# Symmetric Oil Price Shock and the Nigerian Economy: An Empirical Re-Investigation Using SVECM and ARDL Approach

**Adediji Adebisi Moses[1], Adeniji Sesan Oluseyi[2], Timilehin John Olasehinde[3]**

**Abstract:** This study investigates the response of the Nigerian economy to symmetric oil price shock. It made use of annual data that spanned 1960 to 2016. A Structural Vector Error Correction Model (SVECM) and Autoregressive Distributed Lag (ARDL) techniques were employed. The Augmented Dickey-Fuller unit root tests revealed that the variables employed are non-stationary and precisely of order one. A cointegration test among the variables is passed and there is only one unique cointegrating vector. The results from both the SVECM and the ARDL suggest that real GDP will initially respond positively to oil price shock symmetrically but later decreases sharply, with the potential to lapse the Nigerian economy into a long time recession if not properly managed. It is therefore recommended that the productive base of the Nigerian economy should be diversified to other sectors. Also, security arrangements in the key oil- producing areas should be improved in order to avoid negative oil price shocks that could destabilize and plunge the economy.

**Keywords**: Symmetric; Oil Price; Shock; Structural

**JEL Classification:** E32; Q43; C2; C3

## 1. Introduction

Wakeford (2006) defined oil price shock as a fluctuation in oil price resulting from changes in either the demand or the supply-side of the international oil market. Changes in oil price can be chronologically traced to supply side disruption such as OPEC supply quotas, political disruption in the oil-rich economies and the activities of the group of similar interest such as the Niger Delta militant group in Nigeria. The shock should not always be considered negative as it can as well be positive in nature just as the good and the bad news in the volatility concepts. It is believed that a rise in oil price can lead to the decline in economic growth of net import countries and

[1] University of Abuja, Department of Economics, Nigeria, Address: Mohammed Maccido Rd, Nigeria, Corresponding author: confirmedfavorman@gmail.com.
[2] University of Abuja, Department of Economics, Nigeria, Address: Mohammed Maccido Rd, E-mail: adenijisesan55@gmail.com.
[3] Ekiti State University, Department of Economics, Nigeria, Address: Ado Ekiti, Nigeria, Email: timmexdareal@gmail.com.

can as well propel inflation in the net exporting countries and which unarguably lead to a distortion globally.

Theoretically, an increase in oil price translates into higher production cost and the firms will pass this as a burden on to the consumers by increasing the price of the commodities. A rise in price will cause a cut in demand, therefore, leading to fall in aggregate income and hence, fall in the employment level. In essence, a rise in oil price will cause a cut in aggregate demand, thereby leading to declining in consumption. In addition, unstable oil prices can also increase uncertainty and discourage much needed investment in the oil sector. Oil plays a crucial role in the world economy in spite of the fast rise in the switching to the use of alternative renewable natural resources. The role being played by crude oil in the macroeconomic locomotion has not waned yet (Mohammad & Ehsau, 2014). Nigeria economy is an exemplary in which oil plays a crucial role in the conduct of fiscal and monetary policies because, 80% of the government revenue is being accounted for by oil resources. Oil also constituted 90-95% of Nigeria foreign exchange earnings and it also accounted for about 12% of the real GDP (Anyanwu, 1997). For Nigeria as a crude oil exporter and also an importer of refined petroleum products, any volatility or shock in oil prices will definitely affect the economy either positively or negatively.

The subject matter of this study is not new literarily, however, an empirical re-investigation needed to be carried out. Though several empirical studies have been carried out to investigate the effect of oil price shocks on macroeconomic variables in different economies, Nigeria's case is unique due to the structure of the economy, population and market size, high energy intensity, energy mix and dependency on international energy market (Chuku, Effiong & Sam, 2010). The ability to describe with a high degree of accuracy the response of an economy (proxied with real GDP) to oil price shock can provide a firm ground for macroeconomic assessment and effective planning (Chuku, Effiong & Sam, 2010).

## 2. Some Selected Empirical Studies

Ayadi (2000) used a standard VAR which includes oil production, output, the real exchange rate and inflation over the 1975-1992 periods to investigate the effects of oil production shocks on Nigeria as a net exporting country. His findings show that a positive oil production shock was followed by rising in output, reduction in inflation and a depreciation of the domestic currency. Olomola and Adejumo (2006) used a VAR framework to study the effects of oil price shocks on output, inflation, real exchange rate and money supply in Nigeria. Their study found that oil price shocks did not explain the movements in output and inflation. Olusegun (2008) investigated the impacts of oil price shocks on 7 key Nigerian macroeconomic variables, which are; real gross domestic product, consumer price index, real oil revenue, real money supply, real government recurrent expenditure, real government capital expenditure and real oil price. The data sourced are annual frequency from 1970-2005 and they employed a VAR framework. The forecast error variance decomposition estimated from the VAR model revealed that oil price shocks significantly contribute to the variability of output. Adeniyi, Oyinlola, and Omisakin (2011) used a threshold autoregressive model with a quarterly data spanning 1985-2008 to examine the relationship that exists between oil price shocks and economic growth. The result shows that oil price shocks do not account for a significant proportion of the movement in macroeconomic variables, despite introducing the threshold effects.

Most of the previous studies adopted VAR methodologies believing that only VAR model can take care of shock in fact even without identifying the shocks concerned. Also, some adopt ARDL model without taking some of the necessary and informative dynamics into consideration; they just test for cointegration and estimate the short and the long run parameters only, whereas this has little or no information about the underlying shock. In a similar manner, many studies adopt VECM (Vector Error Correction Model) approach without identifying the underlying shocks. Also, the use of SVAR (Structural Vector Auto Regressive) in some recent empirical studies is likely questionable because real GDP and oil price are likely to show visible upward trends over the years and hence, it is possible for cointegration to exist between them. This study attempts to expand the discussion and bridge the noticeable gap in existing empirical literature by focusing on the real GDP and the oil price, taking the exchange rate into an account as a causal factor. We also account for possible co-trending among the variables by adopting SVECM (Structural Vector Error Correction Model) and ARDL (Autoregressive Distributed Lag) model which are capable of revealing shocks.

## 3. Methodology

Given the nature of this study, it is imperative that the data which permit the estimation of the stochastic equation(s) representing the effect of the oil price shock on Nigerian economy can be collected. These include average crude oil price, real gross domestic product, and the exchange rate of the naira in Nigeria. Time series data were used for the study and they are purely secondary data. The data series covered the periods of 1960-2016. Historical data on real GDP and the exchange rate were obtained from WDI while the average oil price was obtained from STATISTA.

In order to empirically investigate the response of the real GDP to the oil price shock taking the exchange rate into an account, we specify a SVECM (Structural Vector Error Correction Model) and ARDL (Auto Regressive Distributed Lag) model. The technical details of the SVECM will not be discussed in this study[1] but the identification system will be briefly discussed. The ARDL model will as well be discussed briefly as it is no longer new in literature.

### 3.1. The SVECM Model

The SVECM model works in a similar manner to the SVAR model but by accounting for possible cointegration. The identification restriction is similar to the SVAR but by decomposing the identification into three different components of which two are for long-run restriction. Assume that all the variables in questions are I(1), the technicality is simplified below;

In a model of $\boldsymbol{K}$ endogenous variables, there are $\boldsymbol{r}$ $\boldsymbol{(r < K)}$ possible cointegrating vectors and this implies that there is/are $\boldsymbol{k^*}(\boldsymbol{k^* = K - r})$ permanent shock(s) and $\boldsymbol{r}$ temporary or transitory shock(s). The column(s) corresponding to the transitory shock(s) is/are restricted to be zero and it stands for only $\boldsymbol{k^*}$ independent restrictions. Giving the transitory shocks, the corresponding zero columns implies $\boldsymbol{k^*r}$ independent restrictions only. $\boldsymbol{k^*(k^* - 1)/2}$ additional restrictions are needed to identify the permanent shocks exactly. King et al (1991) revealed that $\boldsymbol{r\ (r - 1)/2}$ additional contemporaneous restrictions are needed to identify the transitory shocks. The sum of these restrictions is identical to the SVAR way of identification. Together these are a total of $\boldsymbol{k^*r + k^*(k^* - 1)/2 + r\ (r - 1)/2 = K(K - 1)/2}$ restrictions. We take further steps below to illustrate how the contemporaneous ($\boldsymbol{B}$) and the permanent ($\Xi\mathbf{B}$) restriction can be carried out by assuming that there is a single cointegrating vector among real GDP, oil price and exchange rate. We associate the aggregate supply, oil, and the exchange rate shocks with the equations for productivity (real GDP), oil price, and, exchange rate, respectively, such that $\boldsymbol{\varepsilon_t} = (\boldsymbol{\varepsilon_t^{gdp}}, \boldsymbol{\varepsilon_t^{oil}}, \boldsymbol{\varepsilon_t^{exr}})'$. Following the above technical descriptions, $\boldsymbol{K = 3}$, $\boldsymbol{r = 1}$, $\boldsymbol{k^* = K - r = 2}$, $\boldsymbol{k^*r = 2}$, $\boldsymbol{k^*(k^* - 1)/2 = 1}$, $\boldsymbol{r\ (r - 1)/2 = 0}$

$$\boldsymbol{B} = \begin{bmatrix} * & * & * \\ * & * & * \\ * & * & * \end{bmatrix} \ \boldsymbol{and}\ \Xi\boldsymbol{B} = \begin{bmatrix} \mathbf{0} & * & * \\ \mathbf{0} & * & * \\ \mathbf{0} & \mathbf{0} & * \end{bmatrix}$$

The second matrix shows that we take the shock arising from the real GDP as transitory and also the response of oil to exchange rate shock to be transitory in nature. In essence, the above two matrix shows that our model is exactly identified.

### 3.2. The ARDL Model

The ARDL will be used in this study as single equation method to capture the response of the dependent variable to the independent variable(s) shock. Since we are not really interested in the long run level relationship among the variables used in this study but rather the response of the real GDP to symmetric oil price shock,

[1] See (Lutkepohl & Kratzig, 2004).

we, therefore, do not describe the bound test approach to testing for cointegration. To support this move, ARDL dynamics nature is only needed to compute the impulse response function or the dynamic multiplier. The ARDL model is presented below in product form in order to save space, and the optimal lags (i, j, and k) will be calculated based on the Akaike statistical information criteria.

$$GDP_t = Ae^{v_t}\left(\prod_{i=1}^{i<\infty} GDP_{t-i}^{\theta_i}\right)\left(\prod_{j=0}^{j<\infty} OIL_{t-j}^{\omega_j}\right)\left(\prod_{k=0}^{k<\infty} EXR_{t-k}^{\omega_k}\right) \dots (1)$$

The "$\boldsymbol{A}$" is the total factor productivity, "$\boldsymbol{v}$" is the stochastic error term, and the superscript parameters are the iso-elasticy of real GDP in response to the variables.

## 4. Data Analysis and Findings

### 4.1. Unit Root

**Table 1. Augmented Dickey-Fuller and the Phillips-Perron unit root test result**

| $H_0$: Unit root $H_1$: Stationary | | ADF @ level | | | ADF @ First difference | | |
|---|---|---|---|---|---|---|---|
| | | lgdp | loil | lexr | lgdp | loil | lexr |
| C | t-stat | 0.3036 | 0.5002 | -1.3604 | -5.3251 | -5.8125 | -6.5848 |
| | Prob. | 0.9765 | 0.9853 | 0.5951 | 0.0000 | 0.0000 | 0.0000 |
| | | n0 | n0 | n0 | *** | *** | *** |
| C&T | t-stat | -1.0685 | -1.8858 | -1.3923 | -5.2930 | -5.8835 | -6.6113 |
| | Prob. | 0.9251 | 0.6486 | 0.8526 | 0.0003 | 0.0000 | 0.0000 |
| | | n0 | n0 | n0 | *** | *** | *** |
| No C&T | t-stat | 3.5063 | 2.2496 | 0.5651 | -4.6337 | -5.1357 | -6.4408 |
| | Prob. | 0.9998 | 0.9936 | 0.8354 | 0.0000 | 0.0000 | 0.0000 |
| | | n0 | n0 | n0 | *** | *** | *** |
| Remark | | | | | I(1) | I(1) | I(1) |

*Source: Author's computation*

Note * (**) (***) denotes null hypothesis at 10%, 5% and 1% respectively, n0 denotes not significant. At least one asterisk means we may accept the null hypothesis. Where made use, C represents Constant while T represents Trend. The prefix "l" of the variables means that they are in log form.

The result of the ADF unit-root tests is presented in Table 1 above. From the result, it can be shown that the variables were stationary at first difference. The empirical implication of the unit root tests results is that the variables have a unit root features. Thus, modeling these series in their level form given their stationarity status may result in spurious regressions with the consequence that the results may spuriously indicate a significant relationship even when that is not the case. However, since all the variables were all I(1) variables, there is a tendency for the presence of cointegration among the variables.

### 4.2. Cointegration Test

**Table 2. Akaike Information Criteria by Rank (rows) and Model (columns)**

| Data Trend: | None | None | Linear | Linear | Quadratic |
|---|---|---|---|---|---|
| Rank or no. of CEs | No Intercept No Trend | Intercept No Trend | Intercept No Trend | Intercept Trend | Intercept Trend |
| 0 | -1.748798 | -1.748798 | -2.175790 | -2.175790 | -2.114427 |
| 1 | -2.216995 | -2.184302 | -2.192610 | -2.359973* | -2.309766 |
| 2 | -2.092409 | -2.084751 | -2.080601 | -2.334380 | -2.311989 |
| 3 | -1.897817 | -1.866757 | -1.866757 | -2.144992 | -2.144992 |

*Source: Author's computation*

*Model type selected with the number of optimal rank

The SIC (Schwarz Information Criterion) tends to be a conservative test in finite samples with a tendency to under-select the cointegrating rank. Hence we resort to the Akaike information criterion. First, it can be revealed that the null hypothesis of no cointegration vector was rejected after taking into consideration a possible intercept and a trend in the cointegrating equation and assuming that as the data generating process. The AIC information criterion revealed that there is one cointegrating vector which is already in line with our previous assumption. We proceed to the VECM (Vector Error Correction Model) first and later to the shock identification in order to make the VECM structural.

### 4.3. SVECM Model Estimates and Oil Price Shock Identification

A VECM model is estimated with a zero lagged difference based on the lag selection criteria. We used one cointegrating vector to estimate the VECM model. Two dummies for the year 1967 and 2004 are also included to capture outliers. However, some of the estimated parameters are found to be insignificant statistically and hence we re-estimate a reduced VECM model by excluding the insignificant parameters and this affects our contemporary restriction matrix (***B*** matrix) above by making the contemporary effect of oil and real GDP on the exchange rate to be zero.

**Table 3. Cointegration vector and loading parameters for VECM with zero lagged differences and cointegrating rank 1.**

**Adjusted sample: 1961-2016 (56 observations)**

| | lgdp | loil | lexr | trend | constant |
|---|---|---|---|---|---|
| **β'** | **1** | **0.684 (4.018)*** ** | **0.393 (2.930)** ** | **-0.143 (-4.909)*** ** | **-24.720 (-91.688)*** ** |
| **α'** | **-0.049 (-4.345)*** ** | **0.000** | **-0.211 (-5.067)*** ** | **-** | **-** |

*Source: Author's computation*

**The parameters in parentheses are the t-stat. * (**) (***) denotes significance at 10%, 5% and 1% respectively**

As described in Section 2.0.1 and above, we obtain the following estimates for the contemporaneous and long-run impact matrix:

$$\boldsymbol{B} = \begin{bmatrix} \mathbf{0.0289} & \mathbf{-0.0534} & \mathbf{0.0169} \\ (\mathbf{5.6596}) & (\mathbf{-5.9684}) & (\mathbf{2.2693}) \\ \mathbf{0.1239} & \mathbf{0.1901} & \mathbf{-0.0368} \\ (\mathbf{4.8637}) & (\mathbf{0.1901}) & (\mathbf{-1.1081}) \\ \mathbf{0} & \mathbf{0} & \mathbf{0.3150} \\ & & (\mathbf{5.4249}) \end{bmatrix} \Xi\boldsymbol{B}$$

$$= \begin{bmatrix} \mathbf{0} & \mathbf{-0.0613} & \mathbf{-0.0642} \\ & (\mathbf{-5.7744}) & (\mathbf{-3.4650}) \\ \mathbf{0} & \mathbf{0.1560} & \mathbf{-0.3849} \\ & (\mathbf{5.7744}) & (\mathbf{-4.4456}) \\ \mathbf{0} & \mathbf{0} & \mathbf{0.3150} \\ & & (\mathbf{5.4249}) \end{bmatrix}$$

In parentheses, we provide bootstrapped t-values obtained using 1,000 bootstrap replications. The estimated long-run effects of symmetric oil price and exchange rate shocks on real GDP are given in the first row of ΞB matrix. Note that, according to our estimate, oil price and exchange rate shocks significantly decrease the real GDP in Nigeria in the long-run. Using the estimates B matrix above, we may also compute the responses to the structural shocks ε_t which provide a more informative picture of the dynamic effects of symmetric oil price shocks to the Nigerian economy. Figure 1 below shows the responses of real GDP to symmetric oil price shock. The figure shows that the response of real GDP to oil price shock is immediate and it is positive though with a smaller magnitude. The figure suggests that oil price shock (ε_t^oil) could drive real GDP down to a recession point and persist for a long period of time. This finding is contrary to the findings of Adeniyi (2012) which despite accounting for threshold, concluded that oil price shocks do not explain a significant proportion on the movement in macroeconomic variables; and the work of Olomola and

Adejumo (2006) which concluded that oil price does not explain the movement in output.

However, our findings agree to some extent with the findings of Ayadi (2000) that a rise in oil price causes an increase in output. We found that rise in oil price is related to diminishing rise in output to a certain level after which the economy totally lapse into recession and persists for a long period of time.

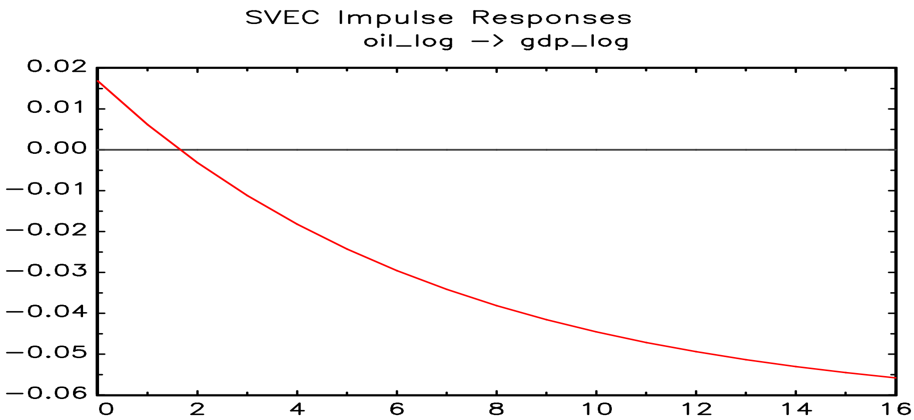


**Figure 1. Response of real GDP to oil price shock**

### 4.4. ARDL Model Estimate

In order to compute the dynamic response of real GDP to symmetric oil price shock using single equation method, we estimate an ARDL (3, 1, 1) model (selected based on the Akaike information criterion) and the result is presented in table 4 below. We notice outliers in the year 1967 and the year 2004; we used dummies to capture and remove the noticeable effect. A battery of tests was carried out to make sure that the estimated model is free of any major regression anomalies (autocorrelation, heteroscedasticity, and model instability).

**Table 4. ARDL (3, 1, 1) estimated parameters**
**Dependent variable: lgdp**
**Adjusted sample: 1963-2016 (54 observations)**

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| lgdp(-1) | 1.138980 | 0.107960 | 10.55004 | 0.0000*** |
| lgdp(-2) | -0.365319 | 0.168726 | -2.165167 | 0.0358** |
| lgdp(-3) | 0.232701 | 0.114062 | 2.040121 | 0.0474** |
| lexr | -0.070322 | 0.030790 | -2.283914 | 0.0273** |
| lexr(-1) | 0.085540 | 0.031872 | 2.683914 | 0.0102** |
| loil | 0.045555 | 0.025827 | 1.763844 | 0.0847* |
| loil(-1) | -0.073426 | 0.026559 | -2.764623 | 0.0083*** |
| Dum2004 | 0.202721 | 0.058679 | 3.454737 | 0.0012*** |
| Dum1967 | -0.226606 | 0.059849 | -3.786302 | 0.0005*** |
| Constant | -0.072000 | 1.032303 | -0.069747 | 0.9447 |
| $R^2$-Adjusted | 0.9899 | | | |
| F-stat | 557.35[0.000]*** | | | |
| $\hat{\sigma}$ | 0.06 | | | |
| RSS | 0.1378 | | | |
| LM(1) | 0.2840[0.5941] | | | |
| LM(2) | 0.6147[0.7354] | | | |
| LM(3) | 0.7779[0.8547] | | | |
| $\chi^2$-ARCH(1) | 0.6371[0.4248] | | | |
| $\chi^2$-ARCH(2) | 0.5968[0.7420] | | | |
| $\chi^2$-ARCH(3) | 0.5214[0.9142] | | | |
| Ramsey (1,43) | 1.1783[0.2838] | | | |
| Ramsey (2,42) | 0.6375[0.5336] | | | |

*Source: Author's computation*

* (**) (***) denotes significance at 10%, 5% and 1% respectively

As we can see in table 1 above, all the estimated parameters are significant statistically except the intercept; though its presence may help remove any noticeable bias. The coefficient estimate for the log of oil price and its one-year lag alternate in sign from negative to positive (previous to recent), showing that the response of real GDP to oil price shock is likely to switch sign. Using the estimates for the lagged log of real GDP and the estimate for the log of oil price and its one year lag above, we compute the real GDP responses to the one-time symmetric oil price shocks which provide a more informative picture of the dynamic effects of symmetric oil price shocks to the Nigerian economy. Figure 2 below shows the responses of real GDP to symmetric oil price shock. The figure shows that the response of real GDP to oil price shock is not immediate but takes a period lag to respond; this is highly similar to that of SVECM impulse response with the difference in the immediate response. The figure reveals that oil price shock is capable of driving real GDP down to recession; this agrees with the SVECM findings above.

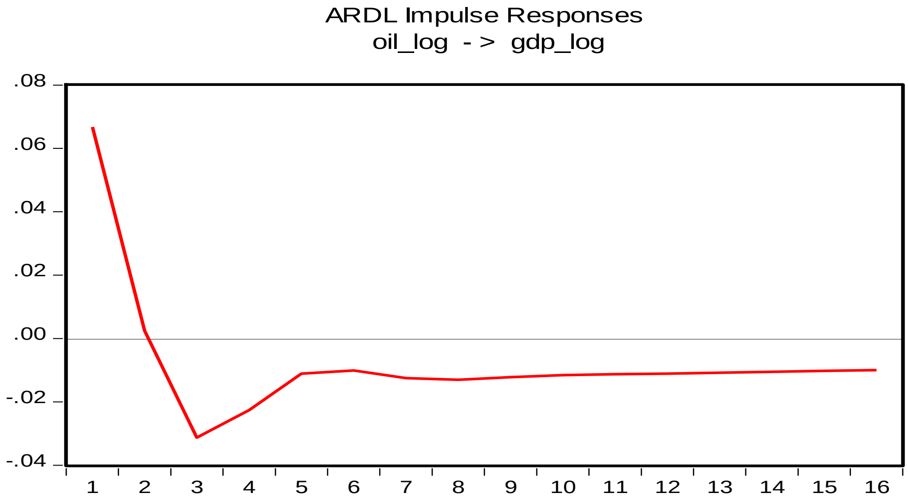


**Figure 2. Response of real GDP to 1% oil price shock**

The economy tried to move to a steady state during the third year but due to the fact that Nigeria relies too much on oil resources, the recession persists for a long period of time. Likewise, this is contrary to the findings of Adeniyi (2012), Olomola and Adejumo (2006) as stated above. However, our finding has some slight similarities with that of Ayadi (2000) as stated in the SVECM result above.

## 5. Conclusion and Policy Recommendations

Some of the researchers that have previously carried out empirical investigations in this area of study applied unrestricted VAR method which has a lot of drawbacks such as optimal lag selection, neglecting possible cointegration and clustering of shocks. These led to different outcomes of the innovation accounting (impulse response, forecast error variance decomposition and the historical decomposition). This is capable of causing confusions and conflicts in policy-making. In addition, VAR model is theoretical, mainly for forecasting. The empirical aspect of this study takes these drawbacks into consideration and adopted the SVECM and the ARDL approach which are capable of handling spuriosity. Unarguably, there is a mutual agreement in the suggested responses of the Nigerian economy to oil price shock when we adopted these methodologies (SVECM and ARDL) that are capable of accounting for possible cointegration between the variables. In essence, oil price shock if left uncontrolled will lapse Nigerian economy gradually into recession for a very long period of time. Base on this notion, we therefore suggest strongly the diversification of the productive base of the Nigerian economy to other sectors such as Agriculture, Manufacturing, Tourism and other service-oriented sectors to open up a wider spectrum for inflow of income to the economy, and break the overreliance of the Nigerian economy on the oil sector. In addition, Nigeria federal government should improve the security base both externally and internally especially in the Niger Delta area with a view to boosting oil output which will lead to increase in oil revenue and by implication, stimulate the growth of the Nigerian economy.

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