

---

# Modeling the Impact of Crude Oil Price Shocks on Some Macroeconomic Variables in Nigeria Using Garch and VAR Models

Audu Isah<sup>1</sup>, Husseini Garba Dikko<sup>2</sup>, Ejiemenu Sarah Chinyere<sup>2</sup>

<sup>1</sup>Department of Mathematics, Federal University of Technology, Minna, Nigeria

<sup>2</sup>Department of Mathematics, Ahmadu Bello University, Zaria, Nigeria

## Email address:

chiejims2@gmail.com (E. Sarah. Chinyere)

## To cite this article:

Audu Isah, Husseini Garba Dikko, Ejiemenu Sarah. Chinyere. Modeling the Impact of Crude Oil Price Shocks on Some Macroeconomic Variables in Nigeria Using Garch and VAR Models. *American Journal of Theoretical and Applied Statistics*.

Vol. 4, No. 5, 2015, pp. 359-367. doi: 10.11648/j.ajtas.20150405.16

---

**Abstract:** This study investigated the impact of crude oil shocks (COP) on exchange rate (EXCHR), external reserves (EXRS), gross domestic product (GDP), inflation rate (INFL), international trade (INTR) and money supply (MSUP) in Nigeria with a quarterly data from 2000 to 2014 using GARCH and VAR models. From the analysis, all the variables were stationary at first difference with p-value less than 0.05. The presence of heteroscedasticity was found in exchange rate with most of its coefficient models being significant at 5% level and the forecasting model for exchange rate is GARCH (2, 1). Crude oil shocks did not pose significant inflationary threat to the Nigerian economy in the short run; rather, it improves the level of gross domestic product. However, external reserves and international trade were significantly affected due to the recent fall in crude oil export. Oil shocks also positively affected money supply showing that monetary policy response to oil price changes; at the same time, money supply did affect GDP. These show that a diversified economy is really needed.

**Keywords:** Crude Oil, Macroeconomic Variables, GARCH, VAR and IRF

---

## 1. Introduction

Crude oil is said to be the backbone of Nigerian economy (Agbede, 2013). It plays a significant role in influencing the economic and political destiny of the country. Nigeria as the largest African country and the 6th largest producer of oil in the world is very vulnerable to fluctuations in the international oil market which present Nigerian macro economy as fragile in nature due to heavy dependence on crude oil (Akpan, 2009). Describing oil shocks, Ogundipe and Ogundipe (2013) referred to it as a sudden, unexpected change in oil price or production. According to (Hamilton 1983, Wakeford 2006 Akpan, 2009), oil price shock is price fluctuations resulting from changes in either the demand or supply side of the international oil market. These changes have been traditionally traced to supply-side disruptions such as OPEC supply quotas, political upheavals in the oil-rich Middle East and activities of militant groups in the Niger Delta region of Nigeria (Akpan, 2009). Naturally, the bigger the oil-price increase and the longer higher prices are sustained, the bigger the macroeconomic impact (Majidi,

2006 and Akpan, 2009).

Recently, Bernard in 'The Guardian newspaper' 3 November 2014 pointed out that crude oil prices collapsed from \$104 per barrel to about \$82 per barrel and dropped further to \$50.28 in 2014; (cen.bank.org, 2014) which is far less than 90% of Nigeria's foreign exchange earnings resulting to deficit of 0.5 per cent of GDP.

From the foregoing, oil price variation plays a significant role in macroeconomic fluctuations in both oil importing and exporting countries, (Akpan, 2009; Mehrara and Mohaghegh, 2011). But the extent to which they are affected by oil shocks is what is brought under consideration in order to know how well it can be minimized, cautioned and managed to stability by some institutional control mechanisms. To this end, the objectives of this study is to evaluate crude oil price and some macroeconomic variables in terms of heteroscedasticity test in order to model and forecast the volatility model; investigate the response of macroeconomic variables to crude oil price shocks and then estimate oil price shocks and its

impact on the economy.

## 2. Literature

Tatyana (2010) studied the dynamics of oil prices (Brent and WTI crude oil markets) and their volatilities by linking four GARCH-related models namely: GARCH(1,1) GJR-GARCH(1,1), EGARCH(1,1) and APARCH(1,1). The findings showed that oil shocks have permanent and asymmetric effects on volatility for both markets considered. Oyetunji (2013) examined the effects of oil price, external reserves and interest rate on exchange rate volatility in Nigeria using GARCH and EGARCH. The result showed that proportionate change in oil price led to a more proportionate change in exchange rate volatility in Nigeria by 2.8%.

Leykun, (2012) studied monthly petroleum oil import over twelve years using GARCH and was found that GARCH(1,1) is more suitable model in forecasting oil import prices of Ethiopia.

Mulyadi (2012) explored the effect of world's oil price on a quarterly-based GDP, inflation and exchange rate in Indonesia as a net oil importer and exporter country using VEC model. The findings revealed that higher oil price led to higher degree of GDP, inflation and exchange rate in the short run but then insignificant. In the long run, higher oil price contributed to higher GDP. As a net oil importer, higher oil price elicited lower GDP, triggered inflation increase and exchange rate but insignificant in Indonesia than the period of it being a net oil exporter.

Olomola and Adejumo (2006) investigated the impact of oil price shocks on aggregate economic activity (output, inflation, the real exchange rate and money supply) in Nigeria using quarterly data from 1970 to 2003 under VAR model. The findings revealed that contrary to previous empirical findings, oil price shocks do not affect output and inflation in Nigeria significantly. However, oil price shocks were found to significantly influence the real exchange rate. The author argues that oil price shocks may give rise to wealth effect that appreciates the real exchange rate and may squeeze the tradable sector, giving rise to the "Dutch-Disease". In a related study, El-Anshasy *et al.* (2005) assessed the effects of oil price shocks on Venezuela's economic performance from 1950 to 2001; adopting VAR and VECM technique to investigate the relationship between oil prices and the variables - governmental revenues, government consumption spending, GDP and investment. The results found two long-run relationships consistent with economic growth and fiscal balance. Furthermore, they found that this relationship is important not only for the long-run performance but also for short-term fluctuations.

Under the assumption that significant shocks in oil market affect macroeconomic indicators like inflation, industrial production, exchange rate, public expenditure and real oil price within the length of 1970<sub>Q1</sub> – 2007<sub>Q4</sub>, Akpan (2009) ascertained the dynamic relationship between oil price shocks and major macroeconomic variables in Nigeria by

applying a VAR approach. The results showed that positive and negative oil price shocks significantly increase inflation and also directly increase real national income through higher export earnings. It also shows a strong positive relationship between positive oil price changes and real government expenditures.

While most empirical works used either GARCH or VAR model to determine the dynamic relationship between oil price shocks and macroeconomic variables, the present study employed the two models to test for heteroscedasticity and to investigate the effects of oil shocks on the study variables. Moreover, Akpan's work which the present study is reviewing, assumed all the variables to be homoscedastic which necessitates the used of VAR model without subjecting the variables to heteroscedasticity test since one of the conditions of VAR is absence of heteroscedasticity but the present study tested the assumption of VAR and noticed that only exchange rate was heteroscedastic which necessitates GARCH estimation but crude oil price, external reserves, gross domestic product, inflation rate and international trade were homoscedastic which require VAR estimation. Microeconomic variables were not considered because macroeconomic variables are internal variables that affect standardized policy in the country from which some are selectively considered.

## 3. Methodology

Data obtained for this study was sourced from CBN Statistical database 2014 comprising of quarterly crude oil export prices (COP), exchange rate (EXCHR), external reserves (EXRS), Gross domestic product (GDP), inflation rate (INFL), international trade (INTR) and money supply (MSUP) beginning from January 1995Q1 to December 2014Q4. These study variables were log transformed (L) to get rid of outliers and as well differenced (D) to attain stationarity.

Enumeration of Models and Tests Utilized

### 3.1. Jarque-Bera Test for Normality

Jarque-Bera is a joint test of skewness and kurtosis that examines whether data series exhibit normal distribution or not; and this test was developed by Jarque and Bera (1980). The test statistic is expressed as:

$$\frac{N}{6} \left( S^2 + \frac{(K-3)^2}{4} \right) \sim \chi^2 \quad (3.1)$$

where  $S$ ,  $K$ , and  $N$  represent skewness, kurtosis, and the size of the macroeconomic variables respectively.

Under the null hypothesis of a normal distribution, Jarque-Bera statistic is  $\chi^2$  distributed with 2 degrees of freedom

### 3.2. The Stationary Test (Augmented Dickey Fuller Test)

Stationarity of the data series is among the key assumptions in financial time series. This assumption can be

checked using a unit root test- Augmented Dickey Fuller test (ADF) which uses a parametric autoregressive structure to capture serial correlation. If not stationary, data series should either undergo transformation or differencing by determining the order of integration (i.e. number of times they are to be differenced to achieve stationarity). The unit root test proposed by Dickey and Fuller (1979) is given by

Null hypothesis as  $H_0 : \phi_1 = 1$  and  
 Alternative hypothesis as  $H_1 : \phi_1 < 1$   
 Test Statistic (t-ratio):

$$= \frac{\phi_1^n - 1}{\text{std}(\phi_1)} = \frac{\sum_{t=1}^T P_{t-1} e_t}{\sigma^2 \sqrt{\sum_{t=1}^T P_{t-1}^2}} \quad (3.2)$$

where  $\phi_1 = \frac{\sum_{t=1}^T p_{t-1} p_t}{\sum_{t=1}^T p_{t-1}^2}$ ,  $\hat{\sigma}^2 = \frac{\sum_{t=1}^T (p_t - \hat{\phi}_1 p_{t-1})^2}{T-1}$ .

$p_t$  is present data series,  $p_{t-1}$  is previous data series,  $e_t$  is the error term at time  $t$ ,  $P_0 = 0$  and  $T$  is the sample size.

The null hypothesis is rejected if the  $t$  calculated value is greater than  $t$  critical value.

**3.3. Test for ARCH Effects (Heteroscedasticity)**

It is necessary to examine the residuals for evidence of heteroscedasticity before considering heteroscedastic models. To test for the presence of heteroscedasticity in the residuals of crude oil price and the macroeconomic variables, Lagrange multiplier (LM) proposed by Engle (1982) was used. The process is to obtain the residuals first from the ordinary least squares regression of the conditional mean equation which might be an autoregressive (AR) process, moving average (MA) process or a combination of AR and MA processes; (ARMA) process using EViews 7 software. If ARMA (1,1) process is considered, for instance, whose conditional mean equation is

$$r_t = \theta_1 r_{t-1} + \varepsilon_t + \theta_1 \varepsilon_{t-1} \quad (3.3)$$

Once the residuals  $\varepsilon_t$  are obtained, the next step is to regress the squared residual on a constant and its  $q$  lags as in the following equation:

$$\varepsilon_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \dots + \alpha_q \varepsilon_{t-q}^2 = \alpha_0 + \sum_{i=1}^q \alpha_i \varepsilon_{t-i}^2 \quad (3.4)$$

The ARCH model ( $q$ ) is

$$\sigma_t = \alpha_0 + \alpha_1 \varepsilon_{t-1} + \dots + \alpha_q \varepsilon_{t-q} + \varepsilon_t = \alpha_0 + \sum_{i=1}^q \alpha_i \varepsilon_{t-i} + \varepsilon_t \quad (3.5)$$

where  $\sigma_t$  is the unconditional variance,  $\alpha_0$  is the constant term,  $\alpha_i$  is the coefficient of the ARCH term,  $\varepsilon_{t-i}$  is the

corresponding lags of the errors at time  $t-1$ ,  $q$  is the length of ARCH lags and  $\varepsilon_t$  is the error term.

The hypothesis is

$H_0 : \alpha_1 = \dots = \alpha_q = 0$  (Absence of ARCH effect up to order  $q$ )

$H_a : \alpha_i \neq 0$  for some  $i \in \{1, \dots, q\}$  (At least one has presence of ARCH effect)

The number of observations times the R-squared ( $TR^2$ ) gives the test statistic for the joint significance of the  $q$ -lagged squared residuals with  $q$  degrees of freedom.  $TR^2$  is tested against  $\chi^2_{(q)}$  distribution. If  $TR^2 > \chi^2_{(q)}$  tabulated, we reject null hypothesis and conclude that there is an ARCH effect in the ARMA model.

**3.4. Generalize Autoregressive Conditional Heteroscedasticity Model (GARCH)**

GARCH ( $p, q$ ) is an extended framework of ARCH ( $q$ ) proposed by Bollerslev (1986) in which the  $p$  lags of past conditional variance were added into equation (3.5). GARCH ( $p, q$ ) model allows for both autoregressive and moving average components in the Heteroscedastic variance. The GARCH ( $p, q$ ) model is stated as:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^q \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^p \beta_j y_{t-j}^2 \quad (3.6)$$

where all the parameters  $\alpha_0, \alpha_i, \beta_j \geq 0$ ;  $\sigma_t^2$  is the conditional variance,  $\alpha_0$  is constant term,  $\alpha_i$  and  $\beta_j$  are coefficients of the ARCH and GARCH term respectively,  $\varepsilon_{t-i}^2$  and  $y_{t-j}^2$  are the squared errors at lag  $t-i$  and  $t-j$  respectively

The GARCH ( $p, q$ ) with  $z_t$  is a discrete time stochastic process defined as:

$\varepsilon_t = z_t \sigma_t$ , and is weakly stationary with

$$E(\varepsilon_t) = 0$$

and

$$\text{var}(\varepsilon_t) = \alpha_0 \left[ 1 - \left( \sum_{i=1}^p \alpha_i + \sum_{j=1}^q \beta_j \right) \right]^{-1}$$

$\text{cov}(\varepsilon_t, \varepsilon_s) = 0$  for  $t \neq s$ , if and only if  $\sum_{i=1}^p \alpha_i + \sum_{j=1}^q \beta_j < 1$ ,

( $\alpha_0 > 0$ )

**3.5. Goodness of Fits Criteria**

Akaike Information Criteria (AIC) and Schwarz Criteria (SIC) are the most commonly used model selection criteria (Vee *et al.*, 2009).

$$\text{AIC} = 2K - 2 \ln(\text{LL}) = 2K + \ln \left( \frac{\text{RSS}}{n} \right) \quad (3.7)$$

where  $k$  is the number of parameters in the model and  $L$  is the maximized value of the likelihood function for the model and  $RSS = \sum_{t=1}^n \epsilon^2$  is the residual sum of squares.

**3.6. Diagnostic Check of the Residuals**

When a model has been fitted to time series, it is appropriate to check the adequacy of fitted estimated ARCH-GARCH models by examining whether there is presence of autocorrelation in the residuals (that is, to say, if the model really does provide an adequate description of the study variables  $\sigma_t$ ). The Lagrange Multiplier of  $\sigma_t$  is used to check the adequacy of the mean equation and that of  $\sigma_t^2$  is used to test the validity of the volatility equation (Peter and Richard, 2002).

**3.7. Forecasting Evaluation**

Evaluating the performance of varied forecasting models is essential in selecting the best accurate models since fiscal and monetary authorities would need to make a decision on the evaluating criteria to base upon. To achieve this, the Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) were employed. The forecast error statistic is as follows:

$$MAE = \frac{1}{n} \sum_{t=1}^n |r_t^2 - \sigma_t^2| \tag{3.8}$$

$$RMSE = \sqrt{\frac{1}{n} \sum_{t=1}^n (r_t^2 - \sigma_t^2)^2} \tag{3.9}$$

where  $r_t^2$  is the realized or actual variance and  $\sigma_t^2$  is the square root of the conditional forecasted variance and  $n$  is the number of fitted parameters (Vee et al, 2009).

The MAE and RMSE hang on the scale of the dependent variable and the differences between volatility value and the forecasted values. The forecasted values of MAE and RMSE range from  $0 \rightarrow \infty$ . If the error statistic is small, the forecasting ability of that model is better in consideration of the measure.

**3.8. Variance Autoregressive (p)-Models with more than Two Variables**

Vector Autoregression (VAR) introduced by Sims (1980) provide a flexible and tractable framework where changes in a particular log transformed variable (LCOP) are related to changes in its own lags and to changes in macroeconomic variables (LEXRS, LGDP, LINFL, LINTR and LMSUP) and the lags of those variable. VAR model treats all variables as endogenous (Eltony, 1999).

A VAR (p)-Model is given as:

$$Y_t = \alpha + \sum_{i=1}^k A_i y_{t-i} + \epsilon_t \tag{3.10}$$

where  $Y_t = (LCOP, LEXRS, LGDP, LINFL, LINTR$  and

LMSUP) is a  $k$  vector of endogenous variables;  $\alpha$  is vector of constants,  $y_{t-1}$  are corresponding lag term for order  $i$ ;  $A_i$  is the  $n \times n$  matrix of coefficients to be estimated,  $k$  is the number of lagged terms and  $\epsilon_t$  is the  $n \times 1$  vector of innovations that may be contemporaneously correlated with each other but are uncorrelated with their own lagged values and all of the right-hand side variables (Akpan, 2009).

According to Sims (1980), the goal of the VAR analysis is to determine the interrelationship among variables in the system and not parameter estimates. Thus, the impulse response functions and variance decomposition tests which are the main strength of VAR model would be used to examine the interrelationships among the variables in the model.

**3.8.1. Impulse Response Function (IRF)**

Since the individual coefficients in the VAR models appeared hard to interpret, the Impulse Response Function is used as an important analysis in the VAR model which traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables in the VAR system (Sims 1983 and Eltony, 1999). Hence, the response of each macroeconomic variable to oil shocks is determined. The innovations  $\epsilon_t$  are usually correlated. For example, a two-variable VAR (1) model can be rewritten as

$$z_t = \sum_{i=0}^{\infty} \phi_i \epsilon_{t-i} \tag{3.11}$$

where

$$z_t = \begin{bmatrix} x_t \\ y_t \end{bmatrix}, \phi_i = \begin{bmatrix} \phi_{11}^{(i)} & \phi_{12}^{(i)} \\ \phi_{21}^{(i)} & \phi_{22}^{(i)} \end{bmatrix}, \epsilon_t = \begin{bmatrix} \epsilon_{1t} \\ \epsilon_{2t} \end{bmatrix}, \text{cov}(\epsilon_1 \epsilon_2) = 0$$

$z_t$  is a vector of (LCOP and LEXRS) endogenous variables,  $\phi_i$  are the matrices impulse response functions of the variables, vector  $\epsilon_t$  is called innovations and  $\epsilon_{t-1}$  is the corresponding lags of the matrices (Akpan, 2009).

**3.8.2. Variance Decomposition (VD)**

This indicates the amount of information each variable contributes to the other variables in a Vector Autoregression (VAR) models (Sims, 1986). It determines how much of the forecast error variance of each of the variable can be explained by exogenous shocks to the other variables.

Forecast error variance decomposition is obtained from the VAR (p) equation as

$$Y_t = A_1 y_{t-1} + A_2 y_{t-2} + \dots + A_p y_{t-p} + \epsilon_t \tag{3.12}$$

Restating it in an infinite moving average form as:

$$Z_t = \sum_{j=0}^{\infty} A_j u_{t-j}$$

The forecast error of predicting  $Z_{t+N}$  conditional on information at time  $t-1$  is given as:

$$\xi(N) = \sum_{\ell=0}^N A_{\ell} u_{t+N-\ell} \tag{3.13}$$

## 4. Results and Discussion

### 4.1. Descriptive Statistics

Table 4.1. Preliminary analysis of the variables.

	LCOP	LEXCHR	LEXRS	LGDP	LINFL	LINTR	LMSUP
Mean	1.638373	2.103145	4.188198	6.472774	1.762451	6.084931	6.141282
Median	1.658447	2.139233	4.259344	6.447593	1.783290	6.260163	6.134508
Std. Dev.	0.319582	0.103431	0.453583	0.379605	0.284525	0.767719	0.547123
Jarque-Bera	6.513325	8.360118	5.352015	5.886305	4.877512	1817.102	6.718879
Probability	0.038517	0.015298	0.068837	0.052699	0.087269	0.000000	0.034755

Table 4.1 showed that the mean of GDP is highest while crude COP oil has the least mean. The Jarque-Bera showed that EXRS, GDP and INFL are normally distributed as the p-values are greater than 1% and 5% level of significance, while COP, EXCHR, INTR and MSUP are not. L stands for log transformation of the variables.

### 4.2. Analysis of the Basic Test

The unit root is tested using Augmented Dickey and Fuller (1979) test in table 4.2 below. The results showed that crude oil price and all macroeconomic variables under study assumed stationarity at first levels.

Table 4.2. Unit Root Test.

Variables	t-statistics	Probability	Remark
LCOP	-6.6915	0.0000 I(1)	First differencing stationarity
LEXCHR	-6.9723	0.0000 I(1)	First differencing stationarity
LEXRS	-8.3759	0.0000 I(1)	First differencing stationarity
LGDP	-8.5353	0.0000 I(1)	First differencing stationarity
LINFL	-4.3117	0.0052 I(1)	First differencing stationarity
LINTR	-9.1602	0.0000 I(1)	First differencing stationarity
LMSUP	-8.2442	0.0000 I(1)	First differencing stationarity

1% level= -4.08; 5% level= -3.47; 10% level= -3.16

### 4.3. Testing for ARCH Effects (Heteroscedasticity)

The obtained residuals of crude oil shocks and the macroeconomic variables from the mean equation are tested for the presence of ARCH effect (heteroscedasticity) through

Table 4.4. Volatility models of Exchange rate.

	Models	Constant	p-values	$\theta_1$	p-values	$\theta_2$	P-values	$\theta_3$	p-values	$\theta_4$	P-values
		ARCH				GARCH					
D(LEXCHR)	GARCH(1,1)	0.0001	0.0000	1.0908	0.0000	-	-	-0.0676	0.1852	-	-
	GARCH(1,2)	8.94E-05	0.0083	0.7825	0.0000	-0.6936	0.0923	0.2033	0.1568	-0.0859	0.0001
	GARCH(2,1)	3.91E-05	0.3144	1.1325	0.0000	-0.3111	0.2750	0.5907	0.1315	-	-
	GARCH(2,2)	0.0001	0.2517	0.6135	0.0059	-	-	0.4821	0.3028	-0.0513	0.6866

### 4.5. Diagnostic Check

On fitting different heteroscedastic models, Lagrange

Beginning with the statistical properties to determine the normality of the study variables, the probability of the Jarque-Bera statistic tells whether the distribution is normal or not. Therefore if the probability is less than 0.05, we reject the null hypothesis and conclude that the distribution is not normal.

Lagrange Multiplier (LM) test proposed by Engle (1982). The F-Statistic and the P-values obtained are summarized in table 4.3.

Table 4.3. Heteroscedasticity test for residual series.

Variables	F-statistic	Probability
D(LCOP)	0.1040	0.7480
D(LEXCHR)	10.6941	0.0016
D(LEXRS)	0.3715	0.5440
D(LGDP)	2.4161	0.1245
D(LINFL)	0.3989	0.5296
D(LINTR)	1.7807	0.1860
D(LMSUP)	0.3651	0.5475

The results above show that only EXCHR is significant (that is, have the presence of heteroscedasticity) while the other six (6) variables are homoscedastic which implies that they did not fulfill the condition of GARCH or volatility estimation rather they fulfill the condition of VAR estimation.

### 4.4. Estimation of Volatility Models

Table 4.4 shows the parameter volatility of exchange rate which from the estimated parameters indicated that most of the coefficients models are significant at 5% level. The high values in the parameter  $\theta_1 > 1$  denotes that EXCHR volatility is spiky and quick to react to market movements; whereas low values in  $\theta_3 < 1$  parameter show that volatility of EXCHR is persistent and takes a short time to change.

Multiplier is used to diagnostically check if ARCH effect is still present in the heteroscedastic models of EXCHR, thus examining the reliability of the analytical results.

**Table 4.5.** Diagnostic checking of EXCHR.

VARIABLE	MODEL	F-statistic	P-value
D(LEXCHR)	GARCH(1,1)	0.1009	0.7516
	GARCH(1,2)	0.4810	0.4901
	GARCH(2,1)	0.1610	0.6893
	GARCH(2,2)	0.0259	0.8727

**Table 4.6.** Forecasting volatility of the models.

MODEL	RSME	MAE	
<b>D(LEXCHR)</b>	GARCH(1,1)	0.1828	0.1628
	GARCH(1,2)	0.1591	0.1413
	GARCH(2,1)	0.1363	0.1204
	GARCH(2,2)	0.1491	0.1322

The table above shows that the ARCH effects initially present in exchange rate was entirely removed by each of the heteroscedastic models considered. The F-statistic was very low for all of the models and the probability values were also greater than 0.05 significant levels for all models fitted. Hence, the initial heteroscedasticity present has been completely removed by each of the heteroscedastic models.

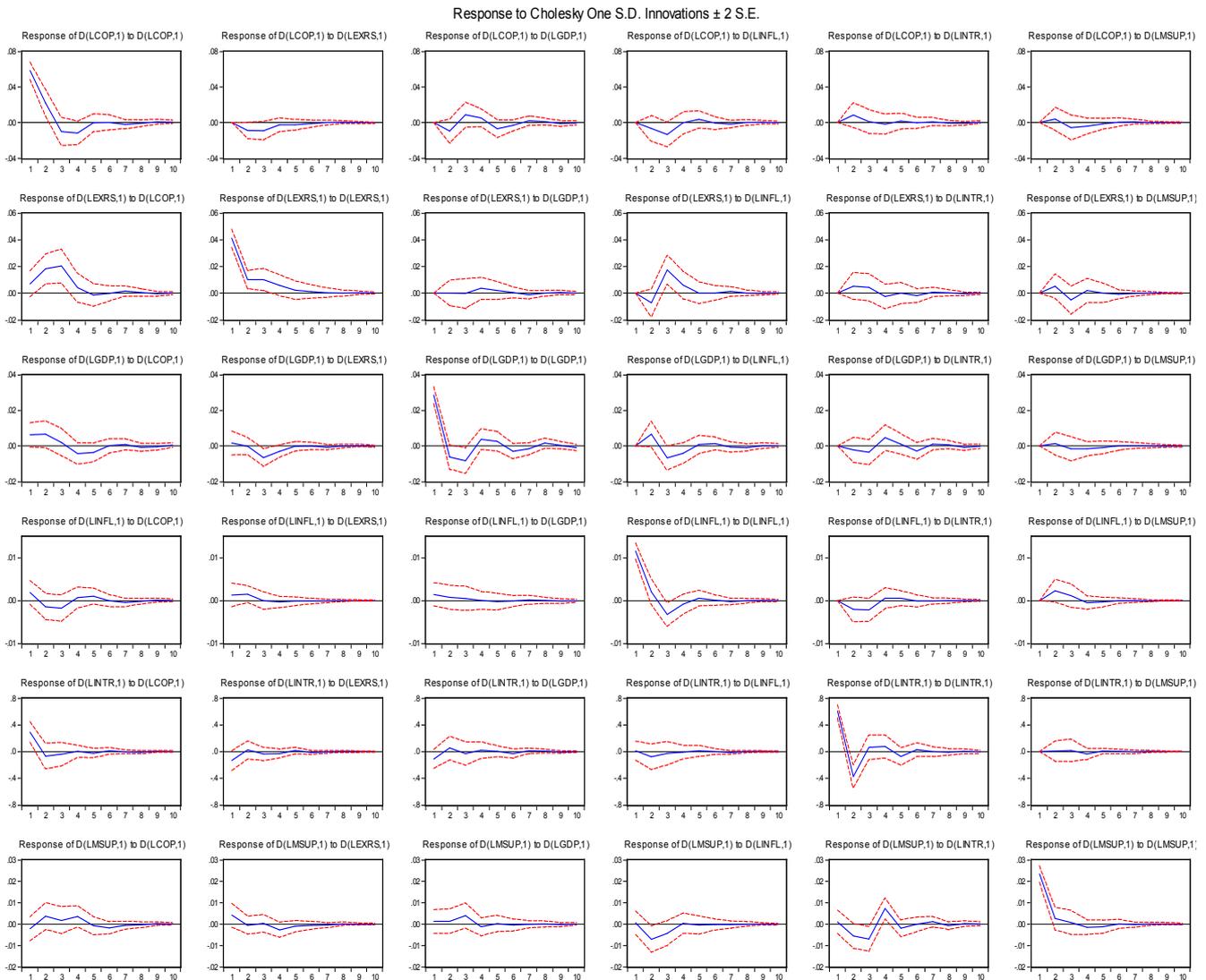
**4.6. Forecasting Volatility Models**

The performance of the fitted model in forecasting future volatility was determined through Root Mean Square Error (RMSE) and Mean Absolute Error (MAE) of different GARCH models for EXCHR as shown in table 4.6.

The table above shows that the RMSE and MAE with the lowest value is the appropriately fitted model for forecasting volatility of the variable. Hence, the forecasting model for EXCHR is GARCH (2, 1).

**4.7. Estimate of Impulse Response Function**

This shows the response of macroeconomic variables to Cholesky one standard-deviation innovation in itself and in other variables in the model over a time period of ten years and it also considered the use of multiple plots to see how the variables respond individually. The plots show the upper and lower boundary using positive and negative two standard errors.



**Figure 4.1.** Cumulative responses of the variables to each structural shock in Nigeria.

Assessment of figure 4.1 revealed generally that EXRS, GDP and MSUP increase in the first four quarters with the

exception of INFL and INTR to negative COP. However, in many cases, this increase has quickly shifted from decrease to stabilized phase over the successive quarters.

Basically, since the responses of macroeconomic variables to oil shocks is the sole interest of this study, a closer look at the first vertical cumulative plots showed that one standard deviation to negative crude oil changes caused a positive (increased) response in the first four quarters of EXRS, GDP and MSUP with consistent fluctuations that led to a momentary drop in EXRS, GDP increasing and MSUP at stability in the later quarters while INFL and INTR responded negatively as it decreases with steady variations leading to a stable increase in INFL and a momentary drop in INTR through the later quarters. This implies that while negative shock to crude oil price triggered steady increase in gross domestic product, money supply and inflation, there

was a temporary drop that occurred in external reserves and international trade in a short term that appeared stable as regards Nigerian economy.

#### 4.8. Estimation of Variance Decomposition

The study further examined the forecasting error variance decomposition to determine the proportion of the movements in the time series (macroeconomic variables) that are due to shocks in their own series as opposed to shocks in the other variable (crude oil price) since the impulse response functions basically analyze the qualitative responses of external reserves, gross domestic product, inflation, international trade and money supply in the system to shocks in crude oil prices. It reduces the uncertainty in one equation to the variance of error terms in all equations.

Table 4.7. Estimate of Variance Decomposition.

	D(lcop,1)	D(lexrs,1)	D(lgdp,1)	D(linfl,1)	D(lintr,1)	D(lmsup,1)
D(lexrs,1)						
1 qtr	24.88	97.12	0.00	0.00	0.00	0.00
4 qtr	24.85	59.26	0.43	12.08	1.61	1.76
7 qtr	24.81	59.05	0.59	12.06	1.72	1.77
10 qtr	24.81	59.03	0.60	12.05	1.73	1.77
D(lgdp,1)						
1 qtr	4.56	0.32	95.12	0.00	0.00	0.00
4 qtr	8.44	4.15	75.34	8.40	3.13	0.55
7 qtr	9.22	4.04	74.04	8.34	3.77	0.59
10 qtr	9.25	4.03	73.94	8.35	3.84	0.58
D(linfl,1)						
1 qtr	2.56	1.31	1.53	94.59	0.00	0.00
4 qtr	5.03	2.37	1.68	82.16	4.99	3.76
7 qtr	5.65	2.36	1.71	81.38	5.12	3.77
10 qtr	5.67	2.36	1.72	81.85	5.12	3.77
D(lintr,1)						
1 qtr	17.98	3.76	2.48	0.04	75.75	0.00
4 qtr	14.23	3.21	2.50	1.04	78.75	0.27
7 qtr	14.15	3.23	2.64	1.06	78.65	0.28
10 qtr	14.16	3.23	2.65	1.06	78.62	0.28
D(lmsup,1)						
1 qtr	0.84	2.90	0.28	0.06	0.18	95.74
4 qtr	4.08	2.90	2.45	8.15	15.91	66.53
7 qtr	4.50	3.05	2.43	8.06	16.28	65.68
10 qtr	4.51	3.05	2.44	8.05	16.34	65.60

Table 4.7 explains the percentages of the variations in EXRS, GDP, INFL, INTR and MSUP that are attributed to COP changes. The variance decomposition indicated that Nigerian crude oil export changes were a significant source of variation for Nigerian EXRS, GDP, INFL, INTR and MSUP.

#### 4.8.1. External Reserves

COP accounted the largest share of shocks as it contributed about 25% in the 1<sup>st</sup> Q and slightly dropped through the 10<sup>th</sup> Q. However, GDP made the least input averaging 1% through 10<sup>th</sup> Q. INFL shocks explained on average 12%; INTR and MSUP contributed less than 0.1% in the 1<sup>st</sup> Q and increased on an average of 2% through the 4<sup>th</sup> Q to the 10<sup>th</sup> Q. This confirms the evidence found by Samuel Imarhiagbe (2014) that oil exports significantly affects external reserves shocks.

#### 4.8.2. Gross Domestic Product

COP shocks explained changes in GDP from about 5% in the 1<sup>st</sup> Q to 9% sharp rise in the 10<sup>th</sup> Q; EXRS shocks explains less than 0.1% in the 1<sup>st</sup> Q with 4% growth in the 4<sup>th</sup> Q but dropped steadily; INFL and MSUP decreased from 4% through the 10<sup>th</sup> Q in varied proportions while INTR input slight percentage rise to GDP shocks. This contradicts expectations that oil price shocks tend to lower GDP (Gordon, 1998) implying that crude oil shocks do not significantly affect GDP (output) in Nigeria which is consistent with olomola (2006).

#### 4.8.3. Inflation Rate

The input of COP is from about 3% in the 1<sup>st</sup> Q rising to 5% in the 4<sup>th</sup> Q and consistently increasing to about 6% in the 10<sup>th</sup> Q. The effects of EXRS, GDP, INTR and MSUP

changes to inflation shocks increased from the 1<sup>st</sup> Q to the 10<sup>th</sup> Q at their respective level of percentages. This finding confirms that COP may not be necessarily inflationary contrary to the finding of Basky and Kilian (2002) but consistent with Akpan (2009).

#### 4.8.4. International Trade

Changes in COP shocks accounted for the biggest share of shocks to INTR by about 18% in the 1<sup>st</sup> Q declining to 14% in the 4<sup>th</sup> Q to the 10<sup>th</sup> Q. EXRS contributed about 4% in the 1<sup>st</sup> Q but marginally dropped to 3% in the 10<sup>th</sup> Q. However, MSUP made the least input and alongside GDP and INFL shocks, a percentage increase occurred from the 1<sup>st</sup> Q to the 10<sup>th</sup> Q respectively. This shows that the rate of INTR in Nigeria is affected by crude oil shocks due to the recent drop of crude oil export and imported resources.

#### 4.8.5. Money Supply

While changes in INTR contributed highly to domestic MSUP shocks, INTR alongside with COP, EXRS, and GDP increased gradually from the 4<sup>th</sup> Q to the 10<sup>th</sup> Q at their respective level of percentages. However, INFL did not contribute well in the 1<sup>st</sup> Q but sharply rise to 8% with little falls along the later Qs. This suggests that COP shocks affected money supply while INTR affected MSUP at long lags. This supports earlier studies that monetary policy responds to oil price shocks (Olomola, 2006 and Akpan, 2009)

## 5. Conclusion

The results demonstrated that presence of heteroscedasticity was found in only in exchange rate with most of its coefficient models being significant at 5% level and the forecasting model for exchange rate was GARCH (2, 1).

Additionally, negative crude oil changes caused a positive (increased) response in the first four quarters of external reserves, gross domestic product, and money supply with consistent fluctuations that led to a momentary decline in external reserves, gross domestic product increasing and money supply at a stable level from the 5<sup>th</sup> Q through the 10<sup>th</sup> quarter quarters while inflation and international trade responded negatively as it decreases with steady variations leading to a stable increase in inflation and a momentary drop in international trade through the later quarters. This implies that while negative shock to crude oil price triggered steady increase in gross domestic product, money supply and inflation, there was a temporary fall that occurred in external reserves and international trade in a short term that remained stable.

In determining the proportionality movement of the macroeconomic variables to oil shocks, it could be concluded that crude oil shocks might not be necessarily inflationary as it significantly affected external reserves and international trade due to the recent fall in the rate crude oil exported to US (highest demander of 40%) most especially because US now fully utilize shale oil and other alternative sources of

energy. Oil shocks also affected money supply, showing that monetary policy response oil changes. However, while oil shocks did not significantly affect output growth (GDP) in Nigeria, money supply did affect GDP.

## Recommendation

Hence, it is recommended that fiscal and monetary policy-makers should deploy institutional mechanisms to manage oil booms and bursts through expenditure restraint, self-insurance, and diversification of the real sector in order to minimize the impact of crude oil as the pillar of the economy and overcome the effect of persistent changes in crude oil prices which frequently culminate into macroeconomic instability. If these key macroeconomic variables are influenced by a volatile, almost unpredictable exogenous variable like crude oil prices, then the economy becomes highly vulnerable to unpredictable external shocks.

## Limitation of the Study

For crude oil price shock to be considered as an exogenous variable while placing all other variables constant might not necessarily be scrutinized. The *ceteris paribus* assumption is likely not fitting due to the inverse causality from macroeconomic variables to oil price shock in which the latter tends to respond to macroeconomic forces. Again, oil price shock is driven by structural demand and supply shocks and without knowing the nature of the shock hitting the economy might imply estimating the impact negative crude oil prices have on the economy.

## References

- [1] Agbade Moses O. (2013) "The Growth Implications of Oil Price Shocks in Nigeria." *Journal of Emergency Trends in Economics and Management*: Pg. 343-349.
- [2] Akpan E. O. (2009) "Oil Price Shocks and Nigeria's Macroeconomy". A Paper Presented at the *Annual Conference of CSAE Conference, Economic Development in Africa*, Oxford.
- [3] Barsky R. B. and Kilian L. (2002) "Oil and the Macroeconomy Since the 1970s". *NBER Working Paper 10855*. Retrieved from <http://www.nber.org/papers/w10855>
- [4] Bernard Okumagba (2014) "Falling Crude Oil Prices and Nigeria's Response". The Guardian Newspaper December 29, 2014.
- [5] Bollerslev, T. (1986) "Generalized autoregressive conditional heteroscedasticity". *Journal of Econometrics*, 31 (3), 307-327.
- [6] Central Bank of Nigeria (2014), <http://www.statistics.cbn.gov.ng/statsonline> [retrieved November 16th, 2014].
- [7] El-Anshasy A, Michael D. Bradley, and Fred Joutzi (2005) "Evidence on the Role of Oil Prices in Venezuela's Economic Performance: 1950-2001". *Working Paper, University of Washington*

- [8] Eltony Nagy M. (1999) "Oil Price fluctuations and their Impact on the Macroeconomic Variables of Kuwait: A Case Study Using VAR Model for Kuwait" No. 6, 14.
- [9] Engle R. F. (1982) "Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of UK Inflation". *Econometrica*, Vol. 50, No. 4, PP. 987-1008.
- [10] Gordon Robert J. (1998) "Supply Shocks and Monetary Policy Revisited". *American Economic Review*. May, 74(2): 38-43.
- [11] Leykun Getaneh (2012) "Forecasting of Petroleum Oil Import Prices by Garch Models: The Case of Ethiopia". Pg 1-10
- [12] Majidi M. (2006) "Impact of Oil on International Economy, International Economics Course, Centre for Science and Innovation Studies.
- [13] Mehrara M. and Mohaghegh M. (2011) "Macroeconomic Dynamics in Oil-Exporting Countries: VAR Study". *International Journal of Business and Social Science*, 2(21).
- [14] Mulyadi Muhammed I.A. (2012) "Oil Price, GDP, Inflation and Exchange Rate: Evidence from Indonesia as a Net Oil Exporter Country and a Net Oil Importer Country". *International Institute of Social Studies*. Pg 9-23.
- [15] Obinna C. (2014) "Oil Price Fluctuations and the Nigerian Economy". 05 Nov 2014 *OPEC Review* 199-217
- [16] Ogundipe A.A and Ogundipe O.M. (2013) "Oil Price and Exchange Rate Volatility in Nigeria". *MPRA Working Paper*
- [17] Olomola and Adejumo (2006) "Oil Price Shock and Macroeconomic Activities in Nigeria". *International Research Journal of Finance and Economics*. Issue 3 (2006).
- [18] Oyetunji Busayo (2013) "Oil Price and Exchange Rate Volatility in Nigeria". Pg 5-32
- [19] Peter J. B. and Richard A. D. (2002) "Introduction to Time Series and Forecasting." *Springer Journal*. 2nd ed. Pg 164 & 167
- [20] Samuel Imarhiagbe (2014) "Examining the Impact of Crude Oil Price on External Reserves: Evidence from Nigeria". *International Journal of Economics and Finance*; Vol. 7, No. 5.
- [21] Sims Christopher A. (1986) "Are Forecasting Models Usable for Policy Analysis?" *Reserve Bank of Minneapolis Quarterly Review, Winter*: 2-16.
- [22] Sims, C. (1980) "Macroeconomics and reality". *Econometrica*, Vol. 48, 1-48.
- [23] Tatyana Gileva (2010) "Econometrics of Crude Oil Markets". Pg 3-5
- [24] Vee D; Gonpot P and Sookia N. (2011) "Forecasting Volatility of USD/MUR Exchange Rate using GARCH (1,1) model with GED and Student's-t errors" *University Of Mauritius Research Journal – Volume 17– 2011*
- [25] Wakeford J. (2006) "Impact of Oil Price Shocks on the South African Macroeconomy: History and Prospects in Accelerated and Shared Growth in South Africa: Determinants, Constraints and Opportunities.