Original Research Article
The Dynamic Relationship between Crude Oil Prices and Stock Market Price Volatility in Nigeria: A Cointegrated VAR-GARCH Model

ABSTRACT

This study investigates the dynamic relationship between crude oil prices and stock market price volatility in Nigeria using cointegrated Vector Generalized Autoregressive conditional Heteroskedasticity (VAR-GARCH) model. The study utilizes monthly data on the study variables from January 2006 to April 2017 and employs Dickey-Fuller Generalized least squares unit root test, simple linear regression model, unrestricted vector autoregressive model, Granger causality test and standard GARCH model as methods of analysis. Results shows that the study variables are integrated of order one, no long-run stable relationship was found to exist between crude oil prices and stock market prices in Nigeria. Both crude oil prices and stock market prices were found to have positive and significant impact on each other indicating that an increase in crude oil prices will increase stock market prices and vice versa. Both crude oil prices and stock market prices were found to have predictive information on one another in the long-run. A one-way causality ran from crude oil prices to stock market prices suggesting that crude oil prices determine stock prices and are a driven force in Nigerian stock market. Results of GARCH (1,1) models show high persistence of shocks in the conditional variance of both returns. The conditional volatility of stock market price log return was found to be stable and predictable while that of crude oil price log return was found to be unstable and unpredictable, although a dependable and dynamic relationship between crude oil prices and stock market prices was found to exist. The study provides some policy recommendations.

Keywords: Cointegration; VAR; GARCH; Dynamic relationship; Crude oil price; Stock market price; Volatility; Nigeria.

1. INTRODUCTION

Crude oil prices have shown to some extent great instability in recent times. This is believed to have caused by financial, economic and political crises. Due to the extensive use of crude oil as a crucial input in the production and manufacturing process as well as a final consumption good, the fluctuations in its prices have a great impact on the overall economic activities, exchange rate, inflation, corporate earnings, and other economic variables. Because crude oil prices has been considered an underlying factor in understanding stock market price fluctuations, many scholars are particularly interested in investigating the dynamic relationship between crude oil price fluctuations and the stock market price volatility after the latest global economic and financial crisis. The asymmetric nature of crude oil price impacts on stock market return volatility has also attracted great attention of many researchers in recent times [1].

It is generally believed that increase in oil price increases the production cost of industrial oil consuming states which raises the cost of importing capital goods and consequently affect the prospects of higher profits earnings for firms trading in such countries. On the side of demand, increases in oil price will raise the general price level in the market leading to lower real disposable income which eventually reduces demand. Apart from the direct impact of oil price on general price levels, it also has secondary effects on national wages which when combined with high general prices lead to increased inflation. Any attempt by the central bank to control inflationary pressures leads to increased interest rates, a situation that makes bond investments more attractive than stock investments which eventually result in reduced stock market prices. Finally, raising import prices trigger a reduction in the terms of trade which imposes welfare losses. Oil-exporting economies, however gain on the other hand from higher export revenues, which could further cause a decline in a global oil demand [1]. An in-depth understanding of the level of susceptibility of stock market prices in developing countries to global oil prices movement is very important. This study therefore aimed at investigating the dynamic relationship between crude oil prices and stock market price volatility in Nigeria using cointegrated Vector Generalized Autoregressive Conditional Heteroskedasticity (VAR-GARCH) models with more recent data. The specific objectives of this study include (i) to examine the long-run stable relationship between crude oil prices and stock market price in Nigeria (ii) to test for Granger causality between crude oil prices and stock market price in Nigeria (iii) to examine the level of volatility shock persistence of the study variables. The rest of the study is organized as follows: Section 2 reviews relevant empirical literature on the subject matter, Section 3 deals with materials and methods, Section 4 focuses on results and discussion while Section 5 dwells on conclusion.

2. LITERATURE REVIEW

Empirical evidence on the relationship between stock market prices and oil prices are well documented in the literature both for developed and emerging economies. See for example, [2] examined the long-term and short-term relationships between three National Indices of Istanbul Stock Exchange (ISE) and international Brent oil price using econometric models. The study found a long term relationship between each of the three index and oil price. Granger causality test indicate a one way causality running from each index of the stock exchange market to oil price but oil price did not Granger cause any of the three indices. Aye [3] investigated the impact of oil price uncertainty on South Africa's stock returns using weekly data covering the period 01/07/1995 to 30/08/2014 using a bivariate GARCH-in-mean vector autoregressive model. Results showed that oil price uncertainty had negative and significant effect on stock returns. The response of stock returns to negative and positive oil price uncertainty shocks was found to be asymmetric. Olivia & Mehtap [4] investigated the relationship between oil price volatility and economic variables such as interest rate, oil price, industrial production and real stock return for US from January, 1987 to May, 2011. Their findings showed that oil price shock had negative and significant impact on the real stock return. Jiranyakul [5] investigated the impact of oil price uncertainty on the Stock Exchange of Thailand using monthly data from May 1987 to December 2013. He employed Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model and pairwise Granger causality test as methods of investigation. The study found that movement in real oil price did not affect real stock market return but stock price volatility affect real stock return. The Granger causality test revealed a positive one-directional volatility transmission running from oil price to stock market. Chittedi [6] investigated the long-run dynamic relationship between crude oil prices and stock market prices in India over the period April 2000- June 2011. He employed Autoregressive Distributed Lag (ARDL) Model as method of investigation. Results revealed that volatility of stock market prices in India had a significant impact on the volatility of crude oil prices. However, a change in the crude oil prices did not have any impact on stock market prices. Buthaina & Ghazi [7] examined the asymmetric responds of the Amman stock market returns to oil price fluctuations for the quarterly period of 2000 to 2015 in Jordan using asymmetric cointegration analysis. Results provided evidence that stock returns react to oil price variations in an asymmetric manner. Increases in oil prices had a significant effect on the behaviour of stock market in Jordan. See [8, 9, 10, 11, 12, 13, 14, 15, 16] for similar contributions and more surveys on the subject matter.

In Nigeria [17] examined the long-run and short-run dynamic effects of oil price on stock returns in Nigeria from January, 1985 to April, 2009 using the Johansen cointegration tests. He specified a bivariate model and empirical results showed a significant positive stock return to oil price shock in the short-run and a significant negative stock return to oil price shock in the long-run. The Granger causality test result showed that oil price shock Granger caused stock returns in Nigeria indicating that variations in the Nigerian stock prices can be explained by oil price volatility. Ogiri *et al.* [18] investigated the relationship between oil prices and stock market performance in Nigeria. They employed Johansen cointegration test, Augmented Dickey-Fuller test, Vector error correction (VEC) model, as well as the Vector autoregressive (VAR) model as methods of analysis. Results showed a significant link between oil prices and stock market performance in Nigeria. Iheanacho [19] conducted a study that employed a multivariate Vector Error Correction Model (VECM) which used Granger causality test and generalized variance decomposition analysis to study the relationship between crude oil prices, exchange rate and stock market performance in Nigeria from January 1995 to December 2014. The study found a short-run positive relationship between crude oil prices and the Nigerian stock market with the direction of causality running from crude oil prices to the Nigerian stock market. The short run relationship between exchange rate and Nigerian stock market was also found to be positive and the direction of causality was from the exchange rate to the Nigerian stock market. Exchange rate was also found to be positively related to the movements in the crude oil prices in the short run with the direction of causality running from crude oil prices to exchange rate. However, the results of a multivariate Johansen cointegration test indicated the existence of negative relationship among the three study variables in the long-run. The variance decomposition analysis showed that the Nigerian stock market performance and exchange rate behaviour were strongly influenced by the movements in crude oil prices. Lawal *et al.* [20] examined the impact of both the exchange rate volatility and oil price volatility on stock market volatility in Nigeria using EGARCH model. The result showed that share price volatility is induced by both the exchange rate volatility and oil price volatility. See also [21] for more surveys in Nigeria.

3. MATERIAL AND METHODS

3.1 Source of Data

This study utilizes monthly data on crude oil prices and all share index from January 2006 to April 2017 obtained from www.cbn.org.ng. The monthly data are converted to monthly returns using $r_t = ln(R_{t-1} - R_t) \times 100$ where r_t is the log return, R_{t-1} is the price of the previous month while R_t is the price of the current month.

3.2 Dickey-Fuller Generalized Least Squares (DF GLS) Unit Root Test

We employ Dickey-Fuller Generalized Least Squares (DF GLS) unit root test to investigate the unit root property and order of integration of oil prices and stock market prices in Nigeria. The DFGLS test involves estimating the standard ADF test equation:

$$\Delta Y_t = \alpha Y_{t-1} + X_t^{'}\delta + \beta_1 \Delta Y_{t-1} + \beta_2 \Delta Y_{t-2} + \cdots + \beta_p \Delta Y_{t-p} + v_t \quad (1)$$

After substituting the DFGLS detrended Y_t^d for the original Y_t, we have

$$\Delta Y_t^d = \alpha Y_{t-1}^d + \beta_1 \Delta Y_{t-1}^d + \cdots + \beta_p \Delta Y_{t-p}^d + v_t \quad (2)$$

As with the ADF test, we consider the t-ratio for $\hat{\alpha}$ from this test equation and evaluate

$$t_\alpha = \frac{\hat{\alpha}}{(se(\hat{\alpha}))} \quad (3)$$

Where $\hat{\alpha}$ is the estimate of α, and $se(\hat{\alpha})$ is the coefficient standard error. The null and alternative hypotheses may be written as: $H_0: \alpha = 0$ against $H_1: \alpha < 0$. The test rejects the null hypothesis of unit root if the DFGLS test statistic is less than the test critical values at the designated test sizes. See [22].

3.3 Linear Regression Model Specification

To investigate the impact of crude oil price on stock market prices and the impact of stock market prices on crude oil price in Nigeria, we employ a simple linear regression models specified as follows:

$$COP_t = \beta_0 + \beta_1 ASI_t + \varepsilon_t \quad (4)$$

$$ASI_t = \beta_0 + \beta_1 COP_t + \varepsilon_t \quad (5)$$

where COP_t represents crude oil prices at time t, ASI_t represents all share index used as proxy for stock market prices at time t, ε_t is the error term, β_0 is the intercept of the regression model while β_1 is the slope coefficient of the independent variable.

3.4 Johansen Cointegration Test

To investigate the long-run stable relationship between crude oil prices and stock market price in Nigeria, we employ Johansen cointegration testing procedure. Johansen [23, 24] developed a Vector Autoregressive based cointegration test methodology as follows: Let a VAR (p) model be define as:

$$Y_t = \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \cdots + \phi_p Y_{t-p} + BX_t + \varepsilon_t \quad (6)$$

where Y_t is the k −vector of non-stationary I(1) variables, X_t is the d −vector of deterministic variables and ε_t is a vector of innovations. We may rewrite this VAR as:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + BX_t + \varepsilon_t \quad (7)$$

$$\text{where } \Pi = \sum_{i=1}^{p} A_i - \boldsymbol{I}, \quad \Gamma_i = -\sum_{j=i+1}^{p} A_j \tag{8}$$

Granger's representation theorem assumes that if the coefficient matrix Π has reduced rank $r < k$, then there exist $k \times r$ matrices α and β each with rank r such that $\Pi = \alpha\beta'$ and $\beta' Y_t$ is I(0). r is the number of cointegrating relations (the cointegrating rank) and each column of β is the cointegrating vector. Johansen cointegration test computes two statistics: trace statistic and maximum eigenvalue statistic. The trace statistic for the null hypothesis of r cointegrating relations is computed as:

$$LR_{tr}(r|k) = -T \sum_{i=r+1}^{k} \log(1-\lambda_i) \tag{9}$$

The maximum eigenvalue test statistic is computed as:

$$LR_{max}(r|r+1) = -T\log(1-\lambda_{r+1}) = LR_{tr}(r|k) - LR_{tr}(r+1|k) \tag{10}$$

where λ_i is the i-th largest eigenvalue of the Π matrix in equation (8), $r = 0, 1, 2, \dots, k-1$.

3.5 Vector Autoregressive (VAR) Model

VAR models are used for analyzing multivariate time series and each variable in VAR model is a linear function of past lags of itself and past lags of the other variables. We consider two different time series variables in this study denoted by $ASI_{t,1}$ and $COP_{t,2}$. The vector autoregressive model of order 1, denoted by VAR (1), is expressed as:

$$\left.\begin{aligned} ASI_{t,1} &= \alpha_1 + \phi_{11} ASI_{t-1,1} + \phi_{12} ASI_{t-1,2} + w_{t,1} \\ COP_{t,2} &= \alpha_2 + \phi_{21} COP_{t-1,1} + \phi_{22} COP_{t-1,2} + w_{t,2} \end{aligned}\right\} \tag{11}$$

Each variable is a linear function of the lag 1 values for all variables in the set. For a VAR (p) model, the first p lags of each variable in the system are used as regression predictors for each variable.

3.6 VAR Granger Causality Test Based on Toda-Yamamoto Procedure

We employ Toda & Yamamoto Granger causality test procedure due to [25] to determine the direction of causality among the study variables. Toda and Yamamoto procedure uses a Modified Wald (MWALD) test for restrictions on the parameters of the VAR (k) model. The model is specified as follows:

$$COP_t = \alpha_1 + \sum_{i=1}^{k+d} \beta_{1i} COP_{t-i} + \sum_{t-i}^{k+d} \beta_{2i} ASI_{t-i} + \varepsilon_{xt} \quad (12$$

$$ASI_t = \alpha_2 + \sum_{i=1}^{k+d} \phi_{1i} ASI_{t-i} + \sum_{t-i}^{k+d} \phi_{2i} COP_{t-i} + \varepsilon_{yt} \tag{13}$$

where k is the optimal lag order; d is the maximal order of integration of the series in the system; ε_{xt} and ε_{yt} are error terms which are assumed to be white noise. The usual Wald test is then applied to the first k coefficient matrices using the standard χ^2-statistics. The test checks the following pairs of hypotheses: COP_t "Granger causes" ASI_t if $\beta_{2i} \neq 0$ in equation (12) against ASI_t "Granger causes" COP_t if $\phi_{1i} \neq 0$ in equation (13)

3.7 The Generalized Autoregressive Conditional Heteroskedasticity (GARCH) Model

To investigate the volatility shock persistence of crude oil prices and stock market price and to further investigate the dependable relationship between crude oil price and stock market prices log returns, we apply the standard GARCH (1,1) model proposed by [26 & 27]. The time series ε_t following a GARCH (p,q) model is defined as:

$$\varepsilon_t = \eta_t \sqrt{h_t} \tag{14}$$

$$h_t = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j h_{t-j} \quad (15)$$

where ω, α_i and β_j are non-negative constraints with $\sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j h_{t-j} < 1$ in order to ensure that the conditional variance (h_t) is positive and stationary. The GARCH (1,1) is the most popular and simplest model for explaining volatility and is expressed as:

$$\varepsilon_t = \eta_t \sqrt{h_t} \quad (16)$$

$$h_t = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} \quad (17)$$

where ε_t is the underlying process, $\{\eta_t\}$ are iid random variables with mean zero and variance 1 and are assumed to be standard normally distributed. For a standard GARCH (1,1) model to be stationary the sum of ARCH term (α_1) and GARCH term (β_1) must be less than one. If $\alpha_1 + \beta_1 > 1$, the conditional variance becomes unstable, non-stationary and therefore explodes.

4. RESULTS AND DISCUSSION

4.1 Unit Root Test Result

This study employs the Dickey-Fuller Generalized Least Squares (DF GLS) unit root test to explore the stationarity characteristics of the study variables with the result presented in Table 1. The DF GLS unit root test result shows that crude oil prices and stock market prices are non-stationary in levels but stationary after the first difference.

Table 1: DF GLS Unit Root Test Results

Variable	Option	DF GLS Test Statistic	Critical Values 1%	5%	10%
ASI	Constant only	-1.5991	-2.5827	-1.9433	-1.6151
	Constant & trend	-2.7634	-3.5416	-2.9980	-2.7080
ΔASI	Constant only	-4.8421**	-2.5827	-1.9433	-1.6151
	Constant & trend	-4.8907**	-3.5428	-2.9990	-2.7090
COP	Constant only	-1.9201	-2.5823	-1.9432	-1.6151
	Constant & trend	-2.5947	-3.5392	-2.9960	-2.7060
ΔCOP	Constant only	-7.2307**	-2.5823	-1.9432	-1.6151
	Constant & trend	-7.3959**	-3.5392	-2.9960	-2.7060

Note: **denotes significance of the DF GLS test statistic at 1% and 5% significance levels

4.2 Simple Linear Regression Results

To investigate the impact of crude oil prices on stock market prices and also determine the impact of stock market prices on crude oil prices, we estimate two simple linear regression models by using stock market prices (ASI) as a dependent variable in one and crude oil prices (COP) as a dependent variable in another. Results are presented in Table 2.

Table 2: OLS Estimates of Dependable Relationship between Study Variables

Dependent Variable: ASI				
Variable	Coefficient	Std. Error	t-Statistic	P-value
C	24106.48	2791.302	8.636288	0.0000
COP	95.62452	32.00445	2.987851	0.0033
Dependent Variable: COP				
C	61.88971	7.366047	8.402025	0.0000
ASI	0.000653	0.000219	2.987851	0.0033
R-squared	0.762460	F-statistic	8.927255	Durbin Watson
Adjusted R-squared	0.554642	Prob (F-statistic)	0.003342	1.90535

The estimated linear regression models in Table 2 can be represented in equation forms as shown:

$$\mathrm{COP_t} = 24106.48 + 95.62452\mathrm{ASI_t} + \varepsilon_t \quad (3.1)$$

$$ASI_t = 61.88971 + 0.000653COP_t + \varepsilon_t \quad (3.2)$$

All the coefficients of the estimated models are statistically significant at 1% marginal significance level. The intercepts in both models are positively related to the dependent variables. Both crude oil prices and stock market prices has positive and significant impact on each other indicating that an increase in crude oil prices will increase stock market prices and vice versa, however the impact of crude oil prices on stock market prices is much higher. The coefficient of variation has shown that about 76.25% of the total variability in the models has been explained. The Durbin Watson statistic value of 1.90535 which is greater than R^2 and adjusted R^2 indicates that the estimated models are non-spurious. This also shows the absence of positive serial correlation in the model. The overall goodness-of-fit of the model is also adequate as the F-statistic p-value is highly statistical significant.

4.3 Johansen Cointegration Test Result

To determine the long-run stable relationship between crude oil prices and stock market prices in Nigeria, we employ Johansen cointegration trace and maximum eigenvalue tests. The results are presented in Table 3

Table 3: Johansen Cointegration Test Results on the Study Variables

Rank	Null Hypothesis	Eigen value	Trace Test		Maximum Eigenvalue Test	
			Trace stat.	P-value	λ_{max} Stat.	P-value
0	$r = 0$	0.045809	7.857918	0.4807	6.142841	0.5949
1	$r \leq 1$	0.013007	1.715077	0.1903	1.715077	0.1903

Both the trace test and maximum eigenvalue test results reported in Table 3 indicate no cointegrating equation at any significance level. This is justified by the non-significant p-values of both the trace test and maximum eigenvalue test statistics. This shows that the study variables are not cointegrated and there is no long-run stable relationship existing between them.

4.4 Vector Autoregressive (VAR) Model Result

Having tested and found no cointegration relationship between the study variables, we proceed with unrestricted VAR estimation. However, before estimating a VAR model, we conduct a VAR lag selection test shown in Table 4. Result shows that a maximum lag of 1 should be included in the VAR model for each study variable.

Table 4: VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-912.4490	NA	4214.914	14.02212	14.15381	14.07563
1	-897.7918	28.19564*	3582.214*	13.85942*	14.07890*	13.94860*
2	-895.3742	4.576839	3670.285	13.88358	14.19085	14.00843
3	-890.50088	3.129636	3522.272	13.87070	14.29798	14.04415

Note: * indicates lag order selected by the criterion

We estimate unrestricted vector autoregressive model in levels using one lag of each variable with a constant. Result is reported in Table 5.

Table 5: Unrestricted VAR Model Parameter Estimates

	COP	ASI
COP(-1)	0.973873	-0.973087
	(0.02217)	(8.13676)
	[43.9323]	[-0.11959]
ASI (-1)	-0.00008	0.971569
	(0.00005)	(0.02118)
	[-0.14109]	[45.8776]
C	2.320598	1004.570
	(2.34188)	(859.603)
	[0.99091]	[1.16864]
R-squared	0.939531	0.944286

Adjusted R-squared	0.938614	0.943441
F-statistic	1025.462	1118.611

Note: Standard errors in ( ) & t-statistics in [ ]

The estimated unrestricted VAR model reasonably explains changes in crude oil and stock market prices well with approximate R-squared and adjusted R-squared of 94% in the short-run. Crude oil and stock market prices appear to have high predictive information on one another since both have large coefficients at lag one which are statistically significant. The F-statistic which measures the overall fitness of the model is reasonably high indicating that the estimated unrestricted VAR model is adequate and a good fit.

The qualitative features of the estimated unrestricted VAR model are captured in the impulse response functions, which aids in assessing whether crude oil prices contains information about the stock market prices sufficiently far into the future to be operationally meaningful. Figure 1 shows the responses to one-standard-deviation positive shocks to each variable over an expanse of 24 months.

The impulse responses of the VAR model showed that shocks to the stock market prices persist and have proportional effects on their own levels in the short run and long run. A positive shock to the stock market prices also persistently raises the crude oil prices in the long run. Responses of crude oil prices to its own innovations also persist but it show some inconsistencies in their effects on stock market prices. There is a little short-run effect of the crude oil prices on stock market prices.

The variance decomposition results for 24 months ahead reported in Table 6 support the result of impulse response functions. Innovations to crude oil prices explain zero percent of the variance of the stock market prices while the crude oil prices have 100 percent of their forecast-error variance explained by own innovations in the first month. These percentages however decrease gradually across the periods. At the 20th and 24th months, innovations to crude oil prices explained 34 percent and 36 percent respectively of the variance of stock market prices while 66 percent and 64 percent respectively of crude oil prices forecast error variance is explained by own innovations in the same period.

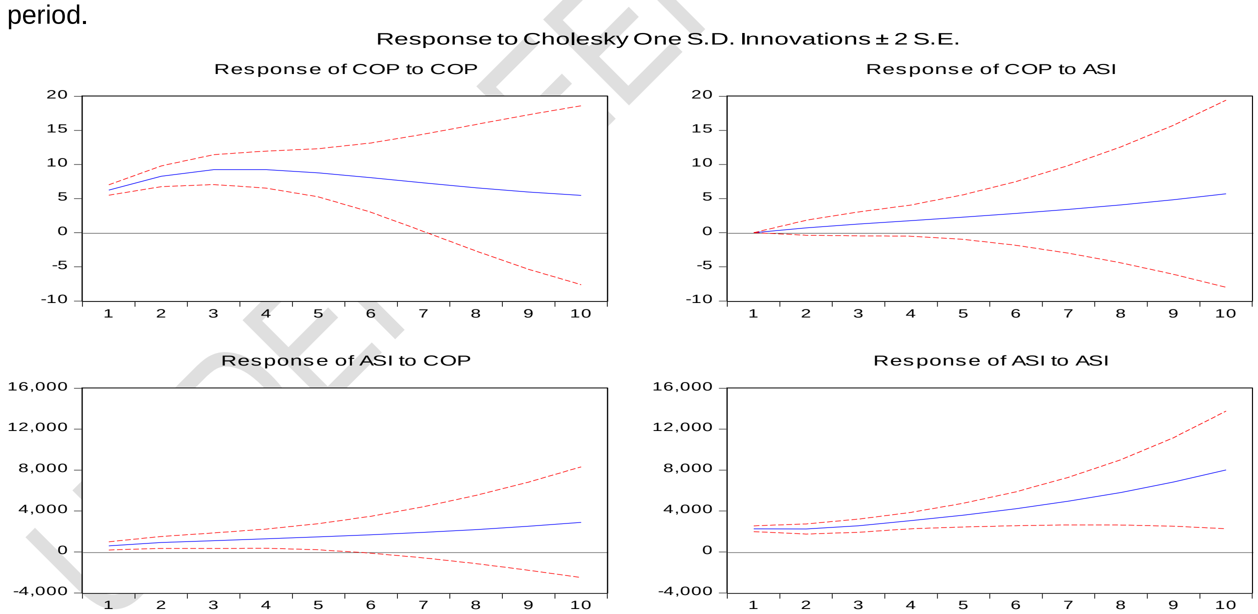

Figure 1: Impulse Responses of the VAR Model of COP and ASI

On the other hand, stock market prices have explained about 6 percent, 28 percent and 31 percent of the variance of crude oil prices in the first, 20th and 24th months respectively while 94 percent, 72 percent and 69 percent of their forecast-error variance is explained by own innovations in the same respective periods. These results showed that crude oil prices and stock market prices have predictive information on one another in the long-run.

Table 6: Variance Decomposition for the VAR Model

Period	Variance Decomposition of COP	Variance Decomposition of ASI

	S.E.	COP	ASI	S.E.	ASI	COP
1	6.252805	100.0000	0.000000	2340.105	93.62062	6.379378
2	10.38845	99.51818	0.481821	3366.840	89.41141	10.58859
3	13.96569	98.88966	1.110340	4364.577	87.45393	12.54607
4	16.84012	98.13078	1.869217	5484.178	86.53812	13.46188
5	19.12320	97.12193	2.878068	6722.219	86.20419	13.79581
6	20.94578	95.77800	4.221996	8113.465	86.23551	13.76449
7	22.44311	94.00230	5.997697	9698.323	86.47269	13.52731
8	23.74017	91.68620	8.313802	11518.77	86.80737	13.19263
9	24.94916	88.71965	11.28035	13622.95	87.17287	12.82713
10	26.17190	85.00469	14.99531	16066.22	87.52934	12.47066
15	35.93018	75.42647	24.57353	35998.08	78.74042	21.25958
20	62.78933	66.18168	33.81832	80032.12	72.15568	27.84432
24	111.5203	63.72296	36.27704	151565.7	69.25210	30.74790

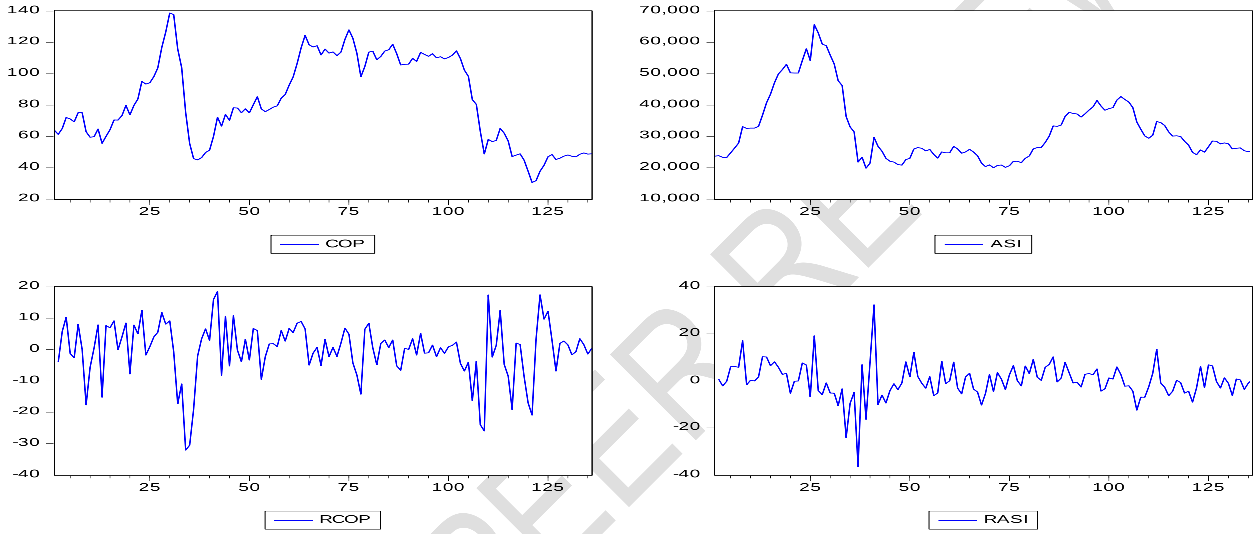

Fig. 2. Time series plots of level series and returns of the study variables

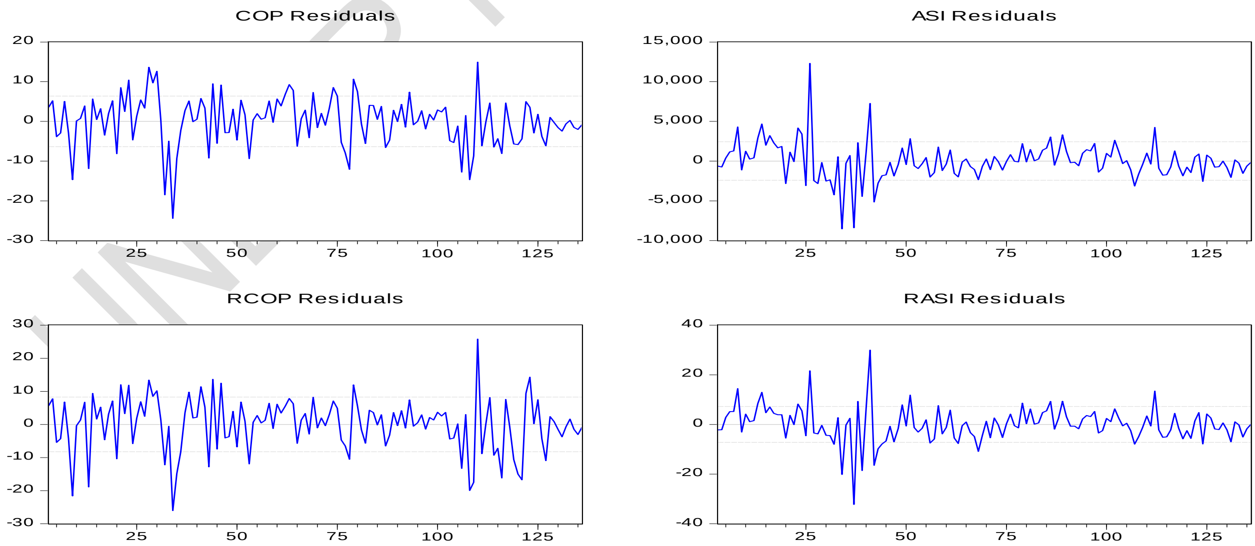

Figure 3: Time plots of residuals of level series and returns

4.4 VAR Granger Causality Test Result

To investigate the direction of causality between crude oil prices and stock market prices, we employ VAR Granger causality test based on Toda-Yamamoto procedure and the result is presented in Table 7.

Table 7: VAR Granger Causality Test based on Toda-Yamamoto Procedure

Dependent Variable: COP			
Excluded	Chi-square	Df	P-value
ASI	12.543948	3	0.0083**
All	12.543948	3	0.0083**
Dependent Variable: ASI			
Excluded	Chi-square	Df	P-value
COP	3.141606	3	0.4988
All	3.141606	3	0.4988

Note: **denotes the significant of the test at 5% significance level

The VAR Granger causality test result shown in Table 7 shows a unidirectional causality running from crude oil prices (COP) to stock market prices (ASI). This result implies that crude oil prices Granger causes stock market prices whereas stock market prices do not Granger cause crude oil prices. This result suggests that crude oil prices are one of the determinants of prices and a driven force in Nigerian stock market.

4.5 Relationship between Crude Oil and Stock Market Prices from GARCH Models

To further investigate the dynamic and dependable relationship between crude oil prices and stock market prices in Nigeria, we estimate two set of GARCH models with and without independent variable in the mean equations. The results are presented in Table 8.

Table 8: GARCH (1,1) Models with and without Independent Variable in the Mean Equation

Parameter	Without independent variable		With independent variable	
	RASI	RCOP	RASI	RCOP
Mean Equation				
μ	1.029029	0.339422*	0.745190*	0.399996
RASI(-1)	-----	-----	-----	0.204370*
RCOP(-1)	-----	-----	0.191829*	-----
Variance Equation				
ω	4.317202*	2.390080*	3.612260	4.471335*
α_1	0.296012*	0.631016*	0.192692*	0.696597*
β_1	0.657203*	0.499231*	0.748309*	0.416798*
$\alpha_1 + \beta_1$	0.953215	1.130247	0.941001	1.113395

Note: * denotes significant parameter while RASI(-1) and RCOP(-1) denote lagged all share index log returns and lagged crude oil price log returns respectively.

The left panel of Table 8 shows the estimation results of GARCH (1,1) models for the stock market log returns and crude oil price log returns without including lagged RCOP(-1) and RASI(-1) variables respectively. The coefficients α_1 and β_1 represent ARCH and GARCH terms, respectively, and are shown to be statistically significant at the 1% marginal significance levels. The dynamics of log returns in both models exhibit high persistence in conditional variance. While the conditional volatility of stock market log return is stable (i.e., $\alpha_1 + \beta_1 = 0.953215 < 1$), the conditional volatility of crude oil price log returns is unstable (i.e., $\alpha_1 + \beta_1 = 1.130247 > 1$). This result suggests that stock market prices in Nigeria are predictable while crude oil prices are unpredictable.

The right panel of Table 8 shows the estimation results of two GARCH (1,1) models when lagged crude oil price log return is included in the stock market log return mean equation and when lagged stock market log return is incorporated into the crude oil log return mean equation respectively. The estimated coefficients of α_1, β_1 and the lagged variables RASI(-1) and RCOP(-1) are statistically significant. This result indicates that incorporating these lagged variables into the respective mean equations significantly reduce shock persistence (noise) and this lead us to conclude that crude oil prices explains volatility in the stock market in the same way as stock market returns help in explaining volatility in crude oil returns. This shows a dependable and dynamic relationship between crude oil prices and stock market prices in Nigeria. The residuals of the estimated GARCH (1,1) models are presented in Figure 3.

5. CONCLUSION

This study investigated the dynamic relationship between crude oil prices and stock market price volatility in Nigeria using monthly data on the study variables from January 2006 to April 2017. The study employs Dickey-Fuller Generalized least squares unit root test to investigate the order of integration of the series, simple linear regression model to determine the impact of each variable on one another, unrestricted vector autoregressive model to determine the predictive power of both variables on each other, Granger causality test to investigate the direction of causality of each study variable and standard GARCH models to determine the persistence of shocks and dependable relationship between the study variables . Results shows that the study variables are integrated of order one, no long-run stable relationship was found to exist between crude oil prices and stock market prices in Nigeria. Both crude oil prices and stock market prices were found to have positive and significant impact on each other indicating that an increase in crude oil prices will increase stock market prices and vice versa. Both crude oil prices and stock market prices were found to have predictive information on one another in the long-run. A one-way causality ran from crude oil prices to stock market prices suggesting that crude oil prices determine stock prices and are a driven force in Nigerian stock market. Results of GARCH (1,1) models show high persistence of shocks in the conditional variance of both returns. The conditional volatility of stock market price log return was found to be stable and predictable while that of crude oil price log return was found to be unstable and unpredictable although a dependable and dynamic relationship between crude oil prices and stock market prices was found to exist. The cointegration test result of this study agrees with the findings of [17, 18, 19, 20] among others.

The findings of this study have some important policy implications. From the economic policy perspective, results of this study have shown that changes in crude oil prices can cause significant changes in Nigerian stock market. Therefore any changes in policy actions with respect to crude oil production need to consider the effect of these on stock market prices. There is need to increase the market depths for both crude oil and stock market by allowing aggressive trading on a wide range so as to make them less volatile.

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