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MODELLING THE MONETARY IMPACT OF OIL PRICE VOLATILITY IN NIGERIA: EVIDENCE FROM GARCH MODELS

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ABSTRACT

This paper investigated the impact of oil price volatility on some monetary variables in Nigeria under the framework of the GARCH models. The paper utilized three alternative error distributions in order to assist in providing better model fits and thus avoid biased results. Using monthly series over a period of 2006-2019, our findings revealed that, apart from the usual normal error distribution other error distributions perform better in the modelling of the impact of oil price volatility on monetary variables in Nigeria. The findings of the study also revealed that the asymmetric parameters of the models show evidence of leverage effect and oil price volatility plays a significant role in the determination of volatility of monetary variables. We, therefore, recommend that in modelling volatility of oil price and monetary variables in Nigeria, different error distributions should be considered.

Contribution/ Originality: In this study, we contribute to the literature by exploring various error distributions. This approach is pertinent because restricting the study to only normal distribution which is the usual practice could lead to biased outcomes as other error distributions can perform better. Our study can be affirmed to have evidence of originality; therefore the validity, reliability and uniqueness cannot be contested.

1. INTRODUCTION

The importance of oil as an energy source cannot be overemphasized. This has thus led to concerns on the part of policymakers regarding the dynamic nature of its price. From a historical perspective, the oil price has been tending volatility (Brini, Jemmali, & Farroukh, 2016). With this unpredictable nature of oil price, the resultant effect has always been for economies to experience macroeconomic volatility. This is so because, over time, price volatility has become a common phenomenon for the oil market which has been mounting pressures on policymakers in different countries. Macroeconomic volatility, according to Abdulkareem and Abdulhakeem (2016) implies the inability of macroeconomic variables to withstand shocks. It is noteworthy to point to the fact that the debate on the nature of the relationship between oil price fluctuations and macroeconomic outcomes is yet to be resolved. Mahmud (2009) contended that some studies have stressed the non-linearity of the nexus between oil price and the macroeconomic variables. The observation is that rising oil prices have more adverse macroeconomic consequences than the benefit accruable from a decrease in oil price.

From the African perspective, Omolade, Ngalawa, and Kutu (2019) noted a strong link between macroeconomic performances and the oil sector in Africa's oil-producing countries, maintaining that the continent's economy remains vulnerable to crude oil price shocks. The case of the Nigerian economy's dependence on oil proceeds as a major source of revenue is worrisome. The oil sector is the mainstay of Nigeria's economy, contributing a larger share of her Gross Domestic Product (GDP). As noted by Nzeh (2020) in recent times, crude oil price, which is Nigeria's main source of revenue, has been falling. The paper expressed concern regarding the country's inability to provide a buffer in terms of saving the oil proceeds over the years. In the absence of this provision, any shock arising from oil price could have spillover effects on the macroeconomic variables.

Concerning the monetary impact of oil price volatility, some studies have observed the association of oil price volatility to monetary variables (Fiyat, Küresel, & Etkileri, 2016; Hošek, Komárek, & Motl, 2011; Rosa, 2013). In Nigeria, empirical findings have also shown this association (Mahmud, 2009; Scot, 2018). According to the International Monetary Fund (2013), the primary source of liquidity in Nigeria has always been the monetization of oil revenue as well as other oil-related inflows. Nzeh et al. (2020) also noted that oil revenue is a major source of capital inflows in Nigeria. The study argued that the effect of this inflow is mainly to raise money supply which will then transmit to other macroeconomic variables. As a way to contend the destabilizing effect of this development on the macroeconomic environment, the Central Bank of Nigeria (CBN) usually employs some measures such as exchange rate intervention. With this particular measure, reserve money is created which will in the end lead to monetary expansion. In another vein, the effect of oil price fluctuations on money supply management in Nigeria can be viewed from the expansionary stance of the fiscal authorities each time there is a boom in oil price. Beginning from the Udorji Award of 1973 that increased salaries exorbitantly to massive expenditure on capital projects occasioned by rising oil prices, the story has always been the same and this usually leads to rising money supply and inflation. As the price of oil falls, it becomes difficult on the part of the fiscal authorities to implement the budget and this usually leads to deficit budgeting that also affects the money supply.

Having provided this brief background, our main concern in this paper is therefore to investigate the implication of oil price volatility on monetary variables in Nigeria. This study is more apt particularly now that the demand for oil price at the international level has fallen owing mainly to the effect of the COVID-19 pandemic which has affected productivity mostly in major industrialized nations whose demand for oil is high. As a major oil exporter, Nigeria is seriously hit by this phenomenon. For instance, there has been an adjustment to the 2020 budget as the provision for both capital and recurrent expenditures have been revised. This is owing to the fall in revenue projections which has affected benchmark projection. As a way out of the logjam, the country was forced to take a $3.4 billion emergency facility from the IMF. Also, she is withdrawing $150m from the stabilization fund of the Nigerian Sovereign Investment Authority (NSIA). The foregoing has implications for monetary policy management in Nigeria and therefore makes this study paramount.

Most research works relating to this topic focus on the effects of oil price on macroeconomic variables, whether high or low, rather than volatility. Similarly, others examine the relation between oil prices and exchange rates or stock market prices. It should be noted that most of the models used in these studies hardly handle asymmetric effects, yet oil price volatility just like the volatility of most assets has both positive and negative effects on macroeconomic variables. We align ourselves to these studies by providing evidence of the link between oil price volatility and monetary variables by applying the Generalized Auto-Regressive Conditional Heteroscedasticity (GARCH) models amid recent data. However, the review of relevant literature in Nigeria shows that authors have ignored the contributions of alternative error distributions while modeling the impact of oil price volatility on macroeconomic variables. Atoi (2014) observed that the application of inappropriate error distribution in a volatility model could lead to model misspecification and hence biased outcomes. Klar, *et al.* (2012) as cited in Atoi (2014) noted that incorrect specification of the error distribution may give rise to a huge loss of efficiency of the corresponding estimators. Thus, this study seeks to bridge the wide gap in the literature by evaluating different error distributions to select the models that perform optimally in modeling oil price volatility and monetary variables in Nigeria.

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1. Empirical Literature Review

The sensitivity of oil price volatility has led to a preponderance of empirical studies that have investigated the effects of this on the macroeconomic variables at both country-specific and cross-country levels.

2.1.1. Empirical Literature from Nigeria

In a country-specific study for Nigeria, Mahmud (2009) used both restricted and unrestricted Structural Vector Auto Regression (SVAR) models to investigate the impact of oil price shocks on monetary policy aggregates in Nigeria. The results show that the channels through which the effects of oil price shocks may pass through other sectors of the economy are through the government expenditure-inflation rate channels. In a similar study, Kazue (2012) studied the effect of oil price volatility on Nigeria's macroeconomic environment. By applying the SVAR model to monthly data series, the results of the finding suggest that Nigeria's exchange rate is affected not only by the changes in the international oil price but also by its price volatility. The study also found that the money supply rises as a response to increasing oil price.

Under the framework of the EGARCH, impulse response function and lag-augmented VAR (LA-VAR) models, Apere and Ijomah (2013) examined the impact of oil price volatility on the macroeconomic activity of Nigeria. The study found evidence of a unidirectional relationship between interest rate, exchange rate and oil prices and the direction of the causality flows from oil prices. However, there was no significant link between oil prices and real GDP. In another study, Abdulkareem and Abdulhakeem (2016) modelled macroeconomic and oil price volatility in Nigeria. By employing the GARCH models with daily, monthly and quarterly data, findings reveal that all the macroeconomic variables considered are highly volatile. Finding also suggests that oil price is a major source of macroeconomic volatility in Nigeria, thus confirming the results of previous studies.

Scot (2018) investigated the effect of oil price volatility on the business cycle in Nigeria. Under the framework of the Auto Regressive Distributed Lag (ARDL) bounds test and the Error Correction Model (ECM) for a period covering 1970-2015, the study finds positive and significant short-run effect of oil price volatility on real GDP but no significant long-run effect. Umoru, Ohiomu, and Akpeke (2018) investigated the influence of oil price volatility on exchange rate variability, external reserves, government expenditure and real GDP. By applying the VAR framework, findings show that oil price variability exerts varying degrees of effect on exchange rate variability, external reserves, government expenditure and real GDP.

2.1.2. Empirical Literature for the Rest of the World

A country-specific study by Bodenstein, Guerrieri, and Kilian (2012) investigated the U.S.A monetary policy responses to oil price fluctuations. The paper demonstrates that no two structural shocks cause identical monetary policy response, even after controlling for the impact response of the real price of oil. Lastly, the paper shows that the policy responses implied by a policy rule, whose coefficients were chosen to maximize welfare, differ substantially from the policy response implied by the same rule estimated on historical data. In another study for the U.S.A, Rosa (2013) examined the impact of conventional and unconventional monetary policy on energy prices, using an event study with intraday data. Estimation results show that monetary policy news strongly impacts the level and volatility of energy futures prices and volumes. It should be noted that this study focuses on the response of oil prices to U.S.A monetary policy instead of the other way round. This goes to show the huge influence of U.S.A domestic policies on the international commodity markets.

Chen, Chen, and Härdle (2015) investigated the relationship between China's macroeconomy and oil price. The study found strong evidence to suggest that rising prices in China owing to oil price shocks, is statistically less than that of its main trade partners. The SVAR results show a positive correlation between China's output level and oil prices. Fiyat et al. (2016) by using daily returns of crude oil prices and under the framework of APGARCH and FIAPGARCH models, compare the various volatility models and also examined the effects of the global financial crisis on volatility. Results of the models show that Student-t and Skewed Student-t distributions best fit oil prices. For MENA countries, Brini et al. (2016) investigated the impact of oil price shocks on inflation and the real exchange rate from January 2000 to July 2015. Under the framework of the SVAR model, the result of the impulse response functions shows a long-run impact of oil price fluctuations on the real exchange rate of Tunisia and Morocco, while the impact on inflation is not too significant. The variance decomposition results show that oil price shocks do not explain the variation in the two considered variables in Algeria and Iran.

In another study involving Iran, Tehranchian and Seyyedkolaee (2017) examined the nexus between oil price volatility and economic growth. By adopting the framework of the threshold regression model for 1980-2014, findings show that the effectiveness of the oil price volatility on economic growth has decreased over time. This result in a way lays credence to finding by Brini et al. (2016). For Norway, Bergholt, Larsen, and Seneca (2017) developed and estimated a two-country New Keynesian model to quantify the importance of oil price shocks. The estimated model provides three key results. First, oil price movements represent an important source of macroeconomic volatility in mainland Norway. Second, while no two shocks cause the same dynamics, conventional trade channels make an economically less significant difference for the transmission of global shocks to the oil exporter than to oil importers. Third, the domestic oil industry's supply chain is an important transmission mechanism for oil price movements, while the prevailing fiscal regime provides substantial protection against external shocks.

Omolade et al. (2019) investigated the influence of crude oil price shocks on the macroeconomic performance of Africa's oil-producing countries between 1980 and 2016. Eight major net oil producers, namely, Algeria, Nigeria, Egypt, Angola, Gabon, Equatorial Guinea and the Congo Republic are included in the study. By applying a Panel SVAR model, the results show that the reaction of output to sharp increases and declines in oil prices differ. It is also observed that structural inflation accompanies sharp declines in oil prices more than monetary inflation. Akhmedov (2019) investigated the correlation between world oil prices and selected Kazakhstan's macroeconomic variables using the VAR method. The macroeconomic variables under consideration demonstrate a significant correlation with oil price fluctuations.

2.2. Theoretical Issues

The volatile nature of oil price, just like the volatility in other assets, has led to studies devoted to investigating the effects of such volatility on the economy. On account of this, several models have been adopted in the investigation of volatility. Among these models, the GARCH model has been noted to be more effective in capturing volatility. Liu and Morley (2009) as cited in Costa (2017) observed that the GARCH models produce better and optimal results compared to other volatility models. In the analysis of asset returns, Engle (1982) pioneered the study on volatility by applying the auto-regressive conditional heteroscedasticity (ARCH) model. In the study, the conditional variance of a disturbance term was made a function of the linear combination of squared residuals in the recent past.

The move later encouraged further researches that have resulted in the development of several other ARCH-type models. To achieve a parsimonious model, Bollerslev (1986) and Taylor (1986) independently proposed the extension of an ARCH model with an Autoregressive Moving Average (ARMA) formulation. This model, which is popularly called the Generalized ARCH (GARCH) model, is specified by making the conditional variance a function of its lagged values as well as squared lagged values of the disturbance term. In capturing the symmetric effect of volatility; the GARCH model has proved to be effective. However, this model is limited in the sense that it assumes that both positive and negative error terms have a symmetric effect on volatility. In a nutshell, the GARCH models assume that good and bad news has the same size effect on volatility in the model. In practice, this assumption is frequently violated as volatility tends to increase more after bad news than after good news. The above proposition is regarded as the leverage effect which was first proposed by Black (1976).

To overcome these constraints, the asymmetric GARCH-family models (which are extensions of the original GARCH model) have been proposed. These include the Exponential GARCH model (EGARCH) proposed by Nelson (1991) the Power GARCH (PGARCH) proposed by Ding, Granger, and Engle (1993) the Threshold GARCH (TGARCH) proposed by Zakoian (1994) and the Beta-t- GARCH family models proposed by Harvey and Chakravarty (2008) and was elaborated by Harvey. and Sucarrat (2012). The central idea behind these asymmetric GARCH-family models is the leverage effect, i.e., the fact that in reality, good and bad news of the same magnitude has differential effects on the volatility.

3. METHODOLOGY

Our interest in this study is on the volatility of the series and because of this, we adopted the GARCH models among other volatility models. The rationale for the choice of GARCH models is based on the fact that they perform better in capturing volatility. In other to achieve our objectives, we employed three phases of the estimation procedure. The first of the phases is to test for ARCH effects, the second is estimating the ARCH models and then the last is carrying out a post estimation test to check for robustness.

It is very essential when estimating the GARCH models to first conduct a test to ascertain whether the series exhibit the ARCH effect; that is to verify if they are volatile. If the series shows evidence of non-volatility, then they cannot be included in the estimation because GARCH models only handle volatile series. To conduct a test of the ARCH effect, we begin the process with Equation 1 below as follows:

$$\xi_t = \vartheta_0 + \sigma_1 \xi_{t-1} + \varepsilon_t ; \varepsilon_t \sim IID(0, \sigma^2) \quad (1)$$

Where ξ is the rate of return of the series

Having run the regression and obtaining the residuals, the residual is squared and regressed on its lags as follows:

$$\hat{\varepsilon}_t^2 = \kappa_0 + \kappa_1 \hat{\varepsilon}_{t-1}^2 + \eta_t \quad (2)$$

After regressing Equation 2 above, R^2 is obtained and the test statistic is defined as TR^2 which is distributed as $\chi^2(q)$. Here T is the number of observations which is multiplied by the coefficient of determination $(R)^2$. If the probability values of the tests are less than any of the conventional levels of significance, the null hypothesis of no ARCH effect is rejected. It is noteworthy to state that if the null of no ARCH effect is rejected, this implies that the series exhibit the ARCH effect (ie they are volatile)

Having ascertained that the series exhibit the ARCH effect, the next thing is to specify the ARCH models. Two procedures are involved in this specification. The first is to specify the conditional mean equation and the next is to specify the conditional variance. Equations 3 and 4 below are the respective specifications

$$\xi_t = \vartheta_0 + \sum_{i=1}^{p} \psi_i \xi_{t-i} + \varepsilon_t \quad (3)$$

$$\sigma_t^2 = \pi_0 + \sum_{i=1}^{p} \pi_i \varepsilon_{t-1}^2 \quad (4)$$

Where

ε_{t-1}^2 is an ARCH term, $0 \leq \sum_{i=1}^{p} \pi_1 < 1$ represents stationary series. If $\sum_{i=1}^{p} \pi_i \rightarrow 1$ this implies that the series exhibit slow mean-reverting. On the other hand if $\sum_{i=1}^{p} \pi_i \rightarrow 0$, the implication is that the series shows fast mean-reverting. Engle (1982) proposed a test of the null hypothesis for the ARCH (p) that is tested using either the F-test or TR^2 which follows χ^2 distribution. If the null hypothesis of no ARCH effect is rejected it means that there is evidence of the presence of ARCH effect in the model.

Over time it has been realized that the ARCH models are fraught with some limitations one of which is the problem of selecting the appropriate lag length which may lead to the problem of over-parameterizing the model. To bridge this limitation, Bollerslev (1986) and Taylor (1986) came up with the idea of a GARCH model that allows the conditional variance to depend on the previous lags. The GARCH model is specified in Equation 5 below as follows:
Where

$$\sigma_t^2 = \pi_0 + \sum_{i-1}^{p} \pi_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \kappa_j \sigma_{t-j}^2 \quad (5)$$

$0 \leq \sum_{i-1}^{p} \theta_i + \sum_{j=1}^{q} \kappa_j < 1$ is the mean-reverting process.

If $\sum_{i-1}^{p} \theta_i + \sum_{j=1}^{q} \kappa_j \rightarrow 1$, it indicates that the model exhibits slow mean reverting.

If $\sum_{i-1}^{p} \theta_i + \sum_{j=1}^{q} \kappa_j \rightarrow 0$ the implication is that the model has fast mean-reverting.

To broaden the scope and hence improve the estimate of the GARCH model, we also considered the GARCH-in-Mean (GARCH-M). This model allows the conditional mean to depend on its conditional variance. By introducing the conditional variance or standard deviation into the mean equation, the GARCH-in-Mean model is derived (Engle, Lilien, & Robins, 1987). In Equation 6, the GARCH-M model is specified as follows:

$$\xi_t = \vartheta_0 + \sum_{i=1}^{p} \psi \xi_{t-i} + \varepsilon_t + \phi \sigma_t^2 \quad (6)$$

The null and alternative hypothesis for the GARCH-M is H_0: $\phi = 0$, H_1: $\phi \neq 0$. A rejection of the null hypothesis (H_0) indicates that the GARCH-M term is statistically significant implying that the model provides useful information for the volatility.

As it became obvious that a shock to a series has both positive and negative outcomes and that both ARCH and GARCH models cannot account for these possibilities, several extensions of asymmetric GARCH models were introduced. The models were meant to take care of the leverage effect arising from shocks to a variable. Two of such asymmetric models were employed in this study; namely: the threshold GARCH (TGARCH) and Exponential GARCH (EGARCH) to examine the existence of good and bad news arising from the shocks. The threshold GARCH (TGARCH) was introduced independently by Zakoian (1994) and Glosten, Jagannathan, and Runkle (1993). To capture asymmetries in the model, a multiplicative dummy variable is included in the variance equation. The specification of the model is captured in Equation 7 as follows:

$$\sigma_t^2 = \pi_0 + \sum_{j=1}^{q} \pi j \, \sigma_{t-j}^2 + \sum_{i=1}^{p} \kappa_i \gamma_{t-i} \varepsilon_{t-i}^2 + \sum_{k=1}^{p} \tau \varepsilon_{t-1}^2 d_{t-1} \tag{7}$$

Where

γ_{t-i} = 1 if σ_t^2 < 0 and 0 otherwise

If σ_t^2 > 0, it implies good news

If σ_t^2 < 0 it implies bad news

These two shocks have differential effects on the conditional variance. In terms of impact, good news has an impact on πj and bad news has an impact of $\pi j + \kappa_i$. Volatility increases bad news if κ_i > 0 and this implies the existence of leverage effect. On the other hand if $\kappa_i \neq 0$ the news impact is asymmetric.

The next asymmetric model we considered is the EGARCH model which was introduced by Nelson (1991). The modification effected in this model is that the lagged squared autoregressive component (ε_{t-i}^2) which appears in the standard GARCH model is replaced with a standard normal variable. A typical EGARCH model is specified in Equation 8 as follows:

$$l\log(\sigma_t^2) = \Pi_0 + \Pi_i \sqrt{\frac{\varepsilon_{t-1}^2}{\sigma_{t-1}^2}} + \varphi_i \sqrt{\frac{\varepsilon_{t-1}^2}{\sigma_{t-1}^2}} + \varpi_i \log(\sigma_{t-1}^2) \tag{8}$$

where

σ_t^2 > 0 implies good news.

σ_t^2 < 0 implies bad news.

Their total effects are:

$(1+\varpi_i)\left|\varepsilon_{t-i}^2\right|$ and $(1-\varphi_i)\left|\varepsilon_{t-i}^2\right|$ respectively.

If φ_i < 0, it implies that bad news has a higher impact on volatility than good news.

To ensure that the models perform optimally, we employed three error distributions to enable us to observe the basic assumptions about the conditional distribution of the error term which are needed when working with ARCH models. These models are the normal (Gaussian) distribution, Student's *t*-distribution and the Generalized Error Distribution (GED). Equation 9 below is a typical specification of the normal distribution:

$$L(\varpi_t) = -\frac{1}{2}\sum_{t-1}^{T}(\ln 2\lambda + \ln \sigma_t^2 + \frac{\varepsilon_t^2}{\sigma_t^2}) \qquad (9)$$

For the student's *t* distribution, the volatility models estimated are to maximize the likelihood function and this is specified in Equation 10 as below:

$$L(\varpi_t = -\frac{1}{2}\log(\frac{\lambda(r)\gamma r/2^2}{\lambda(r+1)/2)^2}) - \frac{1}{2}\log\sigma_t^2 - \frac{r+1}{2}\log(1+\frac{y_t - x_t^1\varpi)^2}{\sigma_t^2(r-2)} \qquad (10)$$

where

r is the degree of freedom.

The *t*-distribution approaches the normal as $v \to \infty$. and controls the tail behaviour r > 2.

For the Generalized Error Distribution (GED), the specification is captured in Equation 11 below:

$$L(\varpi_t) = -\frac{1}{2}\log(\frac{r1/v^3}{r(3/v)(v/2)^2} - \frac{1}{2}\log\sigma_t^2 - \frac{(r(3/v)(y_t - x_t^1\varpi)^2)^{v/2}}{\sigma_t^2\gamma(1/v)} \qquad (11)$$

where r > 0 the tail parameter. The GED is a normal distribution if r =2, and fat-tailed if r < 2. v is the shape parameter that accounts for the skewness of the returns and v > 0 The higher the value, the greater the weight of the tail. GED reverts to normal distribution if v = 0

We employed monthly data in this study throughout 2006-2019. The variables considered include World oil price (WOP), Broad money supply (M2), the Exchange rate (EXCHR), Inflation rate (INFLR) and Bank reserve (BR)). World oil price is proxied by Brent crude and it was sourced from the Federal Reserve Bank of St. Lious. Other variables were sourced from the Central Bank of Nigeria Statistical Bulletin. We computed the rate of return or growth rate of the variables after converting world oil price, M2, exchange rate and bank reserve into a log. The formula in Equation 12 below guided us in doing this:

$$\xi_t = \frac{v_t - V_{t-1}}{v_{t-1}} \qquad (12)$$

Where ξ_t is the rate of return at time t, while V_t is the variables at time t. We have resolved to reduce the GARCH models to lag 1 because this is capable of producing better results.

4. RESULTS PRESENTATION AND DISCUSSION OF FINDINGS

To avoid a spurious regression it is proper to investigate the stationarity of the series in the model. In this study, we investigated the order of integration of the series under the framework of the Augmented Dickey-Fuller (ADF) and Phillip Perron (PP) tests. The evaluation is carried out at at the 5% level. Results of findings both at the level and at first difference respectively are displayed in Tables 1 and 2. The ADF and the PP results show that none of the variables achieved stationarity at the level. However, when differenced, all the series became stationary.

Table-1. Result of Stationarity at Level.

Variables	ADF t-stat.	PP t-stat.	Critical value at 5% ADF	Critical value at 5% PP	Order of integration
GRM2	0.103636	0.597215	-2.878723	-2.878723	„
GREXCHR	0.659700	0.699350	-2.878937	-2.878937	„
GRINFLR	-2.489985	-1.902834	-2.878937	-2.878723	„
GRBR	0.097458	0.582689	-2.878829	-2.878723	„
GRWOP	-2.641373	-2.234975	-2.878829	-2.878723	„

Note: Figures with asterisks (**) indicate the rejection of the null hypothesis at the 5% level.

Table-2. Result of Stationarity at first Difference.

Variables	ADF t-stat.	PP t-stat.	Critical value at 5% ADF	Critical value at 5% PP	Order of integration
ΔGRM2	-15.13227**	-15.67834**	-2.878829	-2.878829	I(1)
ΔGREXCHR	-11.38614**	-11.31775**	-2.879155	-2.879155	I(1)
ΔGRINFLR	-7.548579**	-11.11639**	-2.878937	-2.878829	(1)
ΔGRBR	-14.99289**	-15.89290**	-2.878829	-2.878829	I 1)
ΔGRWOP	-8.178771**	-8.150581**	-2.878829	-2.878829	I(1)

Note: Figures with asterisks (**) indicate the rejection of the null hypothesis at the 5% level.

4.1. Test for ARCH Effect

The next test we conducted to guide us in the study is a test to determine if the variables exhibit ARCH effect. Results of the test for ARCH are shown in Table 3. The result revealed that both the F-test and the T^*R^2 test conducted at 5% level of significance indicate that all the variables exhibit the existence of ARCH effect. The implication of these results is that all the series used in the study are volatile and therefore qualify to be included in the GARCH model. To corroborate the test, the plot of the residuals of all the series displayed in Figures 1-5 below indicate that all the series experience fluctuation all through the period under review.

Table-3. Results of ARCH Effect.

Test	GRM2	GREXCHR	GRINFLR	GRBR	GRWOP
F-Test	115.3842** (0.0000)	11.31098** (0.0010)	22.21992** (0.0000)	22.35339** (0.0000)	42.90205** (0.0000)
T^*R^2	68.55711** (0.0000)	10.71024** (0.0011)	19.82015** (0.0000)	19.91197** (0.0000)	34.42083** (0.0000)

Note: Figures with asterisks (**) indicate the rejection of the null hypothesis at the 5% level.

4.2. Model Selection

The existence of ARCH effect in the series presupposes that we can go ahead to estimate the GARCH models with the three error distributions to determine the best model. Using the Schwarz Information Criterion (SIC), we selected the optimal models from Table 3 below and the results are displayed in Table 4. From the results it can be seen that the normal distribution with least value of SIC is adequate enough to capture oil price volatility and money supply (M2) under GARCH (11), GARCH-M (11) and TGARCH (11). However, the Student's *t* Distribution provides optimal model under the EGARCH (11). Under the Student's *t* Distribution, the adequacy of the model with the normal distribution is improved by 7.4%.

Table-4. Optimal Model Selection and the improvement of the normal distribution by other error distributions in the model for world oil price and M2.

First Order GARCH Models	Schwarz Information Criterion (SIC)			Percentage Improvement of the Normal Distribution by other Error Distributions	
	Normal Distribution	Student's *t* Distribution	Generalized Error Distribution	Student's *t* Distribution	Generalized Error Distribution
GARCH (1 1)	-12.71075*	-12.60851	- 12.64358		
GARCH-M (11)	-12.70514*	-12.56015	-12.51989		
TGARCH (11)	-12.63618*	-12.54224	-12.56707		
EGARCH (11)	-12.69550	-12.76916*	-12.69842	7.4	

Note: asterisk (*) indicates the selected model.

In Table 5 below, the Generalized Error Distribution with the least SIC is adequate to capture oil price volatility and exchange rate under GARCH (11) and TGARCH (11) but the Student's *t* Distribution performs better under GARCH-M (11) and EGARCH (11). The Generalized Error Distribution improved the adequacy of the normal distribution model by 44.4% under GARCH (11) and 17.9% under TGARCH (11). The Student's *t* Distribution improved the adequacy of the normal distribution model by 27.8% under GARCH-M (11) and 91.9 under EGARCH {11) see Table 6.

Table-5. Optimal model selection and improvement of the normal distribution by other error distributions in the model for world oil price and exchange rate.

First Order GARCH Models	Schwarz Information Criterion (SIC)			Percentage Improvement of Gaussian Process by Non-Gaussian Process	
	Normal Distribution	**Student's *t* Distribution**	**Generalized Error Distribution**	**Student's *t* Distribution**	**Generalized Error Distribution**
GARCH (1 1)	-14.96578	-15.24852	-15.40944*		44.4
GARCH-M (11)	-14.98512	-15.26282*	-14.79883	27.8	
TGARCH (11)	-14.81366	-14.01297	-14.98953*		17.9
EGARCH (11)	-14.60034	-15.51901*	-14.89851	91.9	

Note: asterisk (*) indicates the selected model

In Table 6 below, the Generalized Error Distribution performs better and is adequate to capture oil price volatility and inflation rate under GARCH (11). Also both the Generalized Error Distribution and the Student's *t* Distribution perform better under GARCH-M (11) and TGARCH (11), while under EGARCH (11) the Generalized Error Distribution performs better. The GED improved the adequacy of the model with the Normal Distribution by 0.62% under GARCH (11) and 12% under EGARCH (11). However, both GED and the Student's *t* Distribution improved the model with the Normal distribution by 2.8% and 3.07% under GARCH-M (11) and TGARCH (11) respectively (see Table 10).

Table-6. Optimal model selection and improvement of the normal distribution by other error distributions in the model for world oil price and inflation rate.

First Order GARCH Models	Schwarz Information Criterion (SIC)			Percentage Improvement of Gaussian Process by Non-Gaussian Process	
	Normal Distribution	**Student's *t* Distribution**	**Generalized Error Distribution**	**Student's *t* Distribution**	**Generalized Error Distribution**
GARCH (1 1)	-0.012219	-0.018435	-0.002770*		0.62
GARCH-M (11)	-0.010395	-0.038775*	-0.038775*	2.8	2.8
TGARCH (11)	-0.015628	-0.046281*	-0.046281*	3.07	3.07
EGARCH (11)	-0.102785	-0.101138	-0.114606*		1.2

Note: asterisk (*) indicates the selected model.

In Table 7 below, the Generalized Error Distribution performs better under GARCH (11), GARCH-M (11) and TGARCH (11) and is adequate to capture oil price volatility and bank reserve. It improved the adequacy of the model with the Normal Distribution by 1.2%, 0.38% and 7.71% under GARCH (11), GARCH-M (11) and TGARCH (11) respectively, while the Student's *t* Distribution improved the adequacy of the model with Normal Distribution by 6.9% see Table 11.

Table-7. Optimal model selection and improvement of the normal distribution by other error distribution in the model for world oil price and bank reserve.

First Order GARCH Models	Schwarz Information Criterion (SIC)			Percentage Improvement of Gaussian Process by Non-Gaussian Process	
	Normal Distribution	Student's *t* Distribution	Generalized Error Distribution	Student's *t* Distribution	Generalized Error Distribution
GARCH (1 1)	-8.445469	-8.445469	-8.457535*		1.2
GARCH-M (11)	-8.436843	-8.436843	-8.440679*		0.38
TGARCH (11)	-8.360257	-8.429285	-8.437357*	6.9	7.71
EGARCH (11)	-8.422060*	-8.422060*	-8.072082		

Note: asterisk (*) indicates the selected model.

4.3. Estimation and Interpretation of Results of GARCH Models

The results of the model selection so far have shown that the specification of these volatility models solely with the Normal Distribution is not adequate enough to capture the impact of volatility in oil price and the various monetary variables in Nigeria. Thus the reliance on such error distribution in modelling this relationship could lead to model mis-specification and hence biased outcomes as other error distribution methods could contribute more to the fitness of these models. In this paper, we begin the modelling based on the best model identified by the SIC in Tables 4-7 above.

Starting with the volatility of oil price and money supply in Table 8, the result reveals that the ARCH coefficients in all the models selected are statistically significant, thus confirming the presence of ARCH effect. Further, the results of GARCH (11), GARCH-M (11) and TGARCH (11) under the Normal Distribution show that the volatility of money supply in Nigeria is mean reverting Also, under the Student's *t* Distribution, the result of EGARCH (11) shows that the sum of the ARCH and GARCH (11) coefficients is less than one. This is a clear case of the volatility of money supply been mean reverting and it indicates the non permanence effects of shocks on the volatility of money supply in Nigeria. The coefficient of oil price is significant in all the models and that goes to show the positive link between oil price and money supply in Nigeria. Equally, while we did not find asymmetric effect under the TGARCH (11) to be significant (see Table 7), we found that under the Student's *t* Distribution, the EGARCH (11) model clearly indicates that bad news have more impact on volatility of money supply than good news. Thus, if for instance there is an outbreak of war in any of the major oil producing countries which may push oil price up, this can lead to actions on the part of economic agents that are capable of altering money supply.

Table-8. Results of estimated volatility of world oil price and M2.

Models	Equations	Model Parameter	Normal Distribution			Student's *t* Distribution			Generalised Error Distribution		
			Coefficients	P-Value	SIC	Coefficients	P-Value	SIC	Coefficients	P-Value	SIC
GARCH (1, 1)	Mean	Intercept	0.006357	0.0000	**-12.71075**	0.005948	0.3771	**-12.60851**	0.009627	0.0000	**-12.64358**
		GM2(-1)	0.977557	0.0000		0.985460	0.0000		0.979054	0.0000	
		GWOP	-0.002769	0.0000		-0.003663	0.5439		-0.006248	0.0000	
	Variance	ARCH	-0.056224	0.0002		0.104033	0.1192		0.067294	0.1722	
		GARCH	0.917182	0.0000		0.736529	0.0000		0.794021	0.0000	
GARCH-M (11)	Mean	Intercept	-0.004218	0.0000	-12.70514	-0.001159	0.8455	-12.56015	-0.001475	0.8265	-12.51989
		GM2(-1)	0.997282	0.0000		0.995576	0.0000		0.994299	0.0000	
		GWOP	0.004560	0.0000		0.001937	0.7475		0.002543	0.6703	
	Variance	ARCH	-0.067049	0.0000		0.060506	0.0944		0.059292	0.4330	
		GARCH	0.929357	0.0000		0.761194	0.0000		0.763194	0.0000	
		@SQRT(GARCH)	-0.269337	0.0000		-0.636316	0.0279		-0.027814	0.7078	
TGARCH (1, 1)	Mean	Intercept	0.007739	0.0000	-12.63618	0.004553	0.0928	-12.54224	0.005515	0.3852	-12.56707
		GM2(-1)	0.977984	0.0000		0.985810	0.0000		0.985618	0.0000	
		GWOP	-0.004211	0.0000		-0.002347	0.3086		-0.003267	0.5721	
	Variance	ARCH	0.137322	0.2154		0.153741	0.0170		0.121983	0.3834	
		GARCH	0.848228	0.0000		0.606215	0.0000		0.732149	0.0000	
		Asymmetric	-0.188519	0.1117		0.047076	0.7556		-0.032278	0.8203	
GARCH (1, 1)	Mean	Intercept	0.007339	0.0793	-12.69550	0.006950	0.0000	-12.76916	0.006884	0.0000	
		GM2(-1)	0.976768	0.0000		0.984678	0.0000		0.985921	0.0000	-12.69842
		GWOP	-0.003628	0.3785		-0.004496	0.0000		-0.004645	0.0000	
	Variance	ARCH	-0.118322	0.0079		-0.199367	0.0000		0.002573	0.9796	
		GARCH8	0.070117	0.0609		0.010954	0.8969		0.056815	0.3594	
		Asymmetric	0.950612	0.0000		0.959191	0.0000		0.961102	0.0000	

In Table 9, the results of the models selected for the volatility of oil price and exchange rate reveals that the ARCH coefficients in all the models selected, except TGARCH (11) under the GED are statistically significant, confirming the presence of ARCH effect. Further, the results of GARCH (11) and GARCH-M (11) show that the volatility of exchange rate in Nigeria is not mean reverting (i.e. the sum of their ARCH and GARCH (11) coefficients is more than one). This implies that the effects of shocks on the volatility of exchange rate are permanent. However, the result of the EGARCH (11) model indicated that exchange rate is mean reverting. The parameter of oil price volatility is negative and significant in all the models except EGARCH (11) and this shows that oil price volatility is a significant determinant of exchange rate volatility in Nigeria. Under the TGARCH (11) model, leverage effect does not hold as the coefficient of asymmetric term is not significant (see Table 12 below), however under the EGARCH (11) model, there is the presence of leverage effect as bad news have more impact on volatility of exchange rate than good news. The implication of the result is that any negative concerning oil price could affect the value of the naira. This is possible as the oil sector is the main source of revenue for Nigeria such that news regarding the price of oil will definitely affect the value of the local currency in relation with other currencies.

In Table 10, the results of the models selected for the volatility of oil price and inflation rate reveals that the ARCH coefficients of all the models are statistically significant which confirms the presence of ARCH effect. The results of all the models also show that the volatility of inflation rate in Nigeria is not mean reverting (i.e. the sum of their ARCH and GARCH (11) coefficients is more than one). This implies that shocks on the volatility of inflation is permanent in Nigeria. Nigeria is basically a consumer nation such that any shock to the main source of her revenue will filter through the macroeconomic environment, leading to price instability. Once prices begin to rise, they remain permanent unless there is a policy tool in place to arrest such trend. In most instances, no matter the measures put in place to cushion the effect of rising prices, cases of price stickiness abound in Nigeria. The parameter of oil price volatility is positive and significant in all the models and this shows that oil price volatility is a significant determinant of inflation rate volatility in Nigeria. In Table 12, we noticed leverage effects in all the models which show that bad news has more impact on volatility of inflation rate than good news. However, we do not find the coefficients of the asymmetric terms to be significant in any of the models.

In Table 11, the results of the models selected for the volatility of oil price and bank reserve reveals that the ARCH coefficients for all the models are statistically significant which confirms the presence of ARCH effect. The results of GARCH (11), GARCH–M (11) and TGARCH (11) show that the volatility of bank reserve in Nigeria is not mean reverting (i.e. the sum of their ARCH and GARCH (11) coefficients is more than one. However, the result of EGARCH (11) is mean reverting. The parameter of oil price volatility is significant in all the models and this shows that oil price volatility is a significant determinant of bank reserve volatility in Nigeria. We did not find the asymmetric term in the TGARCH (11) model to be significant so there is no presence of leverage effect. However, a leverage effect occurred in the EGARCH (11) model as bad news has more impact on volatility of bank reserve than good news. Worthy of note here is the outcome of the asymmetric tests under oil price volatility and money supply model and that of oil price volatility and bank reserve model. In both models, the asymmetric term is significant under the EGARCH (11), thus showing the co-movement of money supply and bank reserve. In a nutshell, any news impact on money supply will have similar impact on bank reserve.

Table-9. Result of estimated volatility of oil price and exchange rate.

Models	Equations	Model Parameter	Normal Distribution			Student's *t* Distribution			Generalised Error Distribution		
			Coefficients	P-Value	SIC	Coefficients	P-Value	SI	Coefficients	P-Value	SIC
GARCH (1, 1)	Mean	Intercept	0.004953	0.0000	**-14.96578**	0.014145	0.0000	**-15.24852**	0.000719	0.0000	**-15.40944**
		GEXCHR(-1)	0.976088	0.0000		0.983024	0.0000		0.990907	0.0000	
		GWOP	-0.004808	0.0000		-0.013883	0.0000		-0.000682	0.0000	
	Variance	ARCH	1.398848	0.0001		0.825221	0.0102		1.645543	0.0141	
		GARCH	0.368207	0.0000		0.520676	0.0000		0.421853	0.0000	
GARCH-M (11)	Mean	Intercept	0.007748	0.0000	-14.98512	0.011800	0.0000	-15.26282	0.012626	0.0000	-14.79883
		GEXCHR(-1)	0.968970	0.0000		0.980412	0.0000		0.985857	0.0000	
		GWOP	-0.007547	0.0000		-0.011580	0.0000		-0.012196	0.0000	
	Variance	ARCH	1.219899	0.0001		1.149308	0.0388		0.058832	0.0525	
		GARCH	0.399749	0.0000		0.505618	0.0000		0.556620	0.0000	
		@SQRT(GARCH)	0.267767	0.0205		0.294743	0.0141		-0.990206	0.0000	
TGARCH (1, 1)	Mean	Intercept	0.014064	0.0000	-14.81366	0.014159	0.1691	-14.01297	0.014139	0.0000	-14.98953
		GEXCHR(-1)	0.961764	0.0000		0.981903	0.0000		0.987215	0.0000	
		GWOP	-0.013738	0.0000		-0.013884	0.1667		-0.013892	0.0000	
	Variance	ARCH	0.592569	0.0041		0.150000	0.6712		0.458043	0.2444	
		GARCH	0.557002	0.0000		0.600000	0.2879		0.524893	0.0028	
		Asymmetric	0.319234	0.3949		0.050000	0.9189		0.697393	0.3127	
EGARCH (1, 1)	Mean	Intercept	0.014168	0.0000	-14.60034	-0.001412	0.2518	-15.51901	0.014148	0.0000	-14.89851
		GEXCHR(-1)	0.974528	0.0000		1.007377	0.0000		0.985279	0.0000	
		GWOP	-0.013873	0.0000		0.001363	0.2605		-0.013893	0.0000	
	Variance	ARCH	1.379366	0.0000		0.194113	0.0325		1.045719	0.0031	
		GARCH	0.260759	0.0971		-0.499212	0.0000		0.168494	0.4792	
		Asymmetric	-0.002831	0.9729		0.893736	0.0000		0.035049	0.8513	

Table-10. Estimated Result of Oil Volatility and Inflation Rate

Models	Equations	Model Parameter	**Normal Distribution**			**Student's *t* Distribution**			**Generalised Error Distribution**		
			Coefficients	P-Value	SIC	Coefficients	P-Value	SIC	Coefficients	P-Value	SIC
GARCH (1, 1)	Mean	Intercept	-13.91190	0.0000		-13.91202	0.0000		-13.73836	0.0000	
		GINFLR(-1)	0.969198	0.0000	- 0.012219	0.969197	0.0000	- 0.018435	0.970939	0.0000	- 0.002770
		GWOP	13.96772	0.0000		13.96784	0.0000		13.78491	0.0000	
	Variance	ARCH	0.881238	0.0000		0.881277	0.0000		0.820062	0.0000	
		GARCH	0.284993	0.0000		0.284983	0.0000		0.305058	0.0000	
GARCH-M (11)	Mean	Intercept	-10.22861	0.0000	- 0.010395	-14.43932	0.0000		-14.34268	0.0000	- 0.020588
		GINFLR(-1)	0.971020	0.0000		0.968242	0.0000		0.969811	0.0000	
		GWOP	10.31854	0.0000		14.48362	0.0000		14.37571	0.0000	
	Variance	ARCH	0.985466	0.0000		0.888046	0.0000	- 0.038775	0.826532	0.0000	
		GARCH	0.278440	0.0000		0.284256	0.0000		0.303962	0.0000	
		@SQRT(GARCH)	0.071946	0.3850		0.116375	0.2122		0.138296	0.1345	
TGARCH (1, 1)	Mean	Intercept	-14.04632	0.0000	- 0.015628	-14.04639	0.0000	- 0.046281	-13.89477	0.0000	
		GINFLR(-1)	0.968885	0.0000		0.968885	0.0000		0.970373	0.0000	
		GWOP	14.10087	0.0000		14.10094	0.0000		13.94100	0.0000	
	Variance	ARCH	0.812284	0.0006		0.812318	0.0009		0.749498	0.0000	
		GARCH	0.280524	0.0000		0.280517	0.0000		0.300132	0.0000	
		Asymmetric	0.174054	0.5783		0.174048	0.5798		0.172815	0.4312	- 0.029518
EGARCH (1, 1)	Mean	Intercept	-23.83858	0.0000	- 0.102785	-22.89221	0.0000	- 0.101138	-23.80376	0.0000	- 0.114606
		GINFLR(-1)	0.968924	0.0000		0.966370	0.0000		0.966852	0.0000	
		GWOP	23.71324	0.0000		22.82758	0.0000		23.71248	0.0000	
	Variance	ARCH	1.333891	0.0000		1.302938	0.0000		1.249445	0.0000	
		GARCH	0.728756	0.0000		0.729461	0.0000		0.085762	0.0000	
		Asymmetric	0.030964	0.8408		0.024394	0.8758		0.134436	0.9772	

Table-11. Estimated result of volatility of oil price and bank reserve.

Models	**Equations**	**Model Parameter**	**Normal Distribution**			**Student's *t* Distribution**			**Generalised Error Distribution**		
			Coefficients	P-Value	SIC	Coefficients	P-Value	SIC	Coefficients	P-Value	SIC
GARCH (1, 1)	Mean	Intercept	-0.038339	0.0885		-0.038339	0.0885		-0.033974	0.0955	
		GBR(-1)	0.964245	0.0000	-8.445469	0.964245	0.0000	-8.445469	0.973120	0.0000	-8.457535
		GWOP	0.043890	0.0448		0.043890	0.0448		0.038074	0.0557	
	Variance	ARCH	0.285666	0.0483		0.285666	0.0483		0.248755	0.0360	
		GARCH	0.764133	0.0000		0.764133	0.0000		0.783542	0.0000	
GARCH-M (11)	Mean	Intercept	-0.063797	0.0063		-0.063797	0.0063		-0.033127	0.1516	
		GBR(-1)	0.929591	0.0000	-8.436843	0.929591	0.0000	-8.436843	0.1516	0.0000	-8.440679
		GWOP	0.074567	0.0016		0.074567	0.0016		0.041750	0.0707	
	Variance	ARCH	0.284097	0.0807		0.284097	0.0807		0.245849	0.0269	
		GARCH	0.774535	0.0000		0.774535	0.0000		0.785464	0.0000	
		@SQRT(GARCH)	0.321719	0.0858		0.321719	0.0858		0.196165	0.1445	
TGARCH (1, 1)	Mean	Intercept	-0.033338	0.1012	-8.360257	-0.047018	0.0272	-8.429285	-0.032377	0.1147	-8.437357
		GBR(-1)	0.964544	0.0000		0.954259	0.0000		0.955974	0.0000	
		GWOP	0.038953	0.0500		0.054239	0.0088		0.039617	0.0477	
	Variance	ARCH	0.264768	0.0000		0.365604	0.0843		0.304528	0.0223	
		GARCH	0.828769	0.0000		0.800236	0.0000		0.810575	0.0000	
		Asymmetric	-0.176657	0.0527		-0.323180	0.1688		-0.239212	0.1361	
EGARCH (1, 1)	Mean	Intercept	-0.042692	0.0385	-8.422060	-0.042692	0.0385	-8.422060	-0.016777	0.0000	-8.072082
		GBR(-1)	0.960096	0.0000		0.960096	0.0000		0.962929	0.0000	
		GWOP	0.048995	0.0133		0.048995	0.0133		0.023050	0.0000	
	Variance	ARCH	0.433942	0.0051		0.433942	0.0051		0.884916	0.0426	
		GARCH	0.095077	0.3973		0.095077	0.3973		-0.305938	0.2871	
		Asymmetric	0.977154	0.0000		0.977154	0.0000		0.039233	0.8381	

Table-12. News impact in the asymmetric models.

Oil Price Volatility and M2		
	TGARCH (11)	**EGARCH (11)**
Error Distribution	**Normal Distribution**	**Student's *t* Distribution**
Good News Impact	0.137322 NON	-0.199367
Bad News Impact	0.325841 NON	0.759824
Oil Price Volatility and Exchange Rate		
Error Distribution	Generalized Error Distribution	Student's *t* Distribution
Good News Impact	0.458043 NON	0.194113
Bad News Impact	1.155436 NON	1.087849
Oil Price Volatility and Inflation Rate		
Error Distribution	Normal Distribution/ Generalized Error Distribution	Generalized Error Distribution
Good News Impact	0.812284/ 0.304528 NON	1.249445
Bad News Impact	0.986338/ 0.172815 NON	1.383881 NON
Oil Price Volatility and Bank Reserve		
Error Distribution	Generalized Error Distribution	Normal Distribution
Good News Impact	0.304528	0.433942
Bad News Impact	0.065316 NON	1.411096

Note: non indicates non-significant.

4. RESULTS OF ROBUSTNESS TESTS

In testing the robustness of the models, Appendixes 1-4 below show the results of the test of the existence of further ARCH effect in the models. The null hypothesis that there is no remaining ARCH effect in the models is accepted at the 5% level of significance. The results indicate that there is no reason to reject the null hypothesis at the chosen significant level and that is an indication of an evidence of good volatility models. The implication of the result is that ARCH effect has been eliminated. The serial correlation test results are presented in Appendixes 5-8. The probability values of the Qstatistics for all the lags, except some lags in Appendix 7 are higher than 0.05. This is a clear confirmation that there is no serial correlation in the residuals of the estimated models at the 5% significance level.

5. CONCLUSION

This study investigated the impact of oil price volatility on some monetary variables in Nigeria by applying first order GARCH (11) family models alongside three alternative error distributions (Normal Distribution, Student's *t* Distribution and Generalized Error Distribution). Using monthly series on the variables of choice, best fitted models were selected on the basis of SIC. Our findings revealed that other error distributions other than the Normal Distribution perform better in the modelling of oil price volatility and monetary variables in Nigeria. This corroborates our earlier stand and the stand of some empirical findings that the Normal Distribution is inadequate for volatility modelling.

The paper examined both symmetric and asymmetric volatility models in the investigation of the impact of oil price volatility on the volatility of four monetary variables; namely: money supply, exchange rate, bank reserve and inflation rate. Findings of the study reveal that the asymmetric parameters of these models show evidence of leverage effect which implies that oil price volatility in Nigeria does not have equal response to the same magnitude of positive and negative shocks. Oil price volatility plays a significant role in the determination of volatility of monetary variables in Nigeria as it significantly impacts on the volatility of all the variables considered. We contend that fluctuations in oil price bring about instabilities in the setting of monetary policy in Nigeria. We therefore recommend that in modelling volatility of oil price and monetary variables in Nigeria, different error distributions should be considered. Also, monetary policy authorities should factor in oil price when fashioning out monetary policies and there is need on the part of government to diversify the economic base of the country to reduce the impact of oil price shocks on the macroeconomic variables.

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REFERENCES

Abdulkareem, A., & Abdulhakeem, K. A. (2016). Analysing oil price-macroeconomic volatility in Nigeria. *CBN Journal of Applied Statistics, 7*(1), 1-22.

Akhmedov, E. (2019). The impact of oil price shocks on selected Kazakhstan's macroeconomic indicators. *Journal of International Studies, 12*(4), 258-271. Available at: https://doi.org/10.14254/2071-8330.2019/12-4/17.

Apere, O. T., & Ijomah, A. M. (2013). Macroeconomic impact of oil price levels and volatility in Nigeria. *International Journal of Academic Research in Economics and Management Sciences, 2*(4), 15-25.

Atoi, N. V. (2014). Testing volatility in Nigeria stock market using GARCH models. *CBN Journal of Applied Statistics, 5*(2), 65-93.

Bergholt, D., Larsen, V., & Seneca, M. (2017). Business cycles in an oil economy. Bank of International Settlement Working Papers No 618.

Black, F. (1976). *Studies of stock market volatility changes*. Paper presented at the 1976 Proceedings of the American Statistical Association Bisiness and Economic Statistics Section.

Bodenstein, M., Guerrieri, L., & Kilian, L. (2012). Monetary policy responses to oil price fluctuations. *IMF Economic Review, 60*(4), 470-504.

Bollerslev, T. (1986). Generalized autoregressive conditional heteroscedasticity. *Journal of Econometrics, 31*, 307–327.

Brini, R., Jemmali, H., & Farroukh, A. (2016). *acroeconomic impacts of oil price shocks on inflation and real exchange rate: Evidence from selected MENA countries*. Paper presented at the In 15th International Conference Middle East Economic Association (MENA 2016).

Chen, D., Chen, S., & Härdle, W. (2015). The influence of oil price shocks on china's macro-economy: A perspective of international trade. *Journal of Governance and Regulation, 4*(1), 178-189.

Costa, F. J. M. (2017). *Forecasting volatility using GARCH models*. Doctoral Dissertation.

Ding, Z., Granger, C. W., & Engle, R. F. (1993). A long memory property of stock market returns and a new model. *Journal of Empirical Finance, 1*(1), 83-106. Available at: https://doi.org/10.1016/0927-5398(93)90006-d.

Engle, R. F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica: Journal of the Econometric Society, 50*(4), 987-1007.

Engle, R. F., Lilien, D. M., & Robins, R. P. (1987). Estimating time varying risk premia in the term structure: The arch-m model. *Econometrica: Journal of the econometric society, 55*(2), 391-407.

Fiyat, H., Küresel, O., & Etkileri, F. (2016). Modelling crude oil price volatility and the effects of global financial crisis. *Sosyoekonomi, 24*(29), 167-181.

Glosten, L. R., Jagannathan, R., & Runkle, D. E. (1993). On the relation between the expected value and the volatility of the nominal excess return on stocks. *Journal of Finance, 48*(4), 1779-1801.

Harvey, A., & Chakravarty, T. (2008). *Beta-t-(E) GARCH*: Cambridge University Working.

Harvey., A., & Sucarrat, G. (2012). EGARCH models with fat tails, skewness and leverage: Cambridge University Working Papers in Economics.

Hošek, J., Komárek, L., & Motl, M. (2011). Monetary policy and oil prices. Warwick Economic Research Papers No 947.

International Monetary Fund. (2013). *Nigeria: Publication of financial sector assessment program documentation-technical note on strengthening monetary and liquidity management*. Washington, D.C: International Monetary Fund.

Kazue, D. (2012). The effect of crude oil price change and volatility on Nigeria economy.

Mahmud, H. (2009). Oil price shocks and monetary policy aggregates in Nigeria: A structural VAR approach. Munich Personal RePEc Archive Paper No. 25908.

Nelson, D. B. (1991). Conditional heteroskedasticity in asset returns: A new approach. *Econometrica: Journal of the Econometric Society*, *59*, 347-370.

Nzeh, I. C., Nwogwugwu, U. C., Ibikunle, J. A., Uzoechina, B. I., Anthony, C. O., & Anyachebelu, U. M. (2020). Investigating the effectiveness of sterilization policy in controlling money supply and capital inflows in Nigeria. *Acta Economica*, *18*(32), 127 – 150.

Nzeh, I. C. (2020). Public debt and economic growth in Nigeria: Investigating the optimal threshold level. *Asian Development Policy Review*, *8*(2), 112-127.

Omolade, A., Ngalawa, H., & Kutu, A. (2019). Crude oil price shocks and macroeconomic performance in Africa's oil-producing countries. *Cogent Economics & Finance*, *7*(1), 1607431. Available at: https://doi.org/10.1080/23322039.2019.1607431.

Rosa, C. (2013). The high-frequency response of energy prices to monetary policy: Understanding the empirical evidence. Federal Reserve Bank of New York Staff Reports No. 598.

Scot, A. O. (2018). Oil price volatility and business cycles in Nigeria. *Studies in Business and Economics*, *13*(2), 31-40.

Taylor, S. (1986). *Modelling financial time series*. Chichester: Wiley.

Tehranchian, A. M., & Seyyedkolaee, M. A. (2017). The impact of oil price volatility on the economic growth in Iran: An application of a threshold regression model. *International Journal of Energy Economics and Policy*, *7*(4), 165-171.

Umoru, D., Ohiomu, S., & Akpeke, R. (2018). The influence of oil price volatility on selected macroeconomic variables in Nigeria. *Acta Universitatis Bohemiae Meridionalis*, *21*(1), 1-22. Available at: https://doi.org/10.1515/acta-2018-0001.

Zakoian, J.-M. (1994). Threshold heteroskedastic models. *Journal of Economic Dynamics and control*, *18*(5), 931-955. Available at: https://doi.org/10.1016/0165-1889(94)90039-6.

Appendix-1. ARCH LM Test of Estimated Volatility of Oil Price and M2

	Normal Distribution	Student's t Distribution	Generalized Error Distribution
GARCH (11)			
F-Test	0.513031 (0.4748)	1.050449 (0.3069)	0.879167 (0.3498)
nR^2	0.517668 (0.4718)	1.056493 (0.3040)	0.885143 (0.3468)
GARCH-M (11)			
F-Test	0.827724 (0.3643)	0.588721 (0.4440)	0.185331 (0.6674)
nR^2	0.833611 (0.3612)	0.593769 (0.4410)	0.187380 (0.6651)
TGARCH (11)			
F-Test	0.340803() (0.5602)	1.170683 (0.2808)	0.879167 (0.3498)
nR^2	0.344244 (0.5574)	1.176561 (0.2781)	0.885143 (0.3468)
EGARCH (11)			
F-Test	0.887583 (0.3475)	1.211946 (0.2726)	0.971622 (0.3257)
nR^2	0.893571 (0.3445)	1.217727 (0.2698)	0.977679 (0.3228)

Appendix-2. ARCH LM test of estimated volatility of oil price and exchange rate.

	Normal Distribution	Student's t Distribution	Generalized Error Distribution
GARCH (11)			
F-Test	0.269399 (0.6044)	8.21E-05 (0.9928)	0.019641 (0.8887)
nR²	0.272237 (0.6018)	8.31E-05 (0.9927)	0.019879 (0.8879)
GARCH-M (11)			
F-Test	0.123726 (0.7255)	0.000153 (0.9901)	0.605669 (0.4375)
nR²	0.125140 (0.7235)	0.000155 (0.9901)	0.610800 (0.4345)
TGARCH (11)			
F-Test	0.090785 (0.7636)	0.441826 (0.5072)	0.010340 (0.9191)
nR²	0.091841 (0.7618)	0.446013 (0.5042)	0.010465 (0.9185)
EGARCH (11)			
F-Test	0.362474 (0.5480)	0.006512 (0.9358)	0.165000 (0.6851)
nR²	0.366085 (0.5451)	0.006591 (0.9353)	0.166844 (0.6829)

Appendix-3. ARCH LM Test of Estimated Volatility of Oil Price and Inflation Rate

	Normal Distribution	Student's t Distribution	Generalized Error Distribution
GARCH (11)			
F-Test	1.082636 (0.3714)	1.082645 (0.3714)	1.075389 (0.3806)
nR²	38.39605 (0.3614)	38.39629 (0.3614)	38.21400 (0.3692)
GARCH-M (11)			
F-Test	2.520672 (0.1143)	0.054911 (0.8150)	1.176303 (0.2639)
nR²	2.512791 (0.1129)	0.055563 (0.8137)	40.68624 (0.2716)
TGARCH (11)			
F-Test	1.108471 (0.3394)	1.108469 (0.3394)	1.113664 (0.3332)|
nR²	39.03925 (0.3348)	39.03920 (0.3348)	39.16747 (0.3296)
EGARCH (11)			
F-Test	0.553628 (0.4579)	1.305176 (0.1548)	2.150350 (0.1445)
nR²	0.558494 (0.4549)	43.65821 (0.1780)	2.148404 (0.1427)

Appendix-4. ARCH LM Test of Estimated Volatility of Oil Price and Bank Reserve.

	Normal Distribution	**Student's t Distribution**	**Generalized Error Distribution**
GARCH (11)			
F-Test	0.020263 (0.8870)	0.020263 (0.8870)	0.108358 (0.7424)
nR^2	0.020508 (0.8861)	0.020508 (0.8861)	0.109607 (0.7406)
GARCH-M (11)			
F-Test	0.000273 (0.9868)	0.000273 (0.9868)	0.063608 (0.8012)
nR^2	0.000276 (0.9867)	0.000276 (0.9867)	0.064359 (0.7997)
TGARCH (11)			
F-Test	0.997102 (0.4877)	0.658292 (0.4183)	0.722148 (0.3967)
nR^2	36.20085 (0.4593)	0.663656 (0.4153)	0.727750 (0.3936)
EGARCH (11)			
F-Test	0.218740 (0.6406)	0.218740 (0.6406)	0.368188 (0.5448)
nR^2	0.221112 (0.6382)	0.221112 (0.6382)	0.371843 (0.5420)

Appendix-5. Serial correlation test results of selected models for oil price volatility and M2.

Lag	AC	PAC	Q-Stat	Prob*	AC	PAC	Q-Stat	Prob	AC	PAC	Q-Stat	Prob	AC	PAC	Q-Stat	Prob
	GARCH (11)				GARCH –M (11)				TGARCH (11)				EGARCH (11)			
1	-0.039	-0.039	0.2646	0.607	-0.106	-0.106	1.8975	0.168	-0.107	-0.107	1.9639	0.161	-0.140	-0.140	3.3351	0.068
2	0.108	0.107	2.2579	0.323	-0.057	-0.069	2.4487	0.294	-0.108	-0.121	3.9691	0.137	-0.066	-0.088	4.0871	0.233
3	-0.075	-0.068	3.2260	0.358	-0.025	-0.039	2.5561	0.465	0.011	-0.015	3.9904	0.262	-0.033	-0.057	4.2778	0.365
`4	-0.066	-0.083	3.9800	0.409	0.030	0.019	2.7068	0.608	0.032	0.018	4.1628	0.384	-0.015	-0.057	4.3145	0.365
5	-0.045	-0.035	4.3313	0.503	-0.002	-0.001	2.7079	0.745	0.050	0.057	4.5947	0.467	0.028	0.014	4.4560	0.486
6	0.063	0.07 4	5.0325	0.540	0.043	0.046	3.0367	0.804	0.108	0.130	6.6231	0.357	0.099	0.103	6.1647	0.405
7	-0.045	-0.043	5.3851	0.613	-0.147	-0.138	6.8256	0.447	-0.116	-0.078	9.0028	0.252	-0.110	-0.080	8.2910	0.308
8	-0.018	-0.049	5.4439	0.709	-0.134	-0.167	10.017	0.264	-0.093	-0.096	-0.096	0.230	-0.129	-0.146	11.230	0.224
9	-0.098	-0.090	7.1480	0.622	-0.056	-0.090	10.203	0.334	-0.007	-0.061	10.531	0.309	-0.057	-0.113	11.819	0.224
10	0.017	0.023	7.1995	0.706	-0.032	-0.110	10.776	0.375	-0.044	-0.088	10.878	0.367	-0.026	-0.086	11.936	0.289
11	-0.064	-0.049	7.9291	0.720	0.204	0.195	10.958	0.447	-0.006	-0.035	10.884	0.453	0.002	-0.055	11.936	0.224

Appendix-6. Serial correlation test results of selected models for oil price volatility and exchange rate.

Lag	AC	PAC	Q-Stat	Prob*	AC	PAC	Q-Stat	Prob	AC	PAC	Q-Stat	Prob	AC	PAC	Q-Stat	Prob
	GARCH (11)				GARCH –M (11)				TGARCH (11)				EGARCH (11)			
1	0.050	0.050	0.4189	0.518	0.133	0.133	3.0182	0.082	0.102	0.102	1.7757	0.183	0.125	0.125	2.6761	0.102
2	-0.013	-0.015	0.4475	0.800	0.052	0.035	3.4765	0.176	0.071	0.062	2.6489	0.266	0.069	0.054	3.4989	0.174
3	0.032	0.034	0.6278	0.890	0.097	0.087	5.0887	0.162	0.104	0.092	4.5157	0.211	0.050	0.036	3.9349	0.269
4	0.018	0.014	0.6824	0.953	0.092	0.069	6.5508	0.162	0.101	0.080	6.2676	0.180	0.008	-0.006	3.9465	0.413
5	0.014	0.014	0.7175	0.982	0.087	0.062	7.8609	0.164	0.103	0.078	8.1275	0.149	0.059	0.055	4.5515	0.595
6	-0.051	-0.053	1.1707	0.978	0.011	-0.020	7.8838	0.247	0.000	-0.035	8.1275	0.229	-0.015	-0.016	4.6464	0.703
7	-0.021	-0.017	1.2512	0.990	0.047	0.032	8.2798	0.309	0.030	0.007	8.2832	0.308	0.044	0.047	4.9956	0.758
8	0.011	0.010	1.2726	0.998	0.065	0.039	9.0192	0.341	0.064	0.040	9.0038	0.342	-0.044	-0.052	5.3389	0.804
9	-0.011	-0.010	1.2944	0.998	0.054	0.031	9.5363	0.389	0.017	-0.005	9.0553	0.432	-0.133	-0.132	8.5069	0.579
10	0.027	-0.039	1.6284	0.998	-0.021	-0.046	9.6178	0.475	-0.048	-0.064	9.4656	0.489	0.026	0.064	8.6277	0.656
11	0.027	0.033	1.7638	0.999	0.064	0.060	10.363	0.498	0.027	0.028	9.5933	0.567	-0.096	-0.090	10.315	0.588

Appendix-7. Serial Correlation Test Results of Selected Models for Oil Price Volatility and Inflation Rate.

Lag	AC	PAC	Q-Stat	Prob*	AC	PAC	Q-Stat	Prob	AC	PAC	Q-Stat	Prob	AC	PAC	Q-Stat	Prob
	GARCH (11)				GARCH –M (11)				TGARCH (11)				EGARCH (11)			
1	0.172	0.172	5.0172	0.025	0.147	0.147	3.6815	0.055	0.169	0.169	4.8675	0.027	0.114	0.114	2.1936	0.139
2	0.064	0.036	5.7177	0.057	0.062	0.041	4.3430	0.114	0.079	0.052	5.9481	0.051	0.034	0.021	2.3911	0.303
3	0.071	0.056	6.5925	0.086	0.110	0.098	6.4423	0.092	0.103	-0.084	7.7866	0.051	0.133	0.129	5.4468	0.142
4	-0.101	-0.129	8.3744	0.079	-0.111	-0.147	8.5813	0.072	-0.090	-0.128	9.1821	0.057	-0.037	-0.068	5.6811	0.224
5	-0.038	-0.005	8.6200	0.125	-0.024/	0.004	8.6794	0.123	-0.021	0.002	9.2624	0.099	0.036	0.044	5.9056	0.316
6	0.019	0.034	8.6864	0.192	-0.021	-0.020	8.7581	0.188	0.015	0.023	9.3016	0.157	0.067	0.043	6.6818	0.351
7	0.060	-0.053	9.3286	0.230	-0.062	-0.027	9.4256	0.224	-0.052	-0.037	9.7835	0.201	0.026	0.027	6.7977	0.450
8	0.029	0.038	9.4802	0.303	0.030	0.032	9.5828	0.296	0.030	0.035	9.9477	0.269	0.178	0.164	12.394	0.134
9	-0.073	-0.094	10.426	0.317	-0.081	-0.091	10.766	0.292	-0.081	-0.099	11.111	0.268	-0.070	-0.127	13.265	0.151
10	-0.071	-0.034	11.336	0.332	-0.073	-0.047	11.723	0.304	-0.072	-0.035	12.047	0.282	-0.040	-0.022	13.548	0.195
11	-0.048	-0.042	11.760	0.382	-0.036	-0.033	11.959	0.367	-0.047	-0.038	12.446	0.331	0.034	-0.002	13.752	0.247

Appendix-8. Serial correlation test results of selected models for oil price volatility and bank reserve.

Lag	AC	PAC	Q-Stat	Prob*	AC	PAC	Q-Stat	Prob	AC	PAC	Q-Stat	Prob	AC	PAC	Q-Stat	Prob
	GARCH (11)				GARCH –M (11)				TGARCH (11)				EGARCH (11)			
1	0.064	0.064	0.6860	0.408	0.037	0.037	0.2344	0.628	0.064	0.064	0.6860	0.408	0.033	0.033	0.1840	0.668
2	-0.118	-0.123	3.0818	0.214	-0.006	-0.007	0.2404	0.887	-0.118	-0.123	3.0818	0.214	-0.093	-0.095	1.6765	0.432
3	-0.027	-0.011	3.2082	0.361	0.108	0.109	2.2528	0.522	-0.027	-0.011	3.2082	0.361	0.000	0.007	1.6765	0.642
4	-0.008	-0.020	3.2199	0.522	0.029	0.021	2.3943	0.664	-0.008	-0.020	3.2199	0.522	-0.022	-0.032	1.7622	0.779
5	0.029	0.027	3.3672	0.644	0.103	0.105	4.2471	0.514	0.029	0.0270	3.3672	0.644	0.012	0.015	1.7866	0.878
6	-0.014	-0.022	3.4030	0.757	0.091	0.074	5.6892	0.459	-0.014	-0.022	3.4030	0.757	-0.007	-0.013	1.7945	0.938
7	-0.027	-0.019	3.5351	0.831	0.025	0.018	5.7983	0.563	-0.027	-0.019	3.5351	0.831	-0.039	-0.036	2.0641	0.956
8	-0.061	-0.034	3.7311	0.881	0.060	0.041	6.4394	0.598	-0.033	-0.034	3.7311	0.881	-0.031	-0.031	2.2317	0.973
9	-0.061	-0.063	4.3981	0.883	0.049	0.027	6.8703	0.651	-0.061	-0.063	4.3981	0.915	-0.050	-0.055	2.6807	0.976
10	0.035	0.034	4.6170	0.915	0.031	0.013	7.0392	0.722	0.186	0.170	10.869	0.454	-0.031	-0.013	1.7945	0.938
11	0.186	0.170	10.869	0.454	0.445	0.432	42.839	0.000	-0.052	-0.074	11.371	0.497	-0.039	-0.036	2.0641	0.956

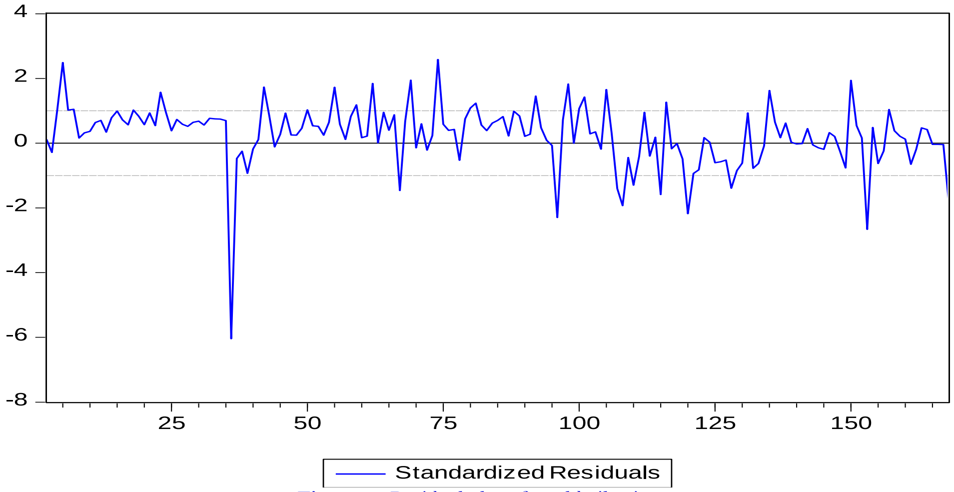

Figure-1. Residual plot of world oil price.

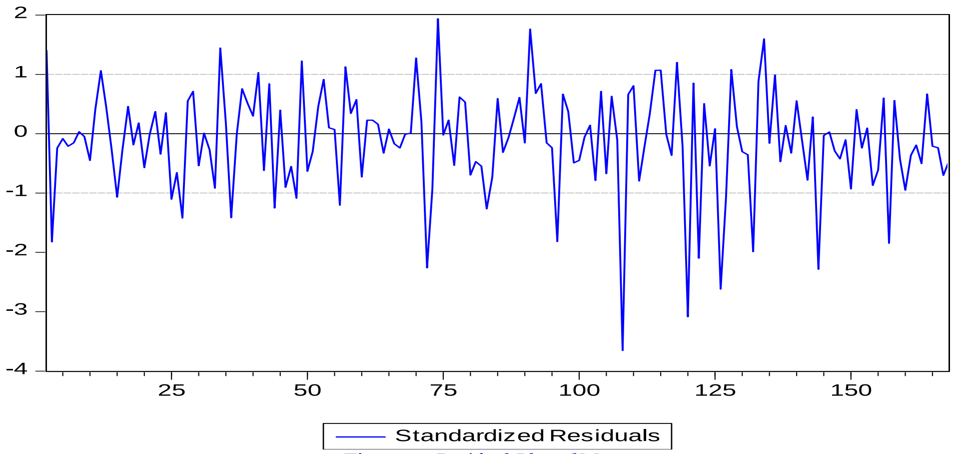

Figure-2. Residual Plot of M2.

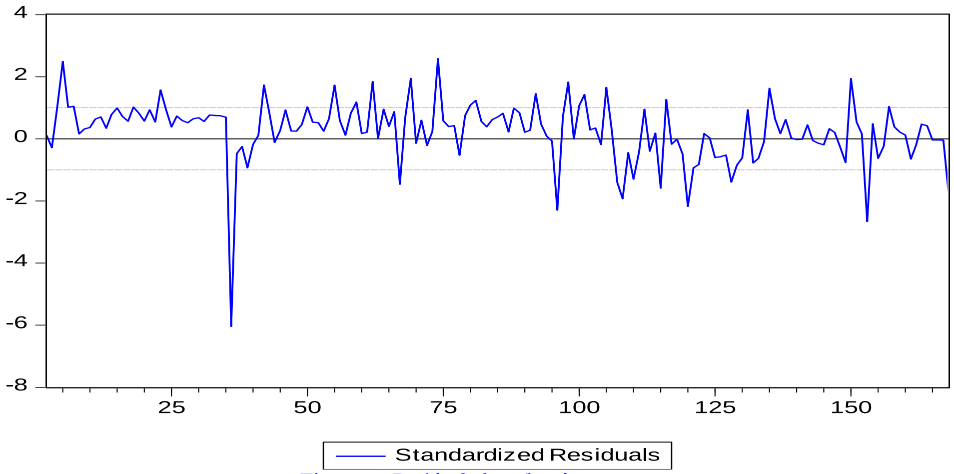

Figure-3. Residual plot of exchange rate.

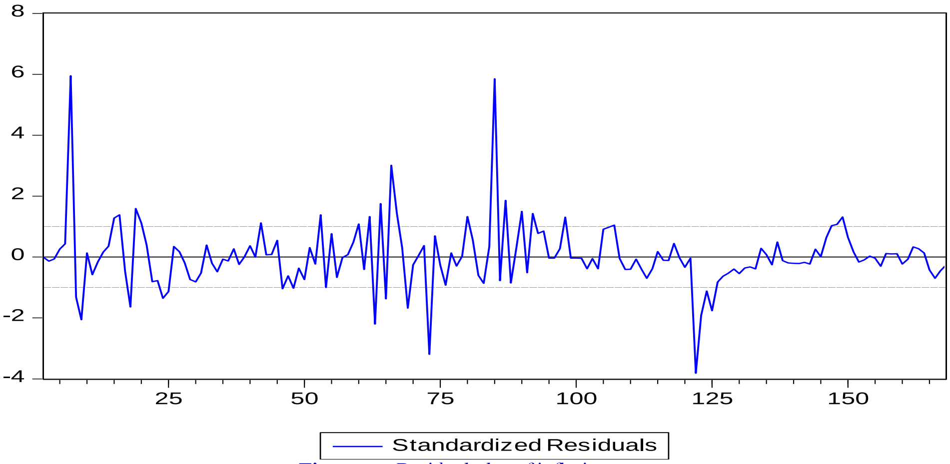

Fig.ure-4. Residual plot of inflation rate.

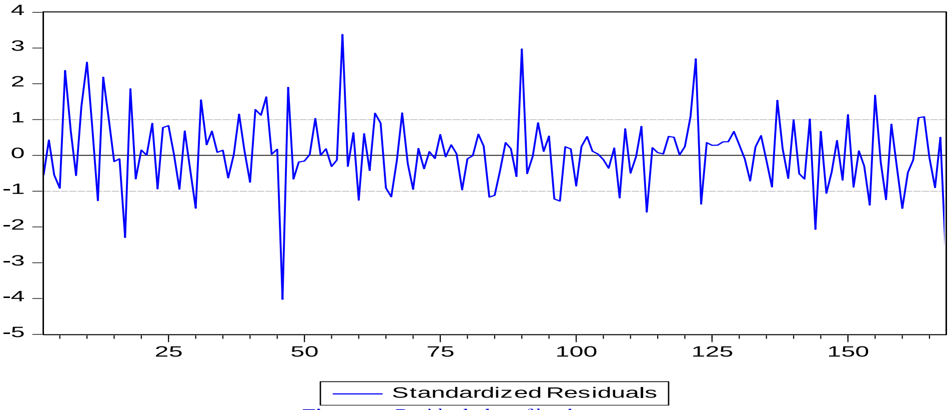

Figure-5. Residual plot of bank reserve.