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Article

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DOES OIL PRICES SHOCK MATTER IN THE NIGERIAN ECONOMY? EMPIRICAL EVIDENCE FROM SIGN-IDENTIFIED STRUCTURAL VECTOR AUTOREGRESSION

Nazifi Aliyu¹, Z.S. Saheed², A.A. Alexander³ and Nafiu B. Abdulsalam⁴

Abstract

This study explores the dynamic linkage of exogenous oil shock and economic activity in Nigeria in Nigeria via a sign-identified Structural Vector Autoregression (SVAR). Specifically, the study utilizes quarterly time series data where the information set uses real gross domestic product, quantity of petroleum demand, exchange rate, interest rate, GDP deflator and inflation rate. We adopt a combination of sign and zero restriction as the identification scheme to impose restrictions in the model. Structural inferences are deduced from structural impulse response function, forecast error variance decomposition and historical decomposition. Findings from structural impulse response function indicates that real gross domestic product react instantaneously, although short-lived, following a unit standard deviation change in oil shock while exchange rate and other variables of interest react, slowly and insignificantly, with several lags after shock initialization. Additionally, it is evident from historical decomposition that fluctuations in real GDP is jointly explained by oil demand and supply shock, with the former exacting more influence than the latter. Recommendations are in two-folds; policies that are shock-absorbing must be strengthened and macroeconomic policies should be formulated that will look into other sources of macroeconomic fluctuations other than oil shocks.

Key Words: SVAR, sign-identification, structural shocks and Impulse response function

JEL: C32, E44, G12, G15.

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1.0 INTRODUCTION

The analysis of oil shocks in relation to macroeconomic variables has been the subject of many studies since the oil crises of the 1970s. One of the early studies was by Hamilton (1983) who reported that several post-war recessions in the US were preceded by oil price shocks. The debate remains on the transmission mechanism of these shocks and their significance, many studies reported that the oil shocks transmission vary from supply effect to demand effect. (Schneider 2004, Sill 2007). It is a general consensus that fluctuations in oil prices affect most economies through different channels including energy market, domestic price movements, aggregate and sectoral economic growths affect countries' economies through several channels, (Hamilton, 2013).

Abel and Bernanke (2001) in their analysis of the transmission mechanism of shocks between oil prices and the macroeconomic argue that increases in oil prices cause the general price level to rise. This is because Oil is one of the major inputs in a production process. Thus, when the price of oil increases, firms respond by using less of the commodity, which leads to a decrease in output. However, study from Hunt, Isard and Laxton (2001) opined that oil price shock is transferred to oil importing countries without cutting the industrial output of net oil importers. The transmission mechanism suggested is in three folds. First, oil price shock leads to transfer of income from oil importing countries to oil exporting countries which lead to decrease in demand of non-oil commodities for oil importing countries. However, due to the low propensity to consume of oil exporting countries which are mostly underdeveloped economies, the reduced demand of oil importing countries cannot be balanced by the increase in demand of oil exporting countries. Second, an increase in cost of oil input leads to rise in the cost of production which will be transferred to oil exporting countries being the major markets of such goods produced.

Third, resistance in decrease of real wages and profits by labour and entrepreneurs in oil importing countries will lead to further increase in the cost of output which will be further transferred to oil exporting countries. Thus, the result will be the non-significant positive increase and a significant negative effect on the oil exporting economies, hence, the asymmetric relationship.

Oil is an important driver of macroeconomic indicators of most net oil exporting countries, heavy dependence on oil revenues makes them more exposed to exogenous oil shocks. Recent findings suggest that the same cannot be said of net oil importing countries, this is largely due to structural changes in favour of non-energy intensive sectors, more flexible labour hours, and improvement in monetary policy (Balanchard and Gali, 2007, Colgni and Manera, 2008).

Oil shocks observed in Nigeria had connections with some movements in key macroeconomic variables in Nigeria. Starting in 1973, the world experienced an oil shock that rippled through Nigeria until the mid-1980s. This oil shock was initially positive for the country, but with mismanagement and military rule embezzlement, it became all economic disaster. During the first oil shock in Nigeria (1973-74), the value of Nigeria's export measured in US dollars rose by about 600 per cent with the terms of trade rising from 18.9 in 1972 to 65.3 by 1974. Government revenue which stood at 8 per cent of GDP in 1972 rose to about 20 per cent in 1975. This resulted in increased government expenditure owing largely from the need to monetize the crude oil receipts. Investment was largely in favour of education, public health, transport, and import substituting industries (Nnanna and Masha, 2003).

The main thrust of the study is to explore the dynamic relationship between exogenous shock on oil and some macroeconomic variables in Nigeria. This is accomplished using modeling framework that allows for the identification of shock and analysis of reaction of endogenous variables in the system. Thus, we adopt small scale structural vector autoregression with restriction imposed via combining sign and zero elements in the variance-covariance matrix.

Our study contributes to the extant literature on oil shocks in the following ways: First, we adopt robust method of shock identification scheme which uses combination of sign and zero restriction Structural Vector Autoregression (SVAR) advanced by Arias, Rubio-Ramírez & Waggoner (2014). This is an improvement on previous works on oil price shocks in Nigeria. For example, recent empirical investigation of oil shocks on macroeconomic variables responses in Nigeria, as in the work of Ademakinwa & Omokanbi (2017), Olanipekun (2016), Yusuf (2015), Shehu (2009), and Iwayemi (2011) used short run restriction, or long run restriction. As noted by Kilian (2011), these methods of shock identification suffer from low power of detecting precise responses of variables to oil shock. To the best of our knowledge, there is little or no empirical application in Nigeria that identifies oil shock using sign and zero restriction. Second, our modeling accommodates monetary policy and exchange rate variables. Thus, we are able to assess the monetary policy reaction as well as exchange rate fluctuations in the wake of oil price crisis in Nigeria. This empirical application has so far been addressed using evidence in Nigeria.

Third, the study provides fresh perspective on the extent of the relationship between oil price shocks and the Nigerian economy. Findings from the study identifies additional sources of macroeconomic fluctuations, such as exchange rate shock. Thus, policies covering other macroeconomic variables can be formulated for the economy.

The paper considers the time period from 1980 to 2017. The time span includes the Global Oil Crises, the Middle East Unrest, Asian Crisis, Russian/Ukraine Crisis, Mexican Financial Crisis, Global Financial Crisis and Arab Spring. (Bastianin and Manera, 2017). The reminder of the paper will be presented as follows; Section two provides empirical literature, Section three provides the methodology, Estimation results and Interpretation are presented in Section four, and section five concludes.

2.0 REVIEW OF EMPIRICAL LITERATURE

Ademakinwa & Omokanbi (2017) examined the effects of crude oil price fluctuations on foreign direct investment (FDI) and economic growth. the study used time series data of six variables; oil price (OILP), foreign direct investment (FDI), exchange rate (EXR), trade-openness (TRAOP), inflation (INF) and gross domestic product (GDP) for period 1980 to 2014. The study found out that the oil price shocks have a great influence on the level of domestic and foreign direct investment which greatly influenced the level of growth in the Nigerian economy. However, oil price shocks insignificantly retard economic growth while oil price itself significantly improves it and FDI. Similarly, Olanipekun (2016) empirically studied the relationship between oil price shocks, exchange rate, external reserve and real GDP in Nigeria with a quarterly data from 1971Q1 to 2014Q4. It was found that the transmission channel of crude oil price shocks to economic performance is through external reserves, exchange rate and inflation, and overall, the study showed that negative oil price shocks pose deleterious effect on macroeconomic variables in Nigeria. Yusuf (2015) also investigated the impact of oil price shocks on economic growth of Nigeria by evaluating the long-run relationship among the variables; oil price, exchange rate, agricultural output, unrest and economic growth, between 1970Q1 and 2011Q4. It was found that there is a positive and negative impact of oil price shocks and unrest to economic growth, which means long-run impact exists. The study concluded that oil price, exchange rate, agricultural output and unrest contained some useful predicting information for Nigeria's economic growth path.

On a similar note, Omojolaibi (2013) also studied the macroeconomic dynamics of domestic price level, economic output, money supply and oil price in Nigeria, which covers the data from 1985:q1 to 2010:q4. The results suggest that domestic shocks and policies, instead of oil-boom should be blamed for inflation. It was also found that money shocks are the main cause of GDP fluctuations, albeit oil shocks have significant positive impacts on economic output. Furthermore, Mordi & Adebisi (2010) analyzed the asymmetric impact of oil shocks on output and price in a unifying model, which they found to be present, and also concluded that Oil price changes play a significant role in determining the variance

decompositions of output and prices. Their study utilized data from 1999:01 to 2008:12 of variables; Gross domestic product, consumer price index, monetary aggregate, deposit rate, real exchange rate, and oil prices asymmetry and all-share index.

One of the early studies was by Hamilton (1983) who reported that several post-war recessions in the US were preceded by oil price shocks. The impact of oil price fluctuations on varying economic indicators of oil exporting countries have been the subject of many studies such as Dash, Sethi, and Bal (2018), Bastianin, Galeotti, and Manera (2017), Emami and Adibpour (2012). And Moshiri & Banihashem (2012). Most of these studies revealed a negative relationship between oil price shocks and variables such as real GDP and Economic Growth, they also acknowledge that the resource curse phenomenon of most oil exporting countries impedes the expected positive response of macroeconomic variables to positive oil shocks.

Findings from Iwayemi and Fayowe (2010), show that positive oil price shocks do not have a major Impact on most macroeconomic variables in Nigeria, results of the Granger-causality and impulse Response analysis revealed that positive oil shocks have not caused output, government expenditure, inflation, and the real exchange rate, however, the effect of negative oil shocks was evident as it was found to have significantly caused output and the real exchange rate. This asymmetric effect of positive and negative oil shocks has also been established for oil exporting countries by Moshiri and Banihashem (2012), results from VAR model with a GARCH-type oil price for six major OPEC Member Oil Exporting Countries revealed that in oil exporting developing countries, lower oil prices would lead to major revenue cuts and stagnation in the economy. However, higher oil prices and accompanying higher revenues do not translate to a sustained economic growth.

This corroborates the findings of Ayadi (2005). Using the Vector Auto Regression (VAR) Model, he was able to establish that oil price changes have an indirect statistically insignificant effect on real exchange rates, which, in turn, affect industrial production. The implication therefore is that an increase in oil prices does not lead to an increase in industrial production in Nigeria.

3.0 METHODOLOGY

3.1 Measurement of variables and Data Description.

Quarterly time series data will be used covering the period 1980Q1 to 2017Q4 which include a period of many interesting developments in the global oil sector. Data of OPEC Reference Basket (ORB) Prices is used for Crude Oil Price (COP), Quantity of Petroleum Demand (QPD), Real Gross Domestic Product (RGDP), Exchange Rate (EXCH), Inflation (INF), GDP Deflator (GDP Def) and Real Interest Rate (IR).

Table 1: Variables measurement.

| <i>S/no</i> | <i>Variables</i> | <i>Description & Measurement</i> |
|-------------|---------------------------|--|
| 1 | Real GDP | Natural logarithm of real GDP |
| 2 | Exchange Rate | Natural logarithm of the exchange rate expressed in US dollars deflated by CPI |
| 3 | Real Interest Rate | Nominal short-term interest rate per quarter, in per cent (computed as $0.25 \times \ln(1 + /100)$) |
| 4 | Inflation Rate | The rate of inflation, calculated by taking the difference of the natural logarithm of the consumer price index |
| 5 | GDP Deflator | The GDP implicit deflator is the ratio of GDP in current local currency to GDP in constant local currency |
| 6 | Quantity Demand of Petrol | This represents the total amount of petrol products used in the country measured by 1000 barrel per day (1000 b/d) |

| | | |
|---|-------------------|--|
| 7 | Oil Supply Shocks | This is the unanticipated flow supply disruption which causes oil production to fall, the real price of oil to increase, and global real activity to fall on impact. |
| 8 | Oil Demand Shocks | This is driven by forward-looking oil inventory behaviour which cause oil production and the real price of oil to increase and global real activity to fall on impact. |

3.2 Model Specification

Consider the specification of the structural vector autoregression in equation 1

$$B_0 y_t = B_1 y_{t-1} + B_2 y_{t-2} + \dots + B_p y_{t-p} + u_t \dots \dots \dots (1)$$

We can therefore define B_0 is the structural impact matrix that contains the structural parameters, B_1, \dots, B_p are the autoregressive parameters of the endogenous variables in the system, u_t are the structural shocks in the system. We re-define the equation in a form of lag operator and re-specifies it in equation (2)

$$B(L)y_t = u_t \dots \dots \dots (2)$$

Now, we define the structural shock as mutually uncorrelated and therefore, we take the expected value of the structural shock by its transpose and we arrive at equation (3).

$$E(u_t u_t') = \Sigma_u = I_K \dots \dots \dots (3)$$

Equally, the system presented in equation (1) cannot be estimated using any available estimation techniques. Thus, a reduced form model must be derived from the structural model in equation (1). thus, pre-multiplying equation (1) by the inverse of the structural impact matrix produces the following equation.

$$B_0^{-1} B_0 y_t = B_0^{-1} B_1 y_{t-1} + B_0^{-1} B_2 y_{t-2} + \dots + B_0^{-1} B_p y_{t-p} + B_0^{-1} u_t \dots \dots \dots (4)$$

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \dots + A_p y_{t-p} + \varepsilon_t \dots \dots \dots (5)$$

$$A(L)y_t = \varepsilon_t \dots \dots \dots (6)$$

In this system, equation (5) and (6) are the reduced form VAR that can be estimated by maximum likelihood method. It must be noted that the error term in the reduced form VAR, ε_t , is called innovation to the system that are mutually correlated.

$$\varepsilon_t = B_0^{-1} u_t \dots \dots \dots (7)$$

Equation (7) defines the relationship between the structural shock and reduced form innovation and it is based on this matrix that proper identification via sign restriction will be imposed. $E(\varepsilon_t \varepsilon_t') = B_0^{-1} E(u_t u_t') B_0^{-1'}$ \dots \dots \dots (8)

$$\Sigma_\varepsilon = B_0^{-1} \Sigma_u B_0^{-1'}$$
 \dots \dots \dots (9)

$$\Sigma_\varepsilon = B_0^{-1} B_0^{-1'}$$
 \dots \dots \dots (10)

Therefore, the SVAR produces shocks that are mutually uncorrelated so that impulse analysis can be interpreted with economic theory. The SVAR framework is generally focused on how the innovations

to one endogenous variable affect other endogenous variables included in the model. Specifically, the justification for using structural vector auto regression (SVAR), is to examine the transmission of shocks from Oil prices and other endogenous variables in the model to the demand of petroleum product. Thus, a structural VAR model serves as a good statistical tool for describing and analyzing the dynamic effects of innovations in the structure of a particular economy and it will be estimated in order to obtain a non-recursive orthogonalization of the error terms for the purpose of impulse response analysis.

Identification in sign-identified models requires that each identified shock is associated with a unique sign pattern. Sign restrictions may be static, in which case we simply restrict the sign of the coefficients in B_0^{-1} . Unlike traditional exclusion restrictions, such sign restrictions can often be motivated directly from economic theory. In addition, one may restrict the sign of responses at longer horizons, although the theoretical rationale of such restrictions is usually weaker.

For a given set of sign restrictions, the paper proceeds as follows. Consider the reduced-form VAR model $G(L)y_t = e_t$, where y_t is the K -dimensional vector of variables, $G(L)$ is a finite-order autoregressive lag polynomial, and e_t is the vector of white noise reduced-form innovations with variance-covariance matrix Σ_e . Let u_t denote the corresponding structural VAR model innovations.

The construction of structural impulse response functions requires an estimate of the $K \times K$ matrix B_0^{-1} in $\varepsilon_t = B_0^{-1}u_t$.

Let P denote the lower triangular Cholesky decomposition that satisfies $\Sigma_e = PP'$. Then $B_0^{-1} = PD$ also satisfies $\Sigma_e = B_0^{-1}B_0^{-1'}$ for any orthogonal $K \times K$ matrix D . Unlike P , PD will in general be nonrecursive. One can examine a wide range of possible solutions B_0^{-1} by repeatedly drawing at random from the set D of orthogonal matrices D . Following Rubio-Ramirez, Waggoner and Zha (2010) the paper constructs the set of admissible models by drawing from the set D and discarding candidate solutions for B_0^{-1} that do not satisfy a set of a priori sign restrictions on the implied impulse responses functions. The resulting set B_0^{-1} in conjunction with the reduced-form estimates characterizes the set of admissible structural VAR models.

Therefore, the equation below summarizes the identification scheme used following Uhlig (2005).

Table 4.1: Identification of Structural Shocks

| STRUCTURAL SHOCKS | QPD_{oil} | GDP_{oil} | $EXCR_{oil}$ | INF_{oil} |
|--|-------------|-------------|--------------|-------------|
| Oil supply | < 0 | ≤ 0 | - | ≤ 0 |
| Oil demand driven by economic activity | > 0 | > 0 | - | > 0 |

From the equation above + and - denotes the postulated sign of the impact response and 0 denotes no restriction. The model is partially identified in that only the response to an unanticipated price and income policy shocks are identified. It is also set-identified in that, sign restrictions are consistent with a range of admissible models. This derives from the evidence in the econometric literature that the minimum number of restrictions required for identifying an SVAR model is $\frac{n(n-1)}{2}$.

4.0 DISCUSSION OF EMPIRICAL RESULTS

4.1 Discussion on the Summary Statistic of Some Selected Variables

This section discuss the summary statistics of some selected variables used in the study. The endogenous variables selected are; Quantity of Petroleum Demand (QPD), Real Gross Domestic Product (RGDP), Exchange Rate (EXCH), Inflation (INF), GDP Deflator (GDP Def) and Real Interest Rate (IR). Oil demand and supply shocks variables are exogenously determined.

Following Killian (2014), oil supply shock is the unanticipated flow supply disruption which causes oil production to fall, the real price of oil to increase, and global real activity to fall on impact. Positive oil demand shock is driven by forward-looking oil inventory behavior which cause oil production and the real price of oil to increase and global real activity to fall on impact.

Table 2: Summary Statistic

| | EXCH | INF | GDP Def | QPD | RGDP | IR |
|---------------------|-----------|----------|----------|----------|----------|----------|
| <i>Mean</i> | 143.00060 | 11.8762 | 17.08726 | 15.87067 | 37.41016 | 14.307 |
| <i>Std. Dev.</i> | 29.58361 | 4.8996 | 1.88911 | 18.49926 | 44.72668 | 10.678 |
| <i>Skewness</i> | 0.953063 | 0.9490 | 0.98543 | 1.802358 | 1.275512 | 2.98509 |
| <i>Kurtosis</i> | 2.623225 | 2.682927 | 3.5952 | 6.003765 | 3.100511 | 3.987405 |
| <i>Observations</i> | 128 | 128 | 128 | 128 | 128 | 128 |

From Table 2, The mean estimate of exchange rate is computed to be 143.00 with a standard deviation of 29.58. Thus, we can say that the volatility of exchange rate is relatively large, indicating significant fluctuation of exchange rate. Also, the variable is characterised with a mild positive skewness of 0.95 and kurtosis value of less than 3. In sum, exchange rate is volatile with a mild positive skewness and a moderate kurtosis.

The mean estimate of real interest rate (IR) is computed to be 14.307 with a standard deviation of 5.04. Thus, we can conclude that the volatility is significant. Also, IR is characterised with a positive skewness of 2.98 and kurtosis value more than 3.

The mean estimate of Real Gross Domestic Product (RGDP) is 37.41 with a standard deviation of 44.73 therefore, we can say the volatility is relatively large, indicating significant fluctuation of RGDP. Also, the RGDP is characterised with positive skewness of 3.10 and kurtosis value of more than 3.

The mean estimate of GDP deflator (GDPD) and quantity of petroleum product demand (QPD) are 17.08 and 15.87 with a standard deviation of 13.89 and 1.88 respectively. Thus, we can say that the volatility is relatively large with significant fluctuation of RGDP, and QPD. Also, GDP deflator and QPD are characterised with a positive skewness of 0.98 and 1.80 respectively and kurtosis value of less than 3 for GDP deflator and more than 3 for QPD.

4.3 Inference from Structural Vector Autoregression

In this section, we attempt to analyze how oil price changes affect the dynamics of real gross domestic product in Nigeria, real exchange rate and quantity of petroleum demand in Nigeria. Quantitative analysis of the responses of these variables are investigated via structural impulse response function, forecast error variance decomposition and historical decomposition.

The main thrust of the study is to quantify the response of key macroeconomic variables in Nigeria induced from sudden global change in identified oil shocks. Thus, the research employs most recent econometric model of shock identification via sign and zero restriction as introduced by Faust (1998), and popularized by Uhlig (2005). This is a contribution to the methodology, as little or no empirical studies in Nigeria so far uses a combination of zero and sign restriction to identify the response of macroeconomic variables in Nigeria due to oil shocks.

The study, as explained earlier in the previous section, adopts the combination of zero and sign restriction to identify two structural shocks. To recast the identification scheme, the study recalls the information in table 4.1

Table 4.1: Identification of Structural Shocks

| STRUCTURAL SHOCKS | QPD_{oil} | GDP_{oil} | $EXCR_{oil}$ | INF_{oil} |
|--|-------------|-------------|--------------|-------------|
| Oil supply | < 0 | ≤ 0 | - | ≤ 0 |
| Oil demand driven by economic activity | > 0 | > 0 | - | > 0 |

Therefore, the study intends to examine the response and reaction of the Nigeria's macroeconomic variables, namely, quantity of domestic demand of petrol, real GDP, real exchange rate, and inflation (QPD , GDP , $EXCR$, and INF). Following Uhlig (2005), the study utilizes rejection method as preached by the author. In addition to these key variables, we also include GDP deflator as a result of the open nature of the Nigerian economy as well as interest rate to analyze reaction of the monetary policy to oil shock.

4.3.1 Results from Estimates of the Contemporaneous Relationship

The strong rationale for estimating structural vector autoregression is that variables are treated endogenously and therefore symmetrically. Therefore, this study estimates the contemporaneous impact matrix for the short run and long run estimates of the variables in the system.

Table 4.2: Contemporaneous impact matrix

| Estimated contemporaneous impact matrix: | | | | |
|--|----------|----------|-----------|---------|
| | Rgdp | e | P | ir |
| Rgdp | 0.58402 | 0.07434 | -0.152578 | 0.06900 |
| E | -0.12029 | 0.26144 | -0.155096 | 0.08978 |
| P | 0.02526 | -0.26720 | 0.005488 | 0.04982 |
| ir | 0.11170 | 0.00000 | 0.483771 | 0.48791 |

Rgdp, e, P and ir stands for real GDP, exchange rate, oil price and interest rate respectively.

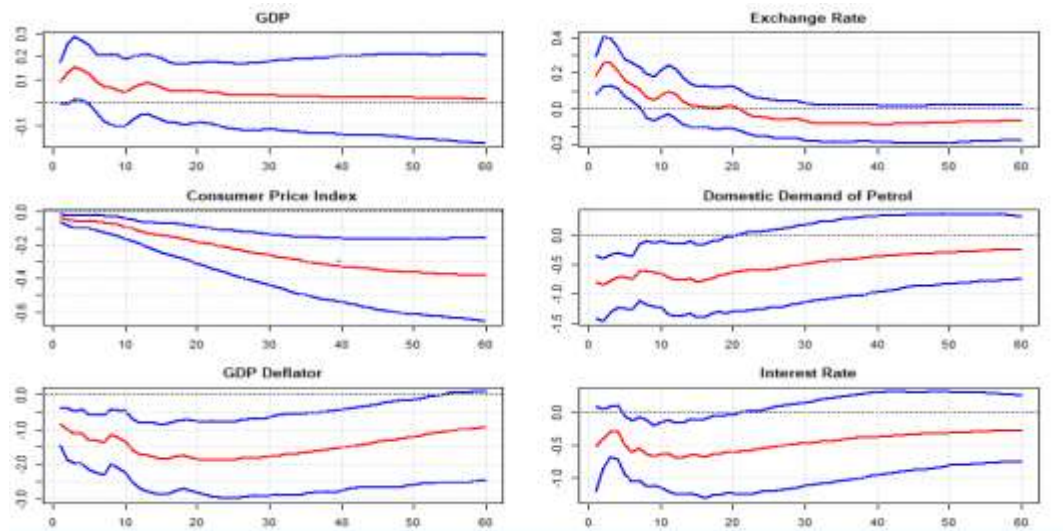
From the estimates of the contemporaneous relationship among the variables in the study, it can be inferred that the variables are reacting to shocks disproportionately. Put differently, it can be said that reaction of the variables in the system exert unequal weight. This will help in imposition restriction which is in line with a given economic theory. The response of real GDP seems to be highest (58% approximately), which is followed by interest rate (48% approximately). Interestingly, we can see that the size of the standard errors of the estimated contemporaneous relationship among the variables are small. This suggests that the variables are characterized with strong comovements and interconnectedness.

4.3.1 Oil Demand Shock

The study aims to explore responses of the macroeconomic variables in Nigeria to increases in global economic activity. We examine the shape and changes in the structural impulse response in the figure below. The oil demand shock can be stimulated via several episodes, one of which is boom in the economic activities in the global economy. The lines below extract the posterior impulse responses and plots the resulting impulse responses to oil demand shock. The important macroeconomic variables to be analyzed via its responses is the real GDP because it gives some understanding about the fluctuation in the level of economic activities in the economy.

Interestingly, structural shock hitting the economy are described in figure 1 where the reaction of the real GDP, quantity of domestic demand of petrol, exchange rate, GDP deflator, consumer price index and interest rate is depicted.

Figure 1: Structural Impulse Response to Oil Demand Shock



From the top left corner of the figure, we can see that real GDP remain positive throughout the shock scenario, with some fluctuations around the mean value. It is also observed from the figure that there is wide error band around the response of the real GDP which may suggests that the real GDP exhibit uncertainty in its path. The uncertainty in the response of real GDP increases as the time horizon goes further into the future. Thus, with oil demand shock which is induced as a result of increase in global economic activity, Nigeria’s real GDP will exhibit positive response. This can be traced to the rise in the price of oil following positive demand shock.

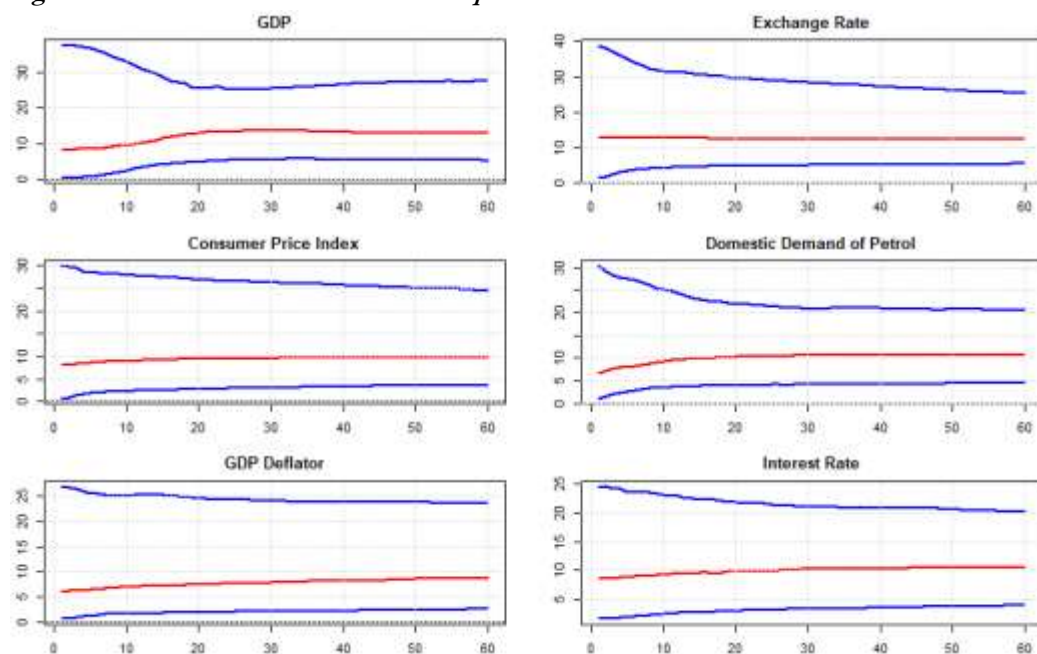
Exchange rate behaves abnormally by reacting, first as appreciation, then consistently depreciates throughout the shock horizon. Put differently, the exchange rate appreciates immediately with oil demand shock and then reacts negatively, approaches zero horizon, and further plunge into depreciation of the country’s currency.

Consumer price index and GDP deflator react quite in opposite directions. While consumer price index consistently and persistently falls, the GDP deflator raises following oil demand shock. This scenario underscores the importance and dominance of external sector in dynamic interaction of the macroeconomic variables in Nigeria.

It can be seen from the figure 1 that quantity of domestic demand of petrol and real interest rate somehow exhibit similar pattern; persistent negative movement all throughout the shock simulation period. Thus, the sign restriction is left open, unrestricted because there is no prior information or belief to suggest the likely reaction of the variables.

Figure 2 illustrates the estimates of forecast error variance decomposition of the structural shock from oil demand. Thus, from the dynamic response of the real GDP in the figure, the study can deduce that real GDP's contribution to the fluctuation of the Nigeria's economy is big-impact movement. The size of the fluctuation in real GDP determines the performance of the economy. Also, as reveal from the figure, exchange rate seems to be important in responding to oil demand shock with almost equal strength as the real GDP. It can be traced to the fact that the Nigeria's economy is best described as a Small-Open Economy (SOE). Thus, exchange rate, which is seen as externally determined, will play significant role in dynamic interaction and reaction of key macroeconomic variables in the Nigerian economy.

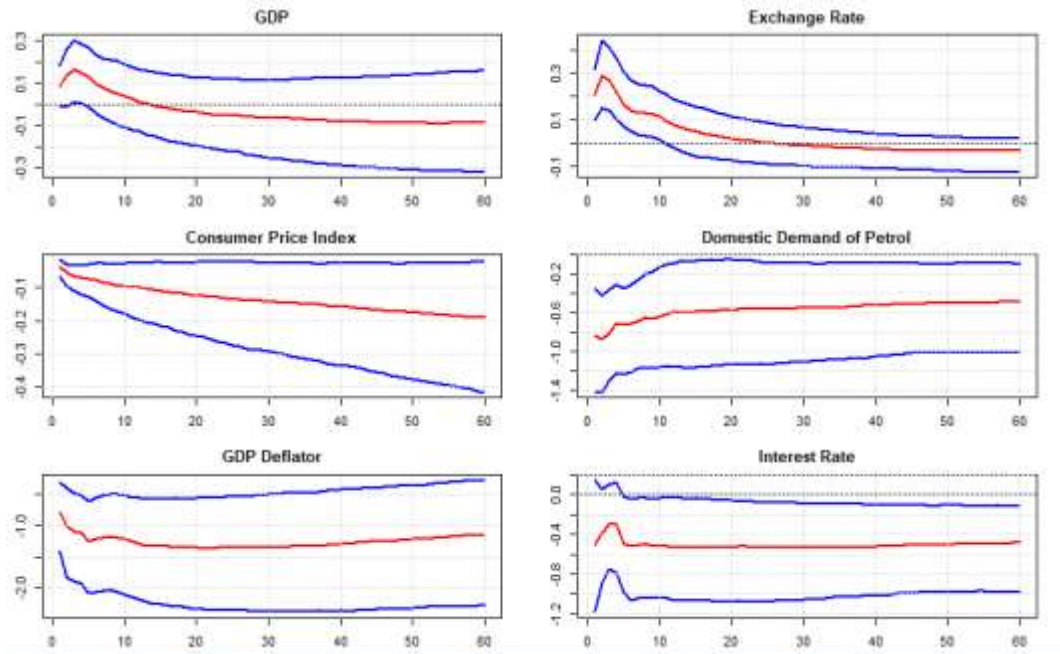
Figure 2: Forecast Error Variance Decomposition



4.3.2 Oil Supply Shock

In this analysis, the study evaluates shape of the orthogonalized impulse response of the endogenous variables in the system. The model is estimated using the same settings as in Uhlig (2005), i.e. 12 lags, no constant, and 60 steps for the impulse response functions. The algorithms use 200 draws from the posterior and 200 sub-draws for each posterior draw to generate the impulse vectors and the candidate impulse responses to which the rejection algorithm will be applied.

Figure 3: Structural Impulse Response to Oil Supply Shock



From the plots of the responses of the key macroeconomic variables, the study can infer about the dynamic response of each of the six-component vector of endogenous variables. The red-line shows the point estimates of the responses while blue-line is error band which is fixed at 68% standard error.

From the top left corner of figure 4, the response of real GDP to a one-unit standard deviation increase in the global oil supply indicates that Nigeria’s real GDP reacts negatively with initial shock transmission into the economy. The persistence decline in real GDP continues rather slowly as the time horizon goes deeper into the future. The shape

of the impulse response of the real GDP further declines until it approaches zero at the 60th horizon before the impact of the shock dies out of the economy. Empirically, the study can establish that fall in oil price due to increase in its supply will generate fall in revenue into the economy. This will translate into lower real GDP in Nigeria.

The unrestricted sign attached to real exchange rate shows that the response of the exchange rate to increase in oil supply is persistent depreciation of Nigeria’s currency. From the top right corner of figure 4, it shows that there is immediate short-lived positive reaction of the Nigeria’s currency with increase in the global supply of oil at the international market which gradually becomes negative induced-movement. The persistent depreciation continues until it reaches zero at 20th horizon and becomes negative throughout the shock scenario.

The consumer price index is negative and remain in the region for the entire period of the shock. This behavior of the consumer price index can be explained in terms of high degree of openness nature of the Nigeria’s economy. The fall in price resulting from increase in oil supply makes the Nigeria’s economy more vulnerable and, therefore, the immediate negative reaction of the consumer price index.

The response of the quantity of domestic demand of petrol to a one-unit increase in the supply of oil is depicted to be positive. The supply shock in oil widens the oil production gap in the economy as the activities of the Niger-Delta increases. Their disruption of oil production increases as a result of the increase in the supply of oil at the global market.

The response of GDP deflator and real interest rate shows that while the former increases positively to the shock, the latter shows a negative reaction. These responses can be attributed to the fact that the economy is heavily influenced by external shocks (trade and financial shocks).

The table 4.2 gives the estimates of the forecast error variance decomposition with oil supply shock. We can see that as the time horizons increases into the future, the contribution of the GDP, exchange rate, consumer price index, quantity of domestic demand of petrol, GDP deflator and interest rate becomes significant in the economy.

Table 4.2: Forecast Error Variance Decomposition

| <i>Horizons</i> | <i>GDP</i> | <i>GDP Def.</i> | <i>CP Index</i> | <i>IR</i> | <i>Exch Rate</i> | <i>QDP</i> |
|-----------------|--------------|-----------------|-----------------|-------------|------------------|-------------|
| <i>1</i> | <i>78.26</i> | <i>16.93</i> | <i>2.83</i> | <i>0.95</i> | <i>0.68</i> | <i>0.35</i> |
| <i>3</i> | <i>69.31</i> | <i>18.27</i> | <i>5.49</i> | <i>2.98</i> | <i>2.59</i> | <i>1.36</i> |
| <i>6</i> | <i>72.16</i> | <i>15.49</i> | <i>8.25</i> | <i>2.16</i> | <i>0.92</i> | <i>1.02</i> |
| <i>12</i> | <i>63.15</i> | <i>19.73</i> | <i>8.43</i> | <i>4.80</i> | <i>2.36</i> | <i>1.53</i> |

From the table above, it can be seen that at the initial forecast horizon, the role of interest rate can be strongly felt by the economy (12.15), although marginal, but exert greater influence in the economy. The contribution of the real IR and real GDP remain strong in the economy till the last end of the forecast error. Thus, the table reveals that much of the fluctuations in the Nigerian economy following oil supply shock is traced to the vulnerability of the of the real measure of economic activity, real GDP and real interest rate. Other significant determinant of the macroeconomic fluctuations in Nigeria's, as revealed from the table, is traced to the role of exchange rate in the country. Thus, the study further illustrates the importance of external economic developments (dis)stabilizing the economy.

We generate cumulative density of the shocks (oil demand and supply) in two different regimes (high oil price volatility and low oil price volatility). This will reveal whether the size of the shocks changes and how the economy has been responding to oil price fluctuations. This is represented in the figure on the next page. From the fluctuations in the real GDP in the figure, we can deduce that both demand and supply oil shock are important in explaining past history in the fluctuations in the economy. We can see that oil demand shock is more pronounced than oil supply shock and this reflect the fact that oil demand shock will naturally raise oil price, which will expand the government revenue and improve the fiscal position of the economy. The expectation is that the economy will respond positively with improved fiscal revenue to finance projects that will stimulate economic activities.

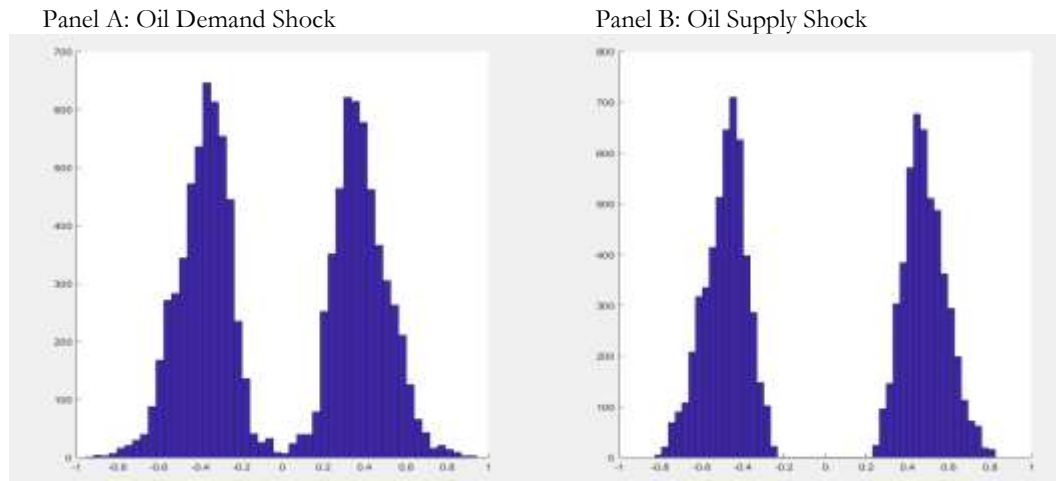


Figure 5: Relative Size of the Shocks in Oil Price Regimes

From the panels in figure 5, we can further deduce that the relative weight of oil demand shock in both periods of high and low oil price volatility is bigger than the relative weight of oil supply shock in both periods of high and low oil price volatility. This can be traced to the transmission channel through which oil demand affect the real sector of the Nigerian economy. Thus, we can account for the fact that with oil demand change, the economy responds (negative/positive) in differently from oil supply change.

5.0 CONCLUSIONS

The study presents exploration to the analysis of the dynamic relationship between the Nigerian economy and oil as an international commodity. The empirical quest set to investigate the behavior of the Nigerian economy during unexpected changes in the global demand or supply of oil. The rationale for the empirical quest is traced to recent development in the global market of oil that has witnessed massive crash of its price. The Nigerian economy is among the worst hit during oil crises as fiscal imbalances is negatively affected due to revenue volatility. Thus, we set to identify the response of the selected macroeconomic variables in the wake of unanticipated changes in oil demand and, or supply. From the estimates of the structural VAR, identified with sign restriction, impulse responses of the measure of economic activity (proxied by real GDP) depict immediate reaction with shocks from oil demand and supply changes. Although, it is observed that, on aggregate, economic activities react positively whenever there is oil demand shock at the global, it must be mentioned that the response is short-lived. Conclusively, other empirical research in Nigeria that have reported *big-impact* may have overestimated the size of the reaction of the real GDP in Nigeria. Equally, the reaction of real GDP in Nigeria due to oil supply shock is not instantaneous as in the case of oil demand shock. However, from the estimate of impulse response function, we can say that the impact die out rather too quickly. We also note that, from estimate of the historical decomposition, demand and supply shocks of oil do not exert equal weights in the fluctuation of the real GDP. This is traced to the nature of the shock and transmission channel. We can therefore recommend that although oil play massive role in explaining the performance of the economy, other specific sectors are equally important. For example, exchange rate crises may be more harmful to the economy than oil crises.

REFERENCES

- Abel, A.B. and Bernanke, B.S. (2001). *Macroeconomics*. 4th ed. Boston: Addison Wesley Longman.
- Adagunodo, M., (2014). An empirical analysis of petroleum products demand in Nigeria: a random trend approach. *Glob. J. Arts Humanity. Social. Sci.* 2 (4), 53–71.
- Adegbulugbe A.O. and F.B. Dayo (1986), Demand analysis of gasoline consumption in Nigeria. *OPEC Energy Review* 10 (2). 131-149
- Ademakinwa A, Omokanbi OJ (2017) Oil Price Shocks and Foreign Direct Investment (FDI): Implications for Economic Growth in Nigeria (1980-2014). *Journal of Economics and Sustainable Development* 8: 170-177.
- Ayadi O. Felix (2005). Oil price fluctuations and the Nigerian economy. *Organization of the Petroleum Exporting Countries review* Sept. 2005.
- Atalla Tarek N., Anwar A. Gasim, Lester C. Hunt (2018). Gasoline demand, pricing policy, and social welfare in Saudi Arabia: A quantitative analysis. *Energy policy* 114, 123-133
- Bastianina, Marzio Galeottib, Matteo Manera (2017), Oil supply shocks and economic growth in the Mediterranean. *Energy Policy* 110, 167–175.
- Blanchard Olivier J. & Jordi Galí, (2007). "The macroeconomic effects of oil price shocks: Why are the 2000s so different from the 1970s?," *Economics Working Papers* 1045, Department of Economics and Business, Universitat Pompeu Fabra, revised Oct 2008.
- Bohi R. Douglas (1981). *Analyzing Demand Behaviour: A Study of Energy Elasticities*. John Hopkins University Press, Baltimore, UK
- Cologni Alessandro and Matteo Manera, (2008), Oil prices, inflation and interest rates in a structural cointegrated VAR model for the G-7 countries, *Energy Economics*, 30, (3), 856-888
- Ebohon Obas John (1996) Energy, economic growth and causality in developing countries A case study of Tanzania and Nigeria. *Energy Policy* 24 (5). 447-53.
- Emami Karim, Mehdi Adibpour (2012). Oil income shocks and economic growth in Iran. *Economic Modelling* 29 (2012) 1774–1779.
- Jon Faust, (1998), The robustness of identified VAR conclusions about money, *Carnegie-Rochester Conference Series on Public Policy*, 49, (1), 207-244
- Hamilton James D. (2014). *The Changing Face of World Oil Markets*. Department of Economics University of California, San Diego July 20, 2014.
- Hamilton James D. (1983). Oil and the Macroeconomy since World War II *Journal of Political Economy* 91 (2) , 228-248
- Hughes, J., Knittel, C., Sperling, D., (2008). Evidence of a Shift in the Short-Run Price Elasticity of Gasoline Demand. *The Energy Journal*. 291, 93-114.
- Hunt, B., Isard, P., and Laxton, D. (2001). "Macroeconomic Effects of Higher Oil Prices". *IMF Working Paper No. WP/01/14*.
- Iwayemi Akin, Babajide Fowowe (2011), Impact of oil price shocks on selected macroeconomic variables in Nigeria. *Energy Policy* 39, 603–612.
- Iwayemi Akin, Adeola Adenikinju, M. Adetunji Babatunde (2010), Estimating petroleum products demand elasticities in Nigeria: A multivariate cointegration approach. *Energy Economics* 32, 73–85.
- Jonas E. Arias Juan F. Rubio-Ramírez Daniel F. Waggoner (2014), "Inference Based on SVARs Identified with Sign and Zero Restrictions: Theory and Applications" Board of Governors of the Federal Reserve System *International Finance Discussion Papers* Number 1100.
- Kilian Lutz and Thomas K. Lee (2014). Quantifying the speculative component in the real price of oil: The role of global oil inventories *Journal of International Money and Finance* 42 71–87.
- Kilian Lutz (2014), "Oil Price Shocks: Causes and Consequences," *Annual Review of Resource Economics*, 6, 133-154.
- Kilian Lutz, and Thomas K. Lee (2014), "Quantifying the speculative component in the real

- price of oil: The role of global oil inventories," *Journal of International Money and Finance*, 42, 71-87.
- Kilian Lutz, and Daniel P. Murphy (2014), "The Role of Inventories and Speculative Trading in the Global Market for Crude Oil," *Journal of Applied Econometrics*, 29, 454-478.
- Kilian Lutz, and Bruce Hicks (2013), "Did Unexpectedly Strong Economic Growth Cause the Oil Price Shock of 2003-2008?" *Journal of Forecasting*, 32 (5), 385-394.
- Kilian Lutz (2009), "Not All Oil Price Shocks Are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market," *American Economic Review*, 99 (3), 1053-1069.
- Mehrara Mohsen (2007). Energy consumption and economic growth: The case of oil exporting countries. *Energy Policy*, 35(5) 2939-2945.
- Mordi Charles N. O, & Adebayo Adebisi (2012). "A Dynamic Stochastic General Equilibrium (Dsge) Model Of Oil Price Shocks And Exchange Rate Pass-Through To Domestic Inflation In Nigeria," *EcoMod2012* 3715, *EcoMod*.
- Nicol C.J. (2003) Elasticities of demand for gasoline in Canada and the United States *Elsevier Energy Economics* 25, 201–214.
- Olanipekun Dayo Benedict (2016), Oil Price Shocks, Exchange Rate and Nigeria's Economy. *International Journal of Economics, Commerce and Management United Kingdom*. 9(8) 254-270
- Omisakin O. A., A M Onyinola and O A Adeniyi (2012). Modeling Gasoline Demand with Structural Breaks: New Evidence from Nigeria. *International Journal of Energy Economics and Policy* 2 (1). 1-9.
- Omojolaibi Joseph Ayoola, 2013. "Does Volatility in Crude Oil Price Precipitate Macroeconomic Performance in Nigeria?," *International Journal of Energy Economics and Policy*, *Econjournals*, vol. 3(2), pages 143-152.
- Polemis Michael L. (2006), Empirical assessment of the determinants of road energy demand in Greece. *Energy Economics* 28. 385–403.
- Rubio-Ramírez Arias, Jonas E. & Juan F. & Waggoner, Daniel F., (2014). "Inference Based on SVARs Identified with Sign and Zero Restrictions: Theory and Applications," *Dynare Working Papers* 30, CEPREMAP.
- Sa'ad, S., (2010). Improved technical efficiency and exogenous factors in transportation demand for energy: an application of structural time series analysis to South Korean data. *Energy* 35 (7), 2745–2751.
- Saeed Moshiri and Arezoo Banihashem (2012). Asymmetric Effects of Oil Price Shocks on Economic Growth of Oil-Exporting Countries.
- Sethi Narayan Devi Prasad Dasha, , Debi Prasad Bal (2018). Is the demand for crude oil inelastic for India? Evidence from structural VAR analysis. *Energy Policy* 11, 552–558.
- Schneider Martin, (2004). "The Impact of Oil Price Changes on Growth and Inflation," *Monetary Policy & the Economy*, Oesterreichische National bank (Austrian Central Bank), issue 2, 27-36.
- Shehu Usman Rano. Aliyu, (2009). "Impact of Oil Price Shock and Exchange Rate Volatility on Economic Growth in Nigeria: An Empirical Investigation," MPRA Paper 16319, University Library of Munich, Germany, revised 10 Jun 2009.
- Sill Keith, (2007), The macroeconomics of oil shocks, *Business Review*, (Q1), 21-31
- Spatafora Nikola and Andrew Warner (2011). Macroeconomic effects of terms-of-trade shocks: the case of oil-exporting countries. *World Bank Policy research working paper* WPS1410.
- Uhlig (2005), What are the effects of monetary policy on output? Results from an agnostic identification procedure. *Journal of Monetary Economics* 52, 381–41.
- Wolde-Rufael Yemane (2005). Energy demand and economic growth: The African experience *Journal of Policy Modeling* 27. 891–903.

Yusuf, M. (2015). An analysis of the impact of oil price shocks on the growth of the Nigerian economy: 1970-2011. *African Journal of Business management*, 9(3), 103-115.

APPENDIX

A. UNIT ROOT TEST RESULTS

Variable 1: Real GDP

```
#####
# Augmented Dickey-Fuller Test Unit Root Test #
#####
```

Test regression trend

Call: lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)

Residuals:

| Min | 1Q | Median | 3Q | Max |
|----------|----------|---------|---------|---------|
| -2.19924 | -0.38994 | 0.04294 | 0.41914 | 1.71660 |

Coefficients:

| Estimate | Std. Error | t value | Pr(> t) |
|-------------|------------|-----------|-----------------|
| (Intercept) | 30.415228 | 15.309403 | 1.987 0.0506 . |
| z.lag.1 | -0.075791 | 0.038134 | -1.988 0.0505 . |
| tt | 0.013896 | 0.006422 | 2.164 0.0336 * |
| z.diff.lag1 | 0.284866 | 0.114359 | 2.491 0.0149 * |
| z.diff.lag2 | 0.080019 | 0.116090 | 0.689 0.4927 |

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.6851 on 76 degrees of freedom
Multiple R-squared: 0.1354, Adjusted R-squared: 0.08993
F-statistic: 2.976 on 4 and 76 DF, p-value: 0.02438

Value of test-statistic is: -1.9875 2.3 2.3817

Critical values for test statistics:

| 1pct | 5pct | 10pct |
|------------|-------|-------|
| tau3 -4.04 | -3.45 | -3.15 |
| phi2 6.50 | 4.88 | 4.16 |
| phi3 8.73 | 6.49 | 5.47 |

Variable 2: Inflation Rate

```
#####
# Augmented Dickey-Fuller Test Unit Root Test #
#####
```

Test regression trend

Call:

lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)

Residuals:

| Min | 1Q | Median | 3Q | Max |
|----------|----------|---------|---------|---------|
| -0.80266 | -0.21963 | 0.01558 | 0.28686 | 0.73058 |

Coefficients:

| | Estimate | Std. Error | t value | Pr(> t) |
|-------------|-----------|------------|---------|--------------|
| (Intercept) | 34.571569 | 18.067986 | 1.913 | 0.0595 . |
| z.lag.1 | -0.037139 | 0.019458 | -1.909 | 0.0601 . |
| tt | 0.014646 | 0.007209 | 2.032 | 0.0457 * |
| z.diff.lag1 | 0.928088 | 0.107620 | 8.624 | 7.02e-13 *** |
| z.diff.lag2 | -0.251322 | 0.112917 | -2.226 | 0.0290 * |

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.3849 on 76 degrees of freedom

Multiple R-squared: 0.597, Adjusted R-squared: 0.5758

F-statistic: 28.15 on 4 and 76 DF, p-value: 2.378e-14

Value of test-statistic is: -1.9087 3.804 2.0874

Critical values for test statistics:

| | 1pct | 5pct | 10pct |
|------|-------|-------|-------|
| tau3 | -4.04 | -3.45 | -3.15 |
| phi2 | 6.50 | 4.88 | 4.16 |
| phi3 | 8.73 | 6.49 | 5.47 |

Variable 3: Exchange Rate

```
#####
# Augmented Dickey-Fuller Test Unit Root Test #
#####
```

Test regression trend

Call:

lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)

Residuals:

| Min | 1Q | Median | 3Q | Max |
|----------|----------|----------|---------|---------|
| -2.16156 | -0.58418 | -0.02107 | 0.50776 | 2.98765 |

Coefficients:

| | Estimate | Std. Error | t value | Pr(> t) |
|-------------|----------|------------|---------|------------|
| (Intercept) | 25.17103 | 8.48052 | 2.968 | 0.00401 ** |
| z.lag.1 | -0.05839 | 0.02092 | -2.791 | 0.00664 ** |
| tt | 0.03394 | 0.01913 | 1.774 | 0.08006 . |
| z.diff.lag1 | 0.18353 | 0.11055 | 1.660 | 0.10102 |
| z.diff.lag2 | -0.04536 | 0.10993 | -0.413 | 0.68102 |

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.8555 on 76 degrees of freedom
 Multiple R-squared: 0.3559, Adjusted R-squared: 0.322
 F-statistic: 10.5 on 4 and 76 DF, p-value: 7.97e-07

Value of test-statistic is: -2.7911 10.1555 9.8367

Critical values for test statistics:

| | 1pct | 5pct | 10pct |
|------|-------|-------|-------|
| tau3 | -4.04 | -3.45 | -3.15 |
| phi2 | 6.50 | 4.88 | 4.16 |
| phi3 | 8.73 | 6.49 | 5.47 |

Variable 4: Interest Rate

```
#####
# Augmented Dickey-Fuller Test Unit Root Test #
#####
```

Test regression trend

Call:

lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)

Residuals:

| Min | 1Q | Median | 3Q | Max |
|----------|----------|----------|---------|---------|
| -0.67131 | -0.20603 | -0.03141 | 0.17007 | 1.09390 |

Coefficients:

| | Estimate | Std. Error | t value | Pr(> t) |
|-------------|-----------|------------|---------|--------------|
| (Intercept) | 0.840673 | 0.275658 | 3.050 | 0.00315 ** |
| z.lag.1 | -0.076468 | 0.026443 | -2.892 | 0.00499 ** |
| tt | -0.002876 | 0.001739 | -1.654 | 0.10217 |
| z.diff.lag1 | 0.517942 | 0.108201 | 4.787 | 8.17e-06 *** |
| z.diff.lag2 | 0.115660 | 0.112812 | 1.025 | 0.30850 |

 Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.3483 on 76 degrees of freedom
 Multiple R-squared: 0.4016, Adjusted R-squared: 0.3701
 F-statistic: 12.75 on 4 and 76 DF, p-value: 5.465e-08

Value of test-statistic is: -2.8918 3.208 4.811

Critical values for test statistics:

| | 1pct | 5pct | 10pct |
|------|-------|-------|-------|
| tau3 | -4.04 | -3.45 | -3.15 |

phi2 6.50 4.88 4.16
 phi3 8.73 6.49 5.47

Variable 5: GDP Deflator

```
#####
# Augmented Dickey-Fuller Test Unit Root Test #
#####
```

Test regression trend

Call:

lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)

Residuals:

| Min | 1Q | Median | 3Q | Max |
|---------|---------|---------|--------|--------|
| -3.4818 | -0.6389 | -0.0654 | 0.5147 | 3.6130 |

Coefficients:

| | Estimate | Std. Error | t value | Pr(> t) |
|-------------|-----------|------------|---------|------------|
| (Intercept) | 0.955605 | 0.324393 | 2.946 | 0.00368 ** |
| z.lag.1 | -0.133496 | 0.043328 | -3.081 | 0.00241 ** |
| tt | -0.004708 | 0.002056 | -2.290 | 0.02326 * |
| z.diff.lag1 | -0.256078 | 0.077843 | -3.290 | 0.00122 ** |
| z.diff.lag2 | -0.139338 | 0.075512 | -1.845 | 0.06677 . |

 Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.106 on 167 degrees of freedom
 Multiple R-squared: 0.1576, Adjusted R-squared: 0.1374
 F-statistic: 7.809 on 4 and 167 DF, p-value: 8.569e-06

Value of test-statistic is: -3.081 3.32 4.9763

Critical values for test statistics:

| | 1pct | 5pct | 10pct |
|------|-------|-------|-------|
| tau3 | -3.99 | -3.43 | -3.13 |
| phi2 | 6.22 | 4.75 | 4.07 |
| phi3 | 8.43 | 6.49 | 5.47 |

Variable 6: Quantity of Petroleum Demand

```
#####
# Augmented Dickey-Fuller Test Unit Root Test #
#####
```

Test regression trend

Call:

lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)

Residuals:

Min 1Q Median 3Q Max
 -3.0409 -0.3183 0.0239 0.3322 6.6508

Coefficients:

Estimate Std. Error t value Pr(>|t|)
 (Intercept) 0.675901 0.266970 2.532 0.012273 *
 z.lag.1 -0.067204 0.025602 -2.625 0.009471 **
 tt -0.002869 0.001622 -1.769 0.078744 .
 z.diff.lag1 0.297757 0.074775 3.982 0.000102 ***
 z.diff.lag2 -0.158452 0.076123 -2.082 0.038911 *

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.973 on 167 degrees of freedom
 Multiple R-squared: 0.1304, Adjusted R-squared: 0.1096
 F-statistic: 6.262 on 4 and 167 DF, p-value: 0.0001017

Value of test-statistic is: -2.6249 2.5311 3.7875

Critical values for test statistics:

1pct 5pct 10pct
 tau3 -3.99 -3.43 -3.13
 phi2 6.22 4.75 4.07
 phi3 8.43 6.49 5.47

B. DIAGNOSTIC TESTS OF SVAR

Serial Autocorrelation Test

Portmanteau Test (asymptotic)
 data: Residuals of VAR object p1ct
 Chi-squared = 233.5, df = 240, p-value = 0.606

Multivariate Normality Tests

JB-Test (multivariate)
 data: Residuals of VAR object p1ct
 Chi-squared = 9.9189, df = 8, p-value = 0.2708

\$Skewness

Skewness only (multivariate)

data: Residuals of VAR object p1ct
 Chi-squared = 6.356, df = 4, p-value = 0.1741

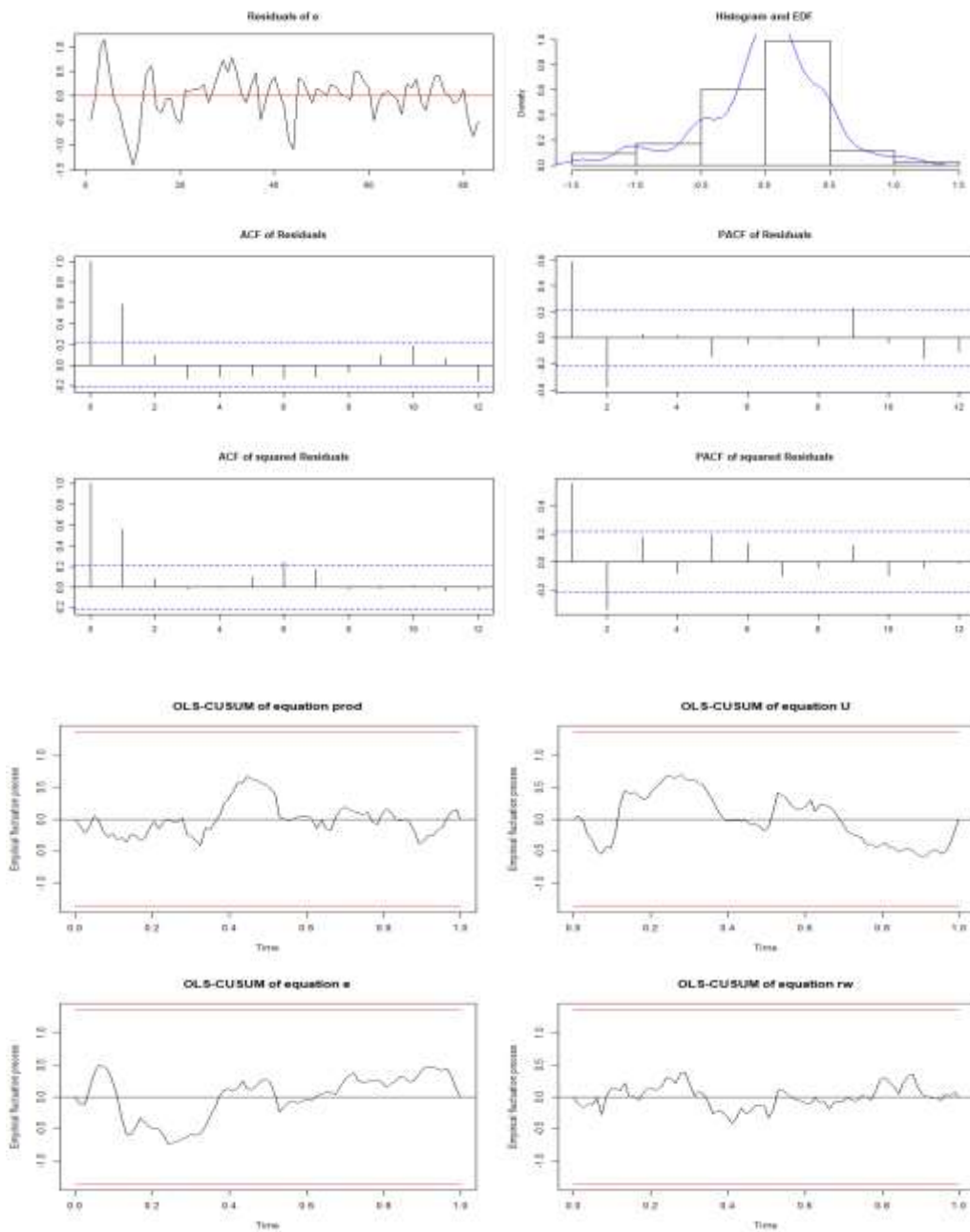
\$Kurtosis

Kurtosis only (multivariate)

data: Residuals of VAR object p1ct
 Chi-squared = 3.5629, df = 4, p-value = 0.4684

ARCH (multivariate)

data: Residuals of VAR object p1ct
 Chi-squared = 570.14, df = 500, p-value = 0.01606



C. CONTEMPORANEOUS ESTIMATES OF THE STRUCTURAL PARAMETERS

SVEC Estimation Results:

=====

Call:

SVAR(x = vecm, LR = LR, SR = SR, r = 1, lrtest = FALSE, boot = TRUE,
runs = 100)

Type: B-model

Sample size: 81

Log Likelihood: -161.838

Number of iterations: 13

Estimated contemporaneous impact matrix:

| rgdp | e | P | ir |
|------|----------|----------|-------------------|
| rgdp | 0.58402 | 0.07434 | -0.152578 0.06900 |
| e | -0.12029 | 0.26144 | -0.155096 0.08978 |
| P | 0.02526 | -0.26720 | 0.005488 0.04982 |
| ir | 0.11170 | 0.00000 | 0.483771 0.48791 |

Estimated standard errors for impact matrix:

| rgdp | e | P | ir |
|------|---------|---------|-----------------|
| rgdp | 0.09667 | 0.12716 | 0.22747 0.08178 |
| e | 0.07996 | 0.06205 | 0.18587 0.04564 |
| P | 0.05955 | 0.05477 | 0.06236 0.03229 |
| ir | 0.15936 | 0.00000 | 0.67859 0.07611 |

Estimated long run impact matrix:

| rgdp | e | P | ir |
|------|---------|---------|-----------|
| rgdp | 0.7910 | 0.0000 | 0.0000 0 |
| e | 0.2024 | 0.5769 | -0.4923 0 |
| P | -0.1592 | -0.3409 | 0.1408 0 |
| ir | -0.1535 | 0.5961 | -0.2495 0 |

Estimated standard errors for long-run matrix:

| rgdp | e | P | ir |
|------|--------|---------|----------|
| rgdp | 0.1615 | 0.00000 | 0.0000 0 |
| e | 0.2729 | 0.19559 | 0.5735 0 |
| P | 0.1291 | 0.09631 | 0.1437 0 |
| ir | 0.1983 | 0.16866 | 0.2551 0 |

Covariance matrix of reduced form residuals (*100):

| rgdp | e | P | ir |
|------|---------|--------|----------------|
| rgdp | 37.4642 | -2.096 | -0.2512 2.509 |
| e | -2.0960 | 11.494 | -6.9273 -4.467 |
| P | -0.2512 | -6.927 | 7.4544 2.978 |
| ir | 2.5087 | -4.467 | 2.9783 48.457 |