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This study provides analytical insight on modelling macroeconomic and oil price volatility in Nigeria. Mainly, the paper employed GARCH model and its variants (GARCH-M, EGARCH and TGARCH) with daily, monthly and quarterly data. The findings reveal that: all the macroeconomic variables considered (real gross domestic product, interest rate, exchange rate and oil price) are highly volatile; the asymmetric models (TGARCH and EGARCH) outperform the symmetric models (GARCH (1 1) and GARCH – M); and oil price is a major source of macroeconomic volatility in Nigeria. By implication, the Nigerian economy is vulnerable to both internal shocks (interest rate volatility, real GDP volatility) and external shocks (exchange rate volatility and oil price volatility). Therefore, it is concluded that more credence should be given to asymmetric models in dealing with macroeconomic volatility in Nigeria and oil price volatility should be considered as relevant variable in the analysis of macroeconomic fluctuations in Nigeria. The study recommends that, the Nigerian economy should be diversified by revamping other sectors such as the agricultural sector and the industrial sector in order to reduce the impact of oil price uncertainty on macroeconomic volatility.

Key words: Volatility, Oil Price, Real GDP, Exchange Rate, Interest Rate, GARCH Models

JEL classification: C22, C58, E43

1.0 Introduction

The provision of plausible explanation for the oil price-macroeconomic relationship has occupied the attention of researchers and policymakers over the last four decades. The attention was drawn by the central role which oil plays in the world economy and the observed linkage between oil price movement and business cycle.

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Oil plays a dominant role in Nigerian economy given its huge contribution to the revenue of the country. For instance, CBN statistical bulletin (2011) shows that oil receipts accounted for 82.1%, 83% and about 90 per cent of the nation's foreign exchange earnings in 1974, 2008 and 2010 respectively. Similarly, the value of Nigeria's total export revenue in 2010 was US$70,579 million and the revenue of petroleum exports from the total export revenue was US$61,804 million which is 87.6% of total export revenue.

However, it is empirically established that oil price is one of the most volatile prices which has significant impact on macroeconomic behavior of many developed and developing economies (Ferderer, 1996; Guo & Kliesen, 2005). Further, Mork, Olsen and Mysen (1994) Hooker (1999), Guo and Kliesen, (2005), Narayan and Narayan (2007), Mehrara (2008), Salisu and Fasanya (2013) found volatility clustering and confirm the existence of asymmetries in oil price volatility.

Therefore, the dependence of the Nigerian economy on oil proceeds as the major source of revenue is capable of raising suspicion about the impact of oil price volatility on macroeconomic volatility in the country. Macroeconomic volatility implies the vulnerability of macroeconomic variables to shocks. It is the tendency of macroeconomic variables such GDP, inflation, exchange rate, interest rate etc to be unstable and weak in terms of withstanding shock. It is a situation whereby little shock in the economy subjects the macroeconomic variables to fluctuations and uncertainty. In the light of this, many studies investigated the impact of oil price changes on macroeconomic variables in Nigeria. The consensus finding is that while oil price changes have direct significant relationship with many macroeconomic variables, it does not significantly affect output growth (Adeniyi, 2011; Omojolaibi, 2013; Olowe, 2009;Wilson, David, Inyiama & Beatrice, 2014; Taiwo, Abayomi & Damilare, 2012; Apere & Ijiomah, 2013).

But,majority of the previous studies focused on the impact of oil price level changes on macroeconomic variables. They failed to investigate the impact of oil price volatility on the volatility of macroeconomic variables and thus volatility models were not aptly employed in their analysis.So, there is the need for the evaluation of the impact of oil price volatility on macroeconomic volatility using appropriate models.Also, none of these studies employed the use of daily data and few of them (Olowe, 2009 Wilson, David, Inyiama & Beatrice, 2014) employed the ARCH and GARCH models without evaluation. Hence, despite the plethora of studies on oil price-macroeconomy relationship, little or nothing has been done to answer the following questions: 1. which volatility model is most appropriate for modelling macroeconomic volatility in Nigeria and 2. What is the impact of the oil price volatility on macroeconomic variables in Nigeria?

In an attempt to answer the aforementioned questions, the objectives of the study are; to examine the volatility of selected major macroeconomic variables (Real GDP, exchange rate and interest rate) and investigate the impact of oil price shocks on the volatility of the selected macroeconomic variables in Nigeria.

The remaining part of the paper is organized as follows: Section 2 reviews relevant literatures, Section 3 outlines the methodology, Section 4 deals with the preliminary data analysis, Section 5 contains the presentation and discussion of empirical results, while Section 6 covers conclusion and policy implications.

2.0 Literature Review

Literature examining the impact of oil price changes and macroeconomic volatility continue to gain prominence since 1970s. Hamilton (1983) observed negative relationship between oil price increase and output growth for the period 1948-1972 and state that the correlation between oil price and evolution of economic output was not a mere historical coincidence. Gisser and Goodwin (1986) and Mork (1989), examining the trend of oil price macroeconomy relationship with the inception of Organization of Petroleum Exporting Countries (OPEC) and extending the period to 1988 in order to include the 1986 oil price decline respectively, confirmed Hamilton's findings. Hooker (1996) explored the robustness of oil price-macroeconomy relationship using granger causality test and Vector Autoregressive (VAR) system with structural stability. The result indicates a break down in the relationship and market collapse. He attributed the break down to misspecification of model rather than weaken relationship.

Mork (1989) decomposed oil price changes in real price increases and decreases for the examination of asymmetric response to oil price changes.

The analysis showed asymmetric effect. Asymmetric effect implies that oil price increase has a clearly different effect from the effect of oil price decline. Mork, Olsen and Mysen (1994) confirmed the asymmetric effect for the OECD countries. Lee, Shwan and Ratti (1995) also revealed that asymmetric effect is stable in the period before and after 1985 regardless of its dependence on other variables.
Similarly, Narayan and Narayan (2007) modelled the volatility of daily oil prices using Exponential Generalized Autoregressive Conditional Heteroscedasticity (EGARCH) model. They revealed that asymmetric effects are evident, persistent, and permanent in the oil price series.

In a trend analysis of crude oil volatility, the Institute for 21st century Energy (2012) showed the evidence that stable energy prices (including crude oil) would boost GDP growth and the economy would perform better in such situation. Hence, volatile energy price poses a significance jolt to the economy.

To examine the importance of thresholds on the relationship between oil price shock and economic growth in Nigeria, Adeniyi (2011) applying Multivariate Threshold Autoregressive Model (MTAM) established that oil price shock do not significantly affect movement of macroeconomic aggregates in Nigeria. Olowe (2009) investigated weekly oil price volatility of all countries average spot price using EGARCH (1, 1) over the period January 3, 1997 to March 6, 2009. He found that the oil Price return series show high persistence of volatility, volatility clustering and asymmetric properties.

Ferderer (1996) focused on counter-inflationary monetary policy, sectorial shocks and uncertainty to explain the asymmetric mechanism between oil price changes and economic activity. The analysis shows that oil price increase helps to predict output growth irrespective of monetary policy variables. Also, asymmetric monetary policy responses of oil price decrease can only explain part of the oil price-output relationship but there is significant relationship between oil price and counter-inflationary policy responses.

Guo and Kliesen (2005) investigated the impact of oil price volatility on macroeconomic activity in U.S. Using Granger Causality Test, they found a significant negative impact of oil price volatility on GDP growth over the period 1984 to 2004. Moreover, the study indicates asymmetric effect of oil price volatility on macroeconomic activities.

Examining macroeconomic dynamics in oil exporting countries with the use of Panel VAR, Mohaghegh and Mehrara (2011) established that oil shocks are not necessarily inflationary. Further, domestic policies, instead of oil boom causes inflation and money is the main cause of macroeconomic fluctuations.

Recently, Ebrahim, Inderwidi and King (2014) embarked on theoretical investigation of macroeconomic impact of oil price volatility. The result showed that oil price volatility constitutes a fundamental barrier to economic growth due to its damaging and destabilizing effect on macroeconomy. Precisely, they show that oil price volatility adversely affect aggregate consumption, investment, industrial production, unemployment and inflation particularly in non-OECD countries.

Wilson, David, inyiama and Beatrice (2012) examined the relationship between oil price volatility and economic development in Nigeria. Applying Ordinary Least Square and Granger Causality Test, the study shows that there is no significant relationship between oil price volatility and key macroeconomic variables (Real GDP, inflation, interest rate and exchange rate).

Contrarily, the study of oil price shocks and volatility of selected macroeconomic indicators in Nigeria carried out by Taiwo, Abayomi and Damilare (2012) using Johasen Cointegration Test and Error Correction Model indicated that crude oil price, stock price and exchange rate have significant influence on the growth of the Nigerian economy. Oriakhi and Osaze (2013) examined the consequences of oil price volatility on the growth of the Nigeria economy within the period 1970 to 2010. With the use of VAR model, the study find that oil price volatility has direct impact on government expenditure, real exchange rate, and real import while real GDP and inflation are indirectly influenced by the oil price volatility. By implication the study shows that changes in oil price determine government expenditure which in turn determines the growth of the Nigerian economy.

Similarly, using monthly data, Apere and Ijomah (2013) indicated unidirectional relationship between interest rate, exchange rate and oil price with direction from oil prices. Also, oil price has no significant impact on real

GDP. They arrived at this conclusion with the use of EGARCH model, Impulse Response Function and Lag-Augmented VAR for the investigation of the macroeconomic impact of oil price levels and volatility in Nigeria during the period 1970-2009.

Over the years, several studies have applied GARCH type models to examine volatility in exchange rates. Elijah and Festus (2008) for example explored the impact of exchange rate volatility on private investment and confirms an adverse effect. Mordi (2006) employing GARCH model argued that failure to properly manage exchange rates can induce distortions in consumption and production patterns and that excessive currency volatility creates risks with destabilizing effects on the economy.. Elijah and Festus (2008) examine the effect of exchange rate volatility and inflation uncertainty on foreign direct investment in Nigeria from 1970 to 2005. Adopting GARCH model, the study shows that exchange rate volatility and inflation uncertainty negatively affect foreign direct investment during the period.

Similarly, Azeez, Kolapo, and Ajayi (2012) examined the effect of exchange rate volatility on macroeconomic performance in Nigeria from 1980 to 2010 employing OLS and co-integration techniques. The findings of the study revealed that oil revenue and exchange rate are positively related to GDP while balance of payment is negatively related to GDP. Also, oil revenue and Balance of Payment exert negative effect while exchange rate volatility has positive effect on the economy.

Despite the identified importance of oil price on the macroeconomic activities, no study has incorporated oil price volatility in the modelling of macroeconomic volatility in Nigeria. Also, interest rate volatility is ignored in the modelling of volatility in Nigeria while few studies on exchange rate volatility use monthly data instead of daily data used in this paper. Likewise, the evaluation of volatility models (ARCH and GARCH models) in the examination of the volatility of GDP growth rate has not received the required attention from researchers. This paper therefore, fills the research gap by modelling the volatility of major macroeconomic variables (Real GDP, exchange rate and interest rate) incorporating the effect of oil price volatility with the use of ARCH and GARCH models with the use of high frequency data(particularly for exchange rate).

3.0 Methodology

This paper uses three steps estimation procedure for volatility modeling.

a. Testing for ARCH effects: Is the series in question volatile?
b. Estimation with ARCH-type Models: This is considered only if the series (real GDP, exchange rate, interest rate and oil price) are volatile.
c. Post Estimation test: This is carried out to verify if the estimated ARCH-type model has captured the ARCH effects in the series. It involves testing for ARCH effects after estimation.

3.1 Testing for ARCH (1) effects

The test, following the procedure of ARCH LM test proposed by Engle (1982), begins with estimation of AR model as specified in equation (1) below;

$$R_t = \alpha + \delta_1 R_{t-1} + \varepsilon_t;\ \varepsilon_t \sim IID(0, \sigma^2) \quad (1)$$

where R is the rate of return of the series.

Estimated residual is obtained from equation (1), then the squared of estimated residual is regressed on its lag as follows:

$$\hat{\varepsilon}^2{}_t = \gamma_0 + \gamma_1 \hat{\varepsilon}^2{}_{t-1} + v_t \quad (2)$$

Ho: $\gamma_1 = 0$, while H_1: $\gamma_1 \neq 0$

The test statistics for the null hypothesis are F-test and nR^2 tests.

The null hypothesis of no ARCH effects is rejected if the probability values (p-values) of these tests are less than any of the conventional levels of statistical significance (10%, 5%, and 1%). The rejection of H_o implies presence of ARCH effect in the series. Thus, if ARCH effects are present, the estimated parameters should be significantly different from zero (the series are volatile). However, if ARCH effects are not present, then, the estimated parameters should be statistically insignificant (the series are not volatile).

3.2 Estimation with ARCH-type Models

The first ARCH model was presented by Engle (1982). The model suggests that the variance of the residuals at time *t* depends on the square of error terms from past periods hence the variance is not constant. Engle simply suggested that it is better to simultaneously model the mean and the variance of a series when we suspect that the conditional variance is not constant. Generally, the mean and variance equations of ARCH (p) are specified as;

$$R_t = \alpha + \sum_{i=1}^{\rho} \varphi_i R_{t-i} + \varepsilon_t \quad (3)$$

$$\sigma_t^2 = \lambda_0 + \sum_{i=1}^{\rho} \lambda_i \, \varepsilon_{t-i}^2 \quad (4)$$

Where ε_{t-i}^2 is an ARCH term, $0 \le \sum_{i=1}^{\rho} \lambda_i < 1$ for a stationary series and as $\sum_{i=1}^{\rho} \lambda_i \rightarrow 1$ it means the series exhibit slow mean reverting, while as $\sum_{i=1}^{\rho} \lambda_i \rightarrow 0$ means fast mean reverting.

The null hypothesis for the ARCH (p) is given as $\lambda_1 = \lambda_2 = \ldots \lambda_\rho = o$ and it is tested using either F-test or nR^2 that follows chi-square distribution proposed by Engle (1982). If the null hypothesis (no ARCH effect) is rejected then there is ARCH effect in the model otherwise there is no ARCH effect.

One of the drawbacks of the ARCH specification, according to Engle (1995), was that it looked more like a moving average specification than an Auto-regression. Therefore, consider in the modelling of macroeconomic volatility is the Generalised Autoregressive Conditional Heteroskedasticity (GARCH) model developed by Bollerslev (1986). This is an extension of the ARCH model which incorporates the lags of the conditional variance in the variance equation. On the basis of the extension, the mean equation remains the same as equation (3) and the variance equation is given as;

$$\sigma^2{}_t = \lambda_0 + \sum_{i=1}^{\rho} \lambda_i \, \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \gamma_j \, \sigma^2{}_{t-j} \quad (5)$$

For stationary series $0 \le \sum_{i=1}^{\rho} \lambda_i + \sum_{j=1}^{q} \gamma_j < 1$, the mean reverting process in the case of GARCH model is as $\sum_{i=1}^{\rho} \lambda_i + \sum_{j=1}^{q} \gamma_j \rightarrow 1$ then the model exhibits slow mean reverting, while as $\sum_{i=1}^{\rho} \lambda_i + \sum_{j=1}^{q} \gamma_j \rightarrow 0$ the model has

fast mean reverting. $p \geq 0, q > 0,\ \lambda_0 > 0, \lambda_i \geq 0, j = 1 \dots q, i = 1 \dots \rho$ Thus it is clear that for q = 0, the model reduces to ARCH (p).
Also considered in this study is the GARCH-in-Mean (GARCH-M) model which allows the conditional mean to depend on its own conditional variance. Therefore, the GARCH-M model has the following form:

$$R_t = \alpha + \sum_{i=1}^{\rho} \varphi_i R_{t-i} + \varepsilon_t + \theta {\sigma^2}_t \tag{6}$$

The null and alternative hypothesis for the GARCH-M (1 1) are $H_0: \theta = 0$, $H_1: \theta \neq 0$. When the null hypothesis (H_0) is rejected, then, the GARCH-M term is statistically significant and the model provides useful information for the volatility (i.e. it improves the estimates of the GARCH model).

A major restriction of the ARCH and GARCH specifications above is the fact that they are symmetric. To capture leverage effect, asymmetric volatility models were considered. First is the Threshold GARCH (TGARCH) introduced by Zakoian (1994), which captures asymmetries by including in the variance equation, a multiplicative dummy variable to check whether or not there is statistically significant difference when shocks are negative. The specification for the conditional variance equations is given as:

$${\sigma^2}_t = \lambda_0 + \sum_{i=1}^{\rho} \lambda_i\, \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \gamma_j\, {\sigma^2}_{t-j} + \phi \varepsilon_{t-1}^2 d_{t-1} \tag{7}$$

Where the dummy variable $d_{t-1} = \begin{cases} 1\ if\, \varepsilon_{i-1} < 0 \\ 0\ if\, \varepsilon_{i-1} \geq 0 \end{cases}$

Also considered for estimation in this study is the Exponential GARCH (EGARCH) model developed by Nelson (1991). The model captures asymmetric effects or leverage effects not accounted for in the ARCH and GARCH models.

$$\ln({\sigma^2}_t) = \lambda_0 + \lambda_1 \left| \sqrt{\varepsilon_{t-1}^2 / {\sigma^2}_{t-1}} \right| + \emptyset \sqrt{\varepsilon_{t-1}^2 / {\sigma^2}_{t-1}} + \theta \ln(\sigma_{t-1}^2) \tag{8}$$

If the asymmetric effect is present $\emptyset < (>)0$ implying that negative (positive) shocks increase volatility more than positive (negative) shocks of the same magnitude while if $\emptyset = 0$, there is no asymmetric effect. The Schwartz Information Criterion (SIC) as given below is used for the choice of best model. $SIC(g) = \log(\grave{\varepsilon}\grave{\varepsilon}/n) + g \log n/n$.The Schwartz information criterion is preferred because it levies the heaviest penalty on the model for the loss of degree of freedom. To evaluate the impact of oil price volatility on the volatility of macroeconomic variables (real GDP, interest rate and exchange rate), oil price volatility is included as explanatory variable in the variance equation for estimation of the different plausible models specified above.

3.3 Nature and Sources of Data

The study uses daily exchange rates (Naira/US dollar), monthly interest rate, quarterly real GDP as well as different frequencies (daily, monthly and quarterly) of oil prices (Brent). The quarterly oil price is generated from monthly oil price using appropriate conversion procedure. The different frequencies were used to conform to the frequency of the data on each of the macroeconomic variables (real GDP, exchange rates and interest rate). Daily crude oil prices(1/2/1986 – 11/3/2014 period averages), daily exchange rate(10/12/2001 - 6//2/2010), monthly interest rate(Jan-2005-Sep-2014) and Real GDP(1950q1-2010q4) data utilized in this study are collected from British Petroleum Review and Central Bank of Nigerian Statistical Bulletin 2013 and Pen World Table 8, respectively.

The rate of return or growth rate of the variables is computed using the continuous compounded growth rate formula which is given as

$$\boldsymbol{GRGDP = log\left(\frac{RGDP_t}{RGDP_{t-1}}\right)},$$

$$\boldsymbol{GEXRATE = log\left(\frac{GEXRATE_t}{GEXRATE_{t-1}}\right)}, \text{ and}$$

$$\boldsymbol{GOPRICE = log\left(\frac{GOPRICE_t}{GOPRICE_{t-1}}\right)}.$$

While the discretely compounded growth rate formula is used to compute the return on interest rate which is given as

$$\textbf{GINTRATE}_t = \frac{INTRATE_t - INTRATE_{t-1}}{INTRATE_{t-1}}$$

where; GRGDP, GEXRATE, GOPRICE and GINTERATE represent the returns on real GDP, exchange rate, crude oil price, and interest rate respectively.

Table 1: Definition of variables

Variables	Meaning
RGDP	Real Gross Domestic Product
GRGDP	Growth rate of GDP
EXRATE	Exchange rate
GEXRATE	Returns on exchange rate
INTRATE	Interest rate
GINTRATE	Return on interest rate
OPRICE	Crude Oil price in dollars
GOPRICE	Return on oil price

Source; Author's computation

3.0 Preliminary Data Analysis

The Preliminary analysis was carried out in two-folds; the first provides trend and descriptive statistics for all the variables and their returns. The second fold involves the ARCH-LM test for all the return series using equation (1).

Table 2A: Descriptive statistics

STATISTICS	EXRATE	GEXRATE	GRGDP	RGDP	GINTRATE	INTRATE	OPRICE	GOPRICE
Mean	138.16	0.01	0	1374.91	0	21.56	42.52	0.02
Median	132.39	0	0	1287.13	0	22.03	26.27	0.06
Maximum	1376.8	230.9	0.17	2188.91	0.12	26.07	145.31	19.15
Minimum	66.09	-231.02	-0.21	980.15	-0.11	17.17	10.25	-40.64
Std. Dev.	26.22	6.13	0.03	269.67	0.03	2.63	31.15	2.51
Skewness	33.38	-0.03	-0.63	0.82	0.72	-0.01	0.99	-0.77
Kurtosis	1578.99	1285.79	15.67	2.89	9.24	1.61	2.58	18.22
Jarque-Bera	3.27E+08	216E+6.	1640.14	27.15	198.1	9.48	1235.03	1235.03
Probability	0	0	0	0	0	0.01	0	0
Sum	436157.2	32.37	0.69	335477.88	0.25	2522.51	309370.4	112.55
Sum Sq. Dev.	2169517	118542.1	0.24	17671693	0.09	802.12	7059121	7059121
Observations	3157	3156	243	244	116	117	7276	7275

Source: Author's computation.

Table 2A shows the descriptive statistics for all the variables and their return series covering different sample periods. The large margins between the minimum and maximum values of all the series indicate evidence of significant variations of the trend of the series over the scope covered. Regarding the statistical distribution of the series, exchange rate, oil prices, Real GDP and growth rate of interest rate show evidence of positive skewness implying that the right tail is extreme while the return series of all the variables except return series of interest rate indicate negative skewness denoting extreme left tail. In relation to kurtosis, all the return series and exchange rate are leptokurtic (i.e. evidence of fatter tail than the normal distribution) while all other series are platykurtic (i.e. evidence of thinner tail than the normal distribution). This is buttressed by the Jaque Bera test which shows that all the series are not normally distributed. Therefore, the alternative inferential statistics such as student-t test, generalized error distribution (GED), student-t distribution with fixed degree of freedom and , generalized error distribution (GED) with fixed degree of freedom (all incorporated in the ARCH and GARCH models and the model selection criteria) become appropriate in this case.

4.1 Trend Analysis

Figure 1: Trends in Nigerian real GDP and its growth rate (1950Q1-2010Q4)

Figure 1 illustrates the dynamics of real GDP and its returns. The behavior of the real GDP and its return follow an unsteady pattern and the returns of real GDP suggest evidence of volatility clustering. That is, periods of high volatility are followed by periods of relatively low volatility.

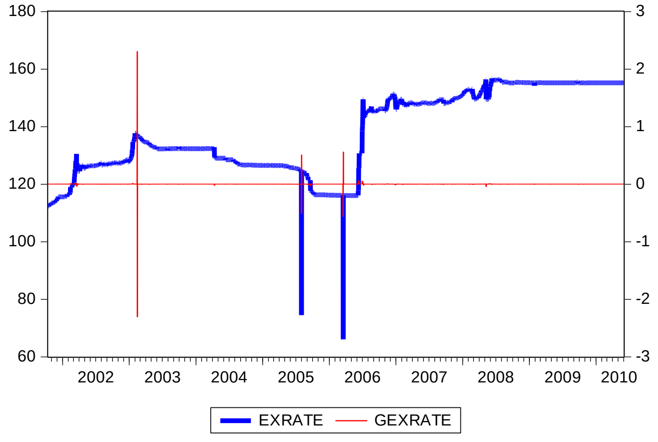

Figure 2: Trends in Nigerian daily exchange rate and its returns (10/12/2001 6/2/2010)

Figure 2 depicts the trend of exchange rate and its return, the notable spikes in the returns of exchange rate indicates evidence of volatility. The exchange rate relatively increased up to about N136/US$ some times in 2003 and it hovered around 125 and 135 before it declines to 75 and 66 in 2005 and 2006 respectively in December, 2006 the exchange rate increased to 150 after which if floated around 145 to 160 throughout the rest of the sample period. This shows that exchange rate in Nigeria witness unprecedented movements over the sample period.

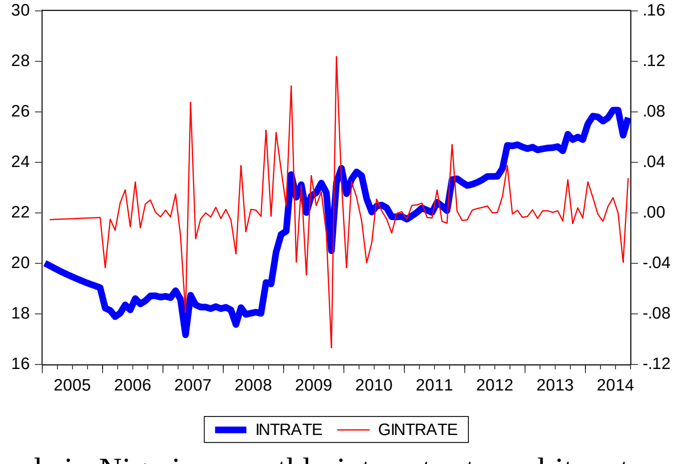

Figure 3: Trends in Nigerian monthly interest rate and its returns (01-2005 to 09-2014)

Similarly, figure 3 shows a combined graph for interest rate and its returns with clear evidence of volatilityin the return series. The trend of the interest rate has been unsteady over the year.

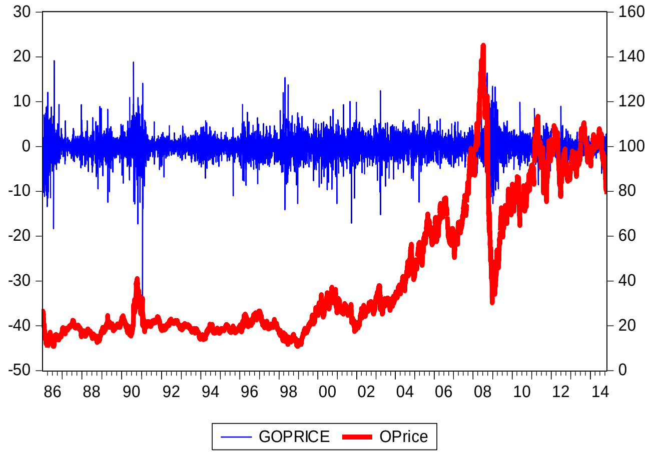

Figure 4: Trends in daily oil price and its returns (1/2/1986 – 11/3/2014)

Clear evidence of volatility clustering indicated in the return series of oil price is shown in figure 4 and the oil price experiences sharp increases mostly followed by sharp declines. This indicates that oil price has not been stable over the years.

4.2 Test for ARCH effect

The result of the ARCH test following the procedure of ARCH LM test proposed by Engle (1982), earlier specified in equation (1) is shown in table 3 below

Table 2B: Result of ARCH (1) test.

TEST	GOPRICE	GEXRATE	GINTRATE	GRGDP
F-test	84.44067***	265.5613***	293.0313***	47.00518***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
nR^2	83.49425***	245.0753***	82.47651***	39.60854***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]

Source: Author’s computation. Note: *** and [] indicates 1%, level of significance P-value respectively.

Both the F-test and the nR^2 test in table 2B indicate the existence of ARCH effect in the growth rate of all the variables at 1% level of significance for the first order autoregressive process. The test for higher order lags is ignored in this paper because the lag one test is sufficient for the estimation of volatility models considered in the paper.

4.0 Estimation and Interpretation of Results

Given the evidence of ARCH effects in all the return series of all the variables, this paper begins the modelling with the estimation of the GARCH (p,q) equation followed by the various extensions specified in section 3 above. The ARCH(q) is not estimated on the theoretical basis that GARCH (p,q) model with lower values of p and q gives a better fit than ARCH(q) model with higher values of q.

Table 3 illustrates the estimates of GARCH (1,1) and GARCH-M(1,1) for real GDP volatility with the effect of oil price. The result reveals that the ARCH coefficients are statistically significant confirming the presence of the ARCH effects. Further, the results of GARCH (1,1) and GARCH-M(1,1) relates that the volatility of real GDP in Nigeria is mean reverting (i.e. the sum of their ARCH and GARCH coefficients is less than one) while the asymmetric GARCH Models(TGARCH and EGARCH) shows contrary results that the variance of the series is not mean reverting (i.e. the sum of their ARCH and GARCH coefficients is more than one).While the later implies that the effects of shocks on the volatility of real GDP is permanent the former holds the revelation that ARCH effects are only temporarily.

The coefficient of the oil price volatility (GOPRICE) is significant in all the models. This portrays the importance of oil price volatility on real GDP volatility in Nigeria. Equally, coefficient of threshold asymmetric term (-0.202938) is statistically significant meaning that negative shocks reduces the volatility of real GDP more than positive shocks. Comparing the models with the use of the SIC, TGARCH is the best model (gives the smallest SIC value (-4.943778) for real GDP volatility in Nigeria when the effect of oil price volatility is considered. Equally, the SIC values for all the models with oil price volatility is less those of the models without oil price. This means the inclusion of oil price volatility improves the performance of the models. The nR^2 test and the F-test shows that all the models captured the ARCH effect

Table 3: Estimates of Real GDP volatility with oil price

Variables	GARCH(1 1)	GARCH – M	TGARH	EGARCH
Mean Equation				
Constant(α)	0.001092	0.044336*	-0.001572***	-0.001482
	(-0.001774)	-0.02323	-0.000552	-0.001402
GRGDP(-1) ϕ	0.757909***	0.706680***	0.814367***	0.750011***
	(-0.094923)	-0.097973	-0.040557	-0.02101
@SQRT(GARCH) θ		0.005698*		
		-0.0031		
Variance Equation				
Constant	0.000488***	0.000495	3.96E-06***	-6.474350***
λ_0	(-0.0000863)	-0.0000708	-0.0000018	-0.448174
ARCH(1)	0.697588***	0.685878**	0.587160***	0.940236***
λ_1	-0.226591	-0.236579	-0.083159	-0.169038
GARCH(1)ϒ	-0.097168	-0.020099	0.732180***	0.229808***
	-0.132733	-0.089542	-0.024253	-0.056148
TRESHOLD(1) ϕ			-0.202938*	
			-0.106022	
ASYMMETRY(1) Ø				-0.029904
				-0.104931
GOPRICE (β)	0.000855***	0.001228***	-0.000168***	3.290460***
	-0.0000634	-0.0000752	-0.0000247	-0.205466
Diagnostic Test				
SIC	-4.542513	-4.546787	-4.943778	-4.640168
ARCH LM Test				
F-test	0.00081	0.011577	0.153979	0.23631
	[0.9773]	[0.9144]	[0.6951]	[0.6273]
nR2	0.000817	0.011674	0.155167	0.238052
	[0.9772]	[0.9140]	[0.6936]	[0.6256]

Source: Author's computation. Note: ***, **and * indicate 1%, 5%and 10% level of significance respectively. While ( ) and [ ] denote standard error and P-value respectively.

For exchange rate volatility with effect of oil price volatility in Nigeria, represented in table 4, all the models reveal the existence of ARCH and GARCH effects. The parameter of the oil price volatility is negative and statistically significant even at 1% in all the models. This shows that oil price volatility is a significant determinant of exchange rate volatility in Nigeria. Thus, negative shocks in the oil market increases exchange rate volatility. This may be borne from the fact that oil is the major source of foreign exchange for the country. The sum of the coefficients of ARCH and GARCH terms is greater than one for EGARCH model but less than one for all other models. The EGARCH model reveals that the variance process of the series is not mean reverting and thus the effect of shocks on exchange rate volatility is permanent. However, other GARCH models (GARCH(1 1), GARCH – M and TGARCH) indicate that the variance is slow mean reverting. Since the coefficient of threshold asymmetric term is not significant, leverage effects are not considered important on the basis of the threshold GARCH. The asymmetry coefficient (-1.673243) in the EGARCH model is negative and significant indicating that negative shocks reduces the volatility of exchange rate in Nigeria more than positive shocks of the same magnitude. Similar to the SIC result in most of the equations considered, the EGARCH gives the best fit for the exchange rate volatility with oil price volatility and the post estimation tests shows that the ARCH effect is sufficiently captured in all the models.

Table 4: Estimates of Exchange rate volatility with oil price

VARIABLES	GARCH(1 1)	GARCH - M	TGARH	EGARCH
Mean Equation				
Constant(α)	0.000477	0.036412	9.52E-05	0.000344***
	(0.0068900)	(0.1745860)	(0.0070030)	(0.0000155)
GEXRATE(-1) φ	-0.487803***	-0.389364	-0.477518***	-1.157018***
	(0.104017)	(0.094343)	(0.079748)	(0.009927)
@SQRT(GARCH) θ		0.005482		
		(0.03735300)		
Variance Equation				
Constant	0.002722***	0.005385***	0.002716***	-5.717803***
λ_0	(0.000487)	(0.000154)	(0.000489)	(0.024341)
ARCH(1)	0.133717	0.096841*	0.085207	3.895704***
λ_1	(0.0906490)	(0.0537060)	(0.0738260)	(0.0340230)
GARCH(1)ϒ	0.585363***	0.393898***	0.584093***	0.275401***
	(0.0800770)	(0.0096000)	(0.0809450)	(0.0029890)
TRESHOLD(1) ϕ			0.0265	
			(0.1663650)	
ASYMMETRY(1) Ø				-1.673243***
				(0.032941)
GOPRICE (β)	-0.031960***	-0.046177***	-0.031810***	-77.91333***
	(0.000147)	(0.006983)	(0.000385)	(0.262341)
Diagnostic Test				
SIC	-2.902551	-2.657171	-2.90407	-4.571663
ARCH LM Test				
F-test	0.018017	0.173096	0.050433	0.001762
	[0.8932]	[0.6774]	[0.8223]	[0.9665]
nR2	0.018028	0.173197	0.050464	0.001763
	[0.8932]	[0.6773]	[0.8223]	[0.9665]

Source: Author's computation. Note: ***and* indicate 1%, and 10% level of significance respectively. While () and [] denote standard error and p-value respectively.

Table 5: Estimates of Interest Rate Volatility with oil prices

Variables	GARCH(1 1)	GARCH – M	TGARCH	EGARCH
Mean Equation				
Constant(α)	-0.000584	-0.007876***	-0.000656	-0.003571*
	(0.002464)	(0.002287)	(0.002534)	(0.002023)
GINTRATE(-1) φ	-0.223066*	-0.273599***	0.084355	0.073428
	(0.124860)	(0.111454)	(0.114192)	(0.093371)
@SQRT(GARCH) θ		0.416924***		
		(0.151709)		
Variance Equation				
Constant λ_0	6.13E-05***	5.28E-05***	0.000101***	-1.408773***
	(0.0000187)	(0.0000126)	(0.0000255)	(0.3663460)
ARCH(1) λ_1	0.090267*	0.060415***	0.0713	0.185090*
	(0.05100)	(0.03265)	(0.07692)	(0.11153)
GARCH(1) γ	0.822091***	0.872323***	0.629817***	0.813657***
	(0.063021)	(0.041774)	(0.075052)	(0.051245)
TRESHOLD(1) ϕ			0.574807**	
			(0.277068)	
ASYMMETRY(1) Ø				-0.656920***
				(0.106317)
GOPRICE (β)	-0.000749***	-0.001149***	-0.000961***	-4.472402***
	(0.000274)	(0.000264)	(0.000374)	(0.758039)
Diagnostic Test				
SIC	-4.454917	-4.522257	-4.433965	-4.587099
ARCH LM Test				
F-test	2.46348	3.267914*	0.08925	0.0062
	[0.1193]	[0.0733]	[0.7657]	[0.9374]
nR2	2.453505	3.231968*	0.090771	0.00631
	[0.1173]	[0.0722]	[0.7632]	[0.9367]

Source: Author's computation. Note: ***and* indicate 1%, and 10% level of significance respectively. While () and [] denote standard error and P-value respectively.

Table 5 shows the results of both the symmetric and asymmetric models for the interest rate volatility with oil price volatility. The results indicate the existence of ARCH and GARCH effect. It also lends support for a slow mean reverting process for all the estimated models. This is consistent with the result of the pre-estimation ARCH LM test. For example the sum of the ARCH and GARCH effect for GARCH (1,1) and GARCH-M (1,1) models is

0.924 and 0.9327 respectively while that of TGARCH(1,1) and EGARCH(1,1) is 0.7011 and 0.9987 respectively. Both are less than but close to one. This is an indication of evidence of high degree of persistence of the volatility of interest rate which varies across the models. The EGARCH (1, 1) indicates highest degree of persistence of the volatility. Further, the TGARCH shows that the coefficient of the threshold effect (0.574807) is statistically significant, depicting the importance of asymmetry in the modelling of interest rate volatility. Likewise, the EGARCH(1,1) the coefficient (-0.656920) of the asymmetric term is negative and significant and therefore negative shock reduces the volatility of interest rate more than positive shock of the same magnitude.

Evaluating comparative performance of the volatility models for interest rate in Nigeria, the GARCH-M(1,1) model appears to give a better fit than the GARCH(1,1) model for the symmetric case on the basis of the SIC value. This is obvious from the result of the GARCH-M(1,1) model where coefficient of @SQRT(GARCH) is statistically significant and thus provides more useful information for the volatility of interest rate. Similarly, in the asymmetric case, the EGARCH(1,1) model provides a better fit than the TGARCH(1,1) model. Overall, the EGARCH(1,1) appears to be superior to the other models when dealing with interest rate volatility taking oil price volatility into consideration. The results of the diagnostic tests of ARCH effect demonstrate that all the models except GARCH-M(1,1) completely captured the ARCH effect. For the GARCH-M(1,1) model the both the F-test and nR^2statistics are significant and so the model is not appropriate in such case.

6.0 Concluding Remarks

This study provides analytical insight on the modeling of macroeconomic volatility in Nigeria. The paper evaluates the plausibility of symmetric and asymmetric volatility models and investigates the impact of oil price volatility on the volatility of three major macroeconomic variables (real GDP, exchange rate and interest rate).

The findings of the study reveal that the asymmetric models TGARCH and EGARCH outperform the symmetric models GARCH (1 1) and GARCH – M, meaning that the asymmetric effects are important in modeling the volatility in Nigeria. Oil price volatility also plays a significant role in the determination of the macroeconomic volatility. By implication, the Nigerian economy is vulnerable to both internal shocks and external shocks. Since the oil price volatility significantly impacts on the volatility of all the variables considered, it is a major source of macroeconomic volatility in Nigeria. Hence, fluctuations in oil price bring about instabilities in the Nigerian economy.

Although different models fit different environments, the study recommends that more credence may be given to asymmetric models for modeling macroeconomic volatility in Nigeria. Oil price may be considered as relevant variable in the analysis of macroeconomic fluctuations in Nigeria. Therefore, the Nigerian economy may be diversified by revamping other sectors such as the agricultural sector and the industrial sector in order to reduce over-dependence on the oil sector.

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