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Examining the Impact of Crude Oil Price on External Reserves: Evidence from Nigeria

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Abstract

This paper studies the impact of crude oil price on the conditional mean and volatility of external reserves and the empirical finding suggests a significant positive impact of crude oil price. The monthly external reserves and crude oil price from January 1995 to December 2013 are modeled using the GARCH-M and EGARCH-M. The Augmented Dickey-Fuller and Phillips-Perron statistical tests for unit root suggest the data to be stationary in first difference. Also, each variable show evidence of ARCH effect. Results from GARCH estimate indicate evidence of a persistent shock to volatility. The findings show the volatility term to be statistically significant in the mean equations implying that the mean is not constant but changes with volatility. In addition, the result shows that oil price variability (volatility) has a positive impact on the volatility of external reserves. While the coefficient, γ is positive in the EGARCH model, meaning that the impact on the conditional variance of the external reserves is asymmetric. Because β is positive, evidence of leverage effects does not exist.

Keywords: unit root, arch, garch, egarch, tarch, volatility, crude oil price, external reserves

1. Introduction

Nigeria relies on external reserves (also known as international reserves, foreign exchange, foreign exchange reserves and foreign currencies) deposits in foreign currencies such as the US dollar, British pound, Euro, and Japanese Yen (Emmanuel, 2013). External reserves also include gold, silver, Special Drawing Rights (SDRs) and International Monetary Fund (IMF). The focus of this paper is to investigate the impact of crude oil price on the external reserves of Nigeria by exploring how the mean and variance (volatility) of the external reserves are affected. From 1970s to present, the foreign exchange reserves from the sales of crude oil constitute a major component of the external reserves. Besides, the oil sector accounts for a significant growth of the domestic economy. Therefore, this empirical study contributes to the literature by applying non-linear modeling of GARCH-M and EGARCH-M to addressing the following questions:

A) Does crude oil price affect the conditional mean and volatility of external reserves?

B) Is there a persistence shock to volatility in the external reserves?

C) Does the monthly mean of external reserves depend on the volatility level?

D) Do positive and negative innovations have different effects on the volatility?

Previous studies have examined the determinants and sustainability of external reserve accumulation, and the effects of external reserves on exchanges and inflation; investigated how changes in macroeconomics variables influences foreign reserves; the relationship between oil price shock and current account balances; the impact of external reserve variability on investment, inflation and exchange rate; and the effect of crude oil price and other macroeconomic variables on real external reserves (Shuaibu & Mohammed, 2014; Emmanuel, 2013; Olokoyo, Osabuohien, & Salami, 2009; Chuku, Akpan, Sam, & Effiong, 2011; Abdul-Lateef & Waheed, 2010; Audu & Okumoko, 2013). It's safe to say that none of these studies have isolated and examined the relationship between crude oil price and external reserves.

1.1 Importance of the Problem

This study is worth pursuing because over 90% of Nigeria's foreign exchange earnings come from crude oil and gas exports (Note 1) (Shuaibu & Mohammed, 2014; Abdulazeez & Omade, 2011). Abiola and Adebayo (2013), proceeds from crude oil predominantly accounts for Nigeria's external reserves. In addition, the 1995 external reserves stood at about US$1.295 billion but rose to US$62.08 in September 2008 and fell to a balance of US$42.54billion as at December 2013 (Note 2). These periods correspond to periods of significant higher world crude oil prices. Nigeria is a member of the Organization of Petroleum Exporting Countries (OPEC); as a result, the nation's external account is believed to be prone to fluctuations in global world oil prices. In addition to other hypotheses, this hypothesis is investigated in this study. Unlike other studies, this study use non-linear models (GARCH and EGARCH) to investigate the relationship between crude oil price and external reserves in Nigeria.

1.2 Literature Review

Most empirical research studies have focused on developed and developing countries, while studies on Nigeria have focused on descriptive analysis and the determinants of external reserves. Of these studies, Abiola and Adebayo (2013) conducted a descriptive analysis, while Emmanuel (2013), Abdul-Lateef and Waheed (2010), Shuaibu and Mohammed (2014) applied Ordinary Least Square (OLS) to estimate the relationship between foreign reserves and macroeconomic variables. AbdulazeezB and Omade (2011) used the OLS estimation technique and found evidence of a positive relationship between the external reserves and GDP. Chinaemerem and Ebiringa (2012) estimated the VAR model in examining long-run relationships between the macroeconomic variables and external reserve management. The authors found that the nature, pattern and level of capital goods and non-capital goods have a direct impact on the external reserve management in Nigeria.

Audu and Okumoko (2013) applied Johnsen Cointegration technique in investigating the Nigeria's real external reserves as determined by real exchange rate, trade openness, crude oil price, credit to the public sector, capital account vulnerability, current account vulnerability, the opportunity cost of holding reserves and foreign direct investment. The authors provided evidence of cointegration among the variables. Chuku, Akpan, Sam and Effiong (2011) studied the relationship between oil price shock and the current account balances of Nigeria and found evidence of oil price shocks having a significant short-run effect on current account balances. Abdullateef and Waheed (2010) studied the effect of external reserves on investment, inflation and exchange rate. Using the OLS and Vector error correction (VEC), the authors found support for a positive relationship between the external reserves the independent variables. Olokoyo et al. (2009) applied the ARDL method, causality tests for Vector Error Correction and variance decomposition in studying the interactive influence of external reserves on GDP, trade, the level of capital inflows, exchange rate and inflation. The authors found evidence of a long-run relationship between the variables and slow speed of adjustment from short-run to long-run.

1.3 Theoretical Foundations of External Reserves, Hypotheses

The International Monetary Fund (IMF) established guidelines for countries to manage external reserves. Like other countries, Nigeria follows these guidelines. The Central Banks of Nigeria is the constitutional monetary authority of the nation and holds external reserves for: (a) financing international transactions, (b) backing the value of domestic currency, (c) accumulating wealth for future use, (d) controlling the money supply and a balance between supply and demand for foreign exchange (Offering to buy or sell foreign currency to banks) in the foreign exchange markets, (e) enhancing of a country's credit worthiness, (f) serving as a "Raining Day" funds and (g) as a buffer against external shocks (Note 3). In line with these guidelines, three theoretical underpinnings for external reserve accumulation emerged for developing countries and these are: (a) Self-insurance theoretical model, (b) Mercantilist theoretical model and c) Macroeconomic stabilization theoretical model. Besides the three theories identified above, other studies have also postulated transactions and precautionary motives as other reasons for holding foreign reserves (Abiola & Adebayo, 2013; Frenkel & Jovanovic, 1981) (Note 4).

1.4 Hypotheses (H) and Research Questions (RQ)

1.4.1 Primary Hypotheses

The goal of this study is to contribute to the literature by addressing the following hypotheses and questions:

Hypothesis #1 (H1): There is a relationship between crude oil price and the external reserves volatility.

RQ #1. Does crude oil price impact conditional mean and volatility of external reserves? To address this question, oil price is introduced into both the GARCH and EGARCH mean and variance equations in Model I. If the signs of the coefficients are positive (negative), then the higher crude price will lead to a higher (lower) level of external reserves. In Model II, crude oil price variability (to capture volatility) is included in the GARCH and EGARCH variance equations.

Hypothesis #2 (H2): The shock to volatility in the external reserves may be persistent.

RQ #2. Is there a persistent shock to volatility in the external reserves? With the GARCH model, persistence of shocks to volatility in the external reserves is captured by adding the ARCH and GARCH coefficients ($\alpha+\beta$ in Model I and Model II).

Hypothesis #3 (H3): The mean of external reserves is influenced by the volatility level.

RQ #3. Does the monthly mean of external reserves depend on the volatility level? However, to investigate RQ #3, a volatility term, log(Var) is included as an explanatory variable in the mean questions in Model I and Model II.

1.4.2 Secondary Hypothesis

Hypothesis #4 (H4): Positive and negative innovations have different effects on the volatility.

RQ #4. Do positive and negative innovations have different effects on the volatility? In the EGARCH variance equations, the asymmetric effect of past shocks is captured by the coefficient γ, although expected to have positive sign, but can also have a negative sign.

Since Section 1 is the introduction, relevance of the problem, hypotheses, research questions and literature review, Section 2 contains the empirical models. Section 3 presents the data description and empirical findings, diagnostic test, while section 4 contains the conclusion.

2. Empirical Models

2.1 ARCH

To answer the research questions 1 to 4, both generalized GARCH-M and EGARCH-M models are specified and estimated with the log levels and first difference of the data. First, the crude oil price and external reserves are tested for evidence of ARCH effect in equations 1a and 1b by Ordinary Least Square. The ARCH test (Heteroskedasticity test) results are reported in Table 2. The Null hypothesis is H_o = there is no ARCH effect and the alternative hypothesis is H_a = there is ARCH effect. Because each p-value (probability) is less than 5%, the Null (H_o) is rejected, while the Alternative (H_a) is accepted, suggesting evidence of ARCH effect in the variables.

2.2 GARCH-M Model

Although ARCH and GARCH models permit the conditional variances to vary over time as a function of past errors, the GARCH model incorporates a lagged conditional variance, σ^2_{t-1}, as seen in Equations 3a and 3b. Bollerslev (1986) mean equation is equation 2a, while the variance equation is equation 3. Following Morales (2008) and Yaya and Shittu (2010), the generalized empirical GARCH-M (1, 1) specified mean equations are equation 2a in Model I and equation 2b in Model II.

$$E = C \tag{1a}$$

$$O = C \tag{1b}$$

$$E_t = b_0 + b_1E_{t-1} + b_1E_{t-2} + b_3O_t + b_4\sqrt{\sigma 2} + \varepsilon_t \tag{2a}$$

$$\Delta E_t = \eta_0 + \eta_1\Delta Et_{-1} + \eta_2\Delta Et_{-2} + \eta_3\sqrt{\sigma 2} + \varepsilon_t \tag{2b}$$

Where E is the log of external reserves, O is the log of the crude oil price, C is a constant, t-1 and t-2 are lagged 1 to 2 months. The lags are included to account for possible bias because of serial correlation. Moreover, equations 2a and 2b are the mean equations with equation 2a being the log level, while equation 2b is estimated with the first difference. In equation 2a the sign of b_3 is postulated to be positive in (hypothesis #1) and expected to be statistically significant to establish the impact of crude oil price on external reserves. Also b_4 and η_3 are expected to be positive (hypothesis #3) and significant meaning that the mean depends on the volatility level and not constant.

$$\sigma_t^2 = \omega + \alpha\varepsilon^2_{t-1} + \beta\,\sigma^2_{t-1} \tag{3}$$

However, to capture the impact of crude oil price volatility (π) on the volatility of external reserves, equation 2b and 3b are estimated and in both equations, π is hypothesized to be positive or negative. Moreover, from equations 3a and 3b, $\omega > 0$, $\alpha > 0$ and $\beta > 0$, and when the sum of $\alpha+\beta$ is close to one (H2: $\alpha+\beta$ close to 1), it means that volatility shocks are persistent, while the variance equation is said to be stationary. If the sum is less than one, then shock recedes after some time. In this study, there is evidence of shocks on the conditional variance persisting over time. Engle and Bollerslev (1986) stated that when $\alpha+\beta = 1$, there is an Integrated GARCH, which shows that the shocks to the conditional variance (volatility) persist into future horizons. RQ #1 to 3 are addressed by estimating equations 2a and 3a, and 2b and 3b:

$$\sigma^2_t = \omega + \alpha\varepsilon^2_{t-1} + \beta\,\sigma^2_{t-1} + \psi O_t \tag{3a}$$

$$\sigma^2_t = \omega + \alpha\varepsilon^2_{t-1} + \beta\,\sigma^2_{t-1} + \pi\Delta O_t \tag{3b}$$

2.3 EGARCH- M Model

Furthermore, Yoon and Lee (2008) argued that a weakness of GARCH model is that it cannot encapsulate leverage effects, asymmetric information effects that influence volatility when negative shocks occurred more than positive shocks. Nelson (1991) proposed the EGARCH model and the conditional variance can be expressed in various ways. The major advantages of EGARCH over GARCH are that the left side of the conditional variance equation is the log of the conditional variance, meaning that the leverage effect is exponential and not quadratic and that forecast of the conditional variance of the external reserves will be nonnegative (Yoon & Lee, 2008). When the relationship between oil price volatility and external reserves is inverse, γ will be negative. Also, even if the parameters are negative, the conditional variance will be positive; hence no need to impose non-negativity constraints on the parameters (Brooks, 2008). In line with Nelson (1991), the conditional variance of the EGARCH model is written as:

$$log\sigma_t^2 = \omega + \beta log\sigma_{t-1}^2 + \propto \left|\frac{\varepsilon_{t-i}}{\sigma_{t-i}}\right| + \gamma\frac{\varepsilon_{t-k}}{\sigma_{t-k}} \quad (4)$$

In equations 4a and 4b, if the absolute value of $\beta < 1$, the conditional variance is stationary. Besides, the scale and the sign of the coefficient, γ captures the asymmetry. It's postulated to be negative (hypothesis #4) meaning everything else being equal, positive shocks create less volatility than negative shocks (Longmore & Robinson, 2004). If $\gamma=0$, negative and positive shocks have the same effect on volatility, while α captured the size effect and is postulated to be positive. This approach encapsulated the sign effect by allowing positive and negative innovations to have different effects on the volatility. In addition, the findings show that γ has different signs in Model 1 and Model II. Longmore and Robinson (2004) stated that using absolute shocks and logs in this parameterization facilitate capturing the size effect because it increases the impact of large shocks on the next period conditional variance. Furthermore, the effect oil price volatility (π) on the external reserve volatility is captured in estimated variance equation 4b, π is hypothesized to be statistically significant. RQ# 2 to 4 are answered by estimating Eq. 2a and 4a, and 2b and 4b:

$$Log(\sigma 2t) = \omega + \beta Log(\sigma 2t\text{-}1) + \propto \left|\frac{\varepsilon_{t-i}}{\sigma_{t-i}}\right| + \gamma\frac{\varepsilon_{t-k}}{\sigma_{t-k}} + \psi Ot \quad (4a)$$

$$Log(\sigma 2t) = \omega + \beta Log(\sigma 2t\text{-}1) + \propto \left|\frac{\varepsilon_{t-i}}{\sigma_{t-i}}\right| + \gamma\frac{\varepsilon_{t-k}}{\sigma_{t-k}} + \pi\Delta Ot \quad (4b)$$

3. Data Description and Empirical Results

3.1 Data Description, Unit Root Analysis

Moreover, the Central Bank of Nigeria 2012 and 2013Q4 Statistical Bulletins contain the data for Nigeria's external reserves from January 1995 to December 2013. The crude oil price for the Nigerian Bonny Light is not available; as a result the West Texas Intermediate (WTI) spot price collected from the US Energy information Administration's website is the proxy. The EViews 7.0 software is used in all analyses. Table 1 contains the descriptive statistics such as the sample mean, median, maximum and minimum. Both variables are skewed to the left (-0.5236 and -0.0334) in log levels, meaning that each variable distribution has a long left tail. Each variable's kurtosis is less than 3 suggesting that the distribution is platykurtic relative to the normal. The correlation between the external reserves and crude oil price is positive and strong (0.8714). While the skewness of the first difference of external reserves is negative, that of the crude oil price is positive and the Jarque-Bera test statistics for the normal distribution is rejected in both log level and first difference. In Table 2, both Augmented Dickey-Fuller and Phillips-Perron statistical tests have the same null hypothesis of a unit root in each variable and the results suggest that external reserves and crude oil price are integrated of order one, that is stationary in first difference.

Table 1. Descriptive statistics and the correlation

	ER (Level)	COP (Level)	ΔER	ΔCOP
Mean	9.5878	3.7293	0.0154	0.0074
Median	9.3783	3.6809	0.0107	0.0153
Maximum	11.0362	4.8882	1.8866	0.2041
Minimum	6.9107	2.4292	-1.6548	-0.332
Std. Deviation	1.0693	0.6604	0.1864	0.0823
Skewness	-0.5236	-0.0334	1.2591	-0.7785
Kurtosis	2.4091	1.6332	74.2368	4.8526
Jarque-Bera	13.7345	17.7904	48057.97	55.3923

Probability	-0.001	-0.0001	0	0
Sum	2186.015	850.2776	3.499	1.6886
Sum Sq. Deviation	259.5659	99.0114	7.8534	1.5293
Sample Size	228	228	227	227

Note. The correlation between External Reserve and Crude Oil Price=0. 8714.

ER = Exter Reserves; COP = Crude Oil Price; Δ = first difference.

Table 2. Unit root in external reserve and crude oil price; Arch test (Heteroskedasticity test)

	ADF		Phillips-Perron		LM Test	
Variables	First Difference	Level	First Deference	F-Statistics	Obs*R-squared	
LER	-0.8199	-12.7944*	-2.0578	-18.4158*	562.3242**	204.1256**
LOPW	-1.1502	-11.7780*	-1.1423	-11.7588	643.3323**	206.4319**

Note. *5% Significance levels; ** P-values are zero, significant at 5% significance level.

3.2 ARCH, GARCH-M and EGARCH-M

The ARCH LM test (Heteroskedasticity Test) results from equations 1a and 1b are reported in Table 2. In each equation, the F-version and LM-statistics p-values (probabilities) are less than 5%; consequently, the null hypothesis of no ARCH effect is rejected, while the alternative is accepted in both variables. The equations are estimated as Model I and Model II with each p-values in parenthesis.

Model I: Log Level		Model II: Log First Difference	
GARCH-M:	Equations 2a and 3a	GARCH-M:	Equations 2b and 3b
EGARCH-M:	Equations 2a and 4a	EGARCH-M:	Equations 2b and 4b

Hypothesis #1 (H): There is a relationship between crude oil price volatility and the external reserves volatility.

RQ #1: Does crude oil price impact conditional and volatility of external reserves?

Model I: From the estimated GARCH and EGARCH mean equations, crude oil price coefficient (b_3) has positive signs and statistically significant at the 5% significance level, meaning that crude oil price impacts the mean of the external reserves. The implication is that, a rise in crude oil price will have a positive impact on the mean of the external reserve balance, while decreases in crude oil price will have the opposite effect. This finding supports hypothesis #1. Abdulazeez and Omade (2011) also found evidence of oil exports affecting external reserves. Also in the variance equations, oil price coefficient, ψ has a negative sign and statistically significant at the 5% significance level.

Model II: Similar to Yaya and Shittu (2010), the impact of oil price variability on the external reserve volatility is captured in the GARCH and EGARCH variance equations 3b and 4b. The coefficients (π) are 0.0014 and 1.71, positive and statistically significant, implying that oil price volatility has a positive impact on the volatility of external reserves. Thus, this finding supports a positive relationship between crude oil price volatility and the external reserves volatility; hence there is evidence in support of hypothesis #1.

Hypothesis #2 (H2): The shock to volatility in the external reserves may be persistent.

RQ #2. Is there a persistent shock to volatility in the external reserves?

Model I: In equation 3a, there is evidence of $\omega > 0$, (0.0012); $\alpha > 0$ (0.1320) and $\beta > 0$ (0.7963) meaning the variance equation is stationary. From the estimated GARCH mean equation 3a, both α and β coefficients are 0.1320 and 0.7962, respectively, and significant at the 5% probability. The sum of the coefficients ($\alpha+\beta$) is 0.9282, although less that one, the magnitude is high; hence there is an evidence of a persistency of shocks to volatility. This evidence supports shocks to volatility to be persistent and hypothesis #2.

Model II: From equation 3b there is evidence of $\omega > 0$, (0.0002); $\alpha > 0$ (0.1103) and $\beta > 0$ (0.7864) meaning this equation is stationary. In addition, the sum of the coefficients ($\alpha+\beta=0.1103+0.7863$) is 0.8993 and is close to one; thus this result supports hypothesis #2.

Hypothesis #3 (H3): The mean of external reserves is influenced by the volatility level.

RQ #3. Does the monthly mean of external reserves depend on the volatility level?

Model I: In the estimated GARCH and EGARCH mean equations, the volatility term coefficient, b_4 is statistically significant, but with different signs implying that the mean depends on the volatility level and not constant. This evidence supports hypothesis #3.

Model II: Furthermore, the volatility term (η_3) is positive and statistically significant in both GARCH and EGARCH mean equations suggesting that the mean is not constant, but changes with volatility and this finding support H3.

Model 1:

Estimated GARCH-M (1 1) equations 2a and 3a.

$E_t = 0.1968 + 0.8896E_{t-1} + 0.0881E_{t-2} + 0.0914O_t + 0.0510\sqrt{\sigma 2} + \varepsilon_t$

(0.0000) (0.0000) (0.000) (0.0000) (0.0000)

$\sigma^2_t = 0.0012 + 0.1320\varepsilon^2_{t-1} + 0.7962\ \sigma^2_{t-1} - 0.0003O_t$

(0.0000) (0.0000) (0.0000) (0.0000)

R2=0.967; Adj. R2=0.967; Max. Log-likelihood=356.7667; Akaike Criterion=-3.0687.

Schwarz criterion=-2.9174; Hannan-Quinn criterion=-3.0077.

P-value in parenthesis are less than 5% probability of significance and are therefore statistically significant.

Estimated EGARCH (1 1 1) equation 2a and 4a.

$E_t = 0.6882 + 0.7927E_{t-1} + 0.0336E_{t-2} + 0.0483O_t - 0.1354\ \sqrt{\sigma 2} + \varepsilon_t$

(0.000) (0.000) (0.3544) (0.0000) (0.0000)

$Log(\sigma^2_t) = -0.0790 + 0.9235Log(\sigma^2_{t-1}) - 0.0999\left|\frac{\varepsilon_{t-i}}{\sigma_{t-i}}\right| - 0.0758\frac{\varepsilon_{t-k}}{\sigma_{t-k}} - 0.0886O_t$

(0.0472) (0.0000) (0.0000) (0.0000) (0.0000)

R^2=0.967; Adj. R^2=0.966; Max. Log-likelihood=362.4599; Akaike Criterion=-3.1103.

Schwarz criterion=-2.9438; Hannan-Quinn criterion=-3.0431.

P-values in parentheses are less than 5% probability of significance and therefore statistically significant.

Model II:

Estimated GARCH-M (1 1) equations 2b and 3b.

$E_t = 0.1183 + 0.1572E_{t-1} + 0.1900\ E_{t-2} + 0.0118\ \sqrt{\sigma 2} + \varepsilon_t$

(0.0000) (0.0107) (0.0027) (0.0001)

$\sigma^2_t = 0.0002 + 0.1103\varepsilon^2_{t-1} + 0.7863\sigma^2_{t-1} + 0.0015\Delta O_t$

(0.0055) (0.0374) (0.0000) (0.0000)

R2=-0.1288; Adj. R2=-0.1441; Max. Log-likelihood=353.9014; Akaike Criterion=-3.0658.

Schwarz criterion=-2.929; Hannan-Quinn criterion=-3.0106.

P-values in parentheses are less than 5% probability of significance and are therefore statistically significant.

Estimated EGARCH (1 1 1) equation 2b and 4b.

$Et = 0.1772 + 0.0762Et\text{-}1 + 0.1450Et\text{-}2 + 0.0266\sqrt{\sigma 2} + \varepsilon t$

(0.000) (0.1854) (0.0155) (0.0000)

$Log(\sigma 2t) = -0.3678 + 0.9595Log(\sigma 2t\text{-}1) + 0.1227\left|\frac{\varepsilon_{t-i}}{\sigma_{t-i}}\right| + 0.0410\frac{\varepsilon_{t-k}}{\sigma_{t-k}} + 1.7172\ \Delta Ot$

(0.0000) (0.0000) (0.0352) (0.3038) (0.0016)

R2=-0.1099; Adj. R2=-0.1249; Max. Log-likelihood=355.5073; Akaike Criterion=-3.0712.

Schwarz criterion=-2.9194; Hannan-Quinn criterion=-3.0010.

P-values in parentheses are less than 5% probability of significance and therefore statistically significant.

Hypothesis #4 (H4): Positive and negative innovations have different effects on the volatility.

RQ#4. Do positive and negative innovations have different effects on the volatility?

Model I: Futhermore, the results indicate that the coefficient, b_1 and b_2 have positive signs and statistically significant at the 5% probability in GRACH and insignificant in EGARCH. In EGARCH variance equation 4a, β is 0.9235, less than one and statistically significant, while γ is -0.07582 and not statistically significant. Thus, the findings suggest that the conditional variance equation has been stationary since $\beta < 1$, while γ captures the asymmetry. The size effect is captured by α and the value is negative (-0.999).

Model II: The results show that b_1 and b_2 are positive in the GARCH and EGARCH mean equations and statistically significant except b_1 in the EGARCH. The results of the estimated EGARCH conditional variance (equation 4b) show that β has a positive sign (0.9595), less than one and statistically significant, while γ is 0.0410 and not statistically significant. These results imply that the conditional variance equation is stationary because $\beta < 1$ while γ captures the asymmetry implying that positive shocks creates less volatility than negative shocks. The size effect is encapsulated with α and as expected the value is positive (0.1227).

3.3 Residual Diagnostics

In the residual diagnostic check, heteroskedasticity, normality and serial correlation tests are conducted on the residual from estimated GARCH-M and EGARCH-M empirical models. The results from LM test and Correlogram Q-statistics are reported in Table 3 and the null hypothesis of ε_t normally distributed is rejected, hence the result is not reported. Also the null hypothesis of no ARCH and no serial correlations failed to be rejected; thus there are no evidence of heteroskedasticity and serial correlation in all estimated models. Therefore, in both GARCH and EGARCH model, ε_t is assumed to follow student's t distributions because the null hypothesis of normal distribution is rejected.

Table 3. ARCH test (Heteroskedasticity test) and serial correlation

GARCH Model (student Statistics)	Heteroskedasticity Test	Serial Correlation Test
F-statistics	0.4462 (0.7751)	Q-Stat (1)=3.0002 (0.083)
Obs*R-squared	1.8109 (0.7705)	Q-Stat (10)=14.149 (0.166)
		Q-Stat (20)=30.893 (0.057)
EGARCH (Student t statistics)		
F-statistics	0.0842 (0.9872)	Q-Stat (1) =0.071 (0.791)
Obs*R-squared	0.3438 (0.9868)	Q-Stat (10)=15.088(0.129)
		Q-Stat (20) =25.783 (0.173)

Note. Q-Stat=Ljung-Box Q-statistics for 1, 10 and 20 lags and the corresponding p-values in parentheses. Significant when the P-values is greater than 5%.

4. Conclusion

This paper pioneer using the GARCH-M and EGARCH-M Models to examine the impact of crude oil price on conditional and volatility of external reserves, and the effect of variability of crude oil price on the volatility of external reserves of Nigeria. The Augmented Dickey-Fuller and Phillips-Perron tests for unit root suggest both variables to be stationary in first difference. Moreover, the findings from estimated GARCH and EGARCH mean equations in Model I show evidence of crude oil price having a positive impact and statistically significant. Furthermore, the sum of the ARCH and GARCH terms are less than one, implying evidence of shocks to volatility to be persistent over time. However, from the variance equations in Model I, the crude oil price has negative impact on the volatility of external reserves. In addition, the volatility term in the mean equations is also statistically significant, but with different signs suggesting the mean is not constant but subject to the volatility levels. In Model II, the coefficient of crude oil price variability term (π) included in the GARCH and EGARCH variance equations has positive signs and statistically significant, indicating transmission of crude oil price volatility to volatility in external reserves.

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Notes

Note 1. See The Guardian online: http://ngrguardiannews.com/news/national-news/185308-falling-crude-oil-price-and-Nigeria-s-response

Note 2. External reserves data were collected from the Central Bank of Nigeria (CBN) 2012 and 2013Q4 Statistical Bulletins.

Note 3. See http://www.cenbank.org

Note 4. This paper does not estimate demand for foreign reserves, rather it attempts to explore the relationship between foreign reserves and crude oil price.