR polynomial shows that the estimated VAR is covariance stationary. This is made evident since all roots have modulus less than one and lie inside the unit circle. In effect, the variance decomposition of the forecast error and the impulse response are valid. What this means is that the mean and variance of the process are both finite and independent of time; and the covariances between pairs of random values from the process only depends on how far apart the values are in time, but not the value of time itself.

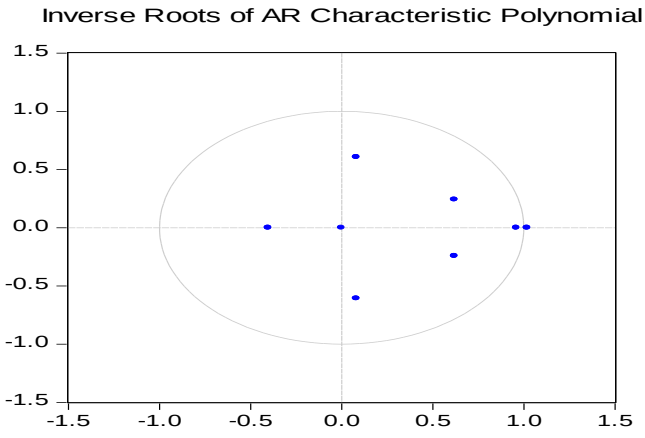

Figure 5: Inverse Root

Rgdp,Oilpv(-i)	Rgdp,Oilpv(+i)	i	lag	lead
. |********** |	. |********** |	0	0.8806	0.8806
. |********** |	. |********** |	1	0.8648	0.8450
. |********* |	. |********* |	2	0.8289	0.8299
. |********* |	. |********* |	3	0.7946	0.8262
. |********* |	. |********* |	4	0.7722	0.8097
. |********* |	. |********* |	5	0.7553	0.7754
. |******** |	. |********* |	6	0.7173	0.7589
. |******** |	. |********* |	7	0.6741	0.7527
. |******* |	. |******** |	8	0.6451	0.7371
. |******* |	. |******** |	9	0.6244	0.7047
. |******* |	. |******** |	10	0.5763	0.6860
. |****** |	. |******** |	11	0.5211	0.6768
. |****** |	. |******** |	12	0.4960	0.6611
. |****** |	. |******* |	13	0.4812	0.6304
. |***** |	. |******* |	14	0.4455	0.6102
. |***** |	. |******* |	15	0.4124	0.5987
. |***** |	. |******* |	16	0.4070	0.5830
. |***** |	. |******* |	17	0.3988	0.5539
. |***** |	. |****** |	18	0.3636	0.5309
. |**** |	. |****** |	19	0.3368	0.5184
. |**** |	. |****** |	20	0.3466	0.5091
. |**** |	. |****** |	21	0.3515	0.4853
. |**** |	. |****** |	22	0.2971	0.4589
. |*** |	. |***** |	23	0.2353	0.4386
. |*** |	. |***** |	24	0.1997	0.4237
. |*** |	. |***** |	25	0.1656	0.4005
. |** |	. |***** |	26	0.1290	0.3751
. |** |	. |***** |	27	0.0990	0.3563
. |** |	. |**** |	28	0.0832	0.3433
. |** |	. |**** |	29	0.0664	0.3224
. |* |	. |**** |	30	0.0343	0.2990
. |* |	. |**** |	31	0.0053	0.2820
. |* |	. |**** |	32	-0.0171	0.2690
. |* |	. |*** |	33	-0.0385	0.2483
. |. |	. |*** |	34	-0.0677	0.2259
. |. |	. |*** |	35	-0.0878	0.2102
. |. |	. |*** |	36	-0.1043	0.1988

Figure 6: Asymptotic Correlation Matrix

Figure 6 shows the asymptotically consistent approximations of the correlation matrix. This makes provision of estimated VAR coefficients. The VAR global goodness-of-fit is made evident as it compares favourably with covariance-based structural equation modelling.

6. Conclusion

This study finds that fluctuation in oil prices cause swings in economic growth in Nigeria. The study contributed to the large body of research that oil price fluctuation has contractionary consequences on GDP growth rate in Nigeria. Based on the findings of the study, we recommend the need for the country to branch out its revenue sources. This will further shield the dangle effect of the fluctuation in prices of oil.

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