

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

5  
6  
7 **ABSTRACT**  
8

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.

9  
10 *Keywords: Cointegration; VAR; GARCH; Dynamic relationship; Crude oil price; Stock market price;*  
11 *Volatility; Nigeria.*

12  
13 **1. INTRODUCTION**

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

24 It is generally believed that increase in oil price increases the production cost of industrial oil  
25 consuming states which raises the cost of importing capital goods and consequently affect the  
26 prospects of higher profits earnings for firms trading in such countries. On the side of demand,  
27 increases in oil price will raise the general price level in the market leading to lower real disposable  
28 income which eventually reduces demand. Apart from the direct impact of oil price on general price  
29 levels, it also has secondary effects on national wages which when combined with high general prices  
30 lead to increased inflation. Any attempt by the central bank to control inflationary pressures leads to  
31 increased interest rates, a situation that makes bond investments more attractive than stock  
32 investments which eventually result in reduced stock market prices. Finally, raising import prices  
33 trigger a reduction in the terms of trade which imposes welfare losses. Oil-exporting economies,  
34 however gain on the other hand from higher export revenues, which could further cause a decline in a  
35 global oil demand [1]. An in-depth understanding of the level of susceptibility of stock market prices in  
36 developing countries to global oil prices movement is very important. **There may be several published**

37 works on the subject, but to the best of the author's knowledge, no study has employed VAR-GARCH  
38 approach to examine the dependable relationship between crude oil prices and stock market volatility  
39 in Nigeria or elsewhere. This study therefore extends the existing literature and contributes to the  
40 existing body of knowledge by investigating the dynamic relationship between crude oil prices and  
41 stock market price volatility in Nigeria using cointegrated Vector Generalized Autoregressive  
42 Conditional Heteroskedasticity (VAR-GARCH) models using more recent data. The specific objectives  
43 of this study include (i) to examine the long-run stable relationship between crude oil prices and stock  
44 market price in Nigeria (ii) to test for Granger causality between crude oil prices and stock market  
45 price in Nigeria (iii) to examine the level of volatility shock persistence of the study variables. The rest  
46 of the study is organized as follows: Section 2 reviews relevant empirical literature on the subject  
47 matter, Section 3 deals with materials and methods, Section 4 focuses on results and discussion  
48 while Section 5 dwells on conclusion.

## 49 **2. LITERATURE REVIEW**

50 Empirical evidence on the relationship between stock market prices and oil prices are well  
51 documented in the literature both for developed and emerging economies. See for example, [2]  
52 examined the long-term and short-term relationships between three National Indices of Istanbul Stock  
53 Exchange (ISE) and international Brent oil price using econometric models. The study found a long  
54 term relationship between each of the three index and oil price. Granger causality test indicate a one  
55 way causality running from each index of the stock exchange market to oil price but oil price did not  
56 Granger cause any of the three indices. Aye [3] investigated the impact of oil price uncertainty on  
57 South Africa's stock returns using weekly data covering the period 01/07/1995 to 30/08/2014 using a  
58 bivariate GARCH-in-mean vector autoregressive model. Results showed that oil price uncertainty had  
59 negative and significant effect on stock returns. The response of stock returns to negative and  
60 positive oil price uncertainty shocks was found to be asymmetric. Olivia & Mehtap [4] investigated the  
61 relationship between oil price volatility and economic variables such as interest rate, oil price,  
62 industrial production and real stock return for US from January, 1987 to May, 2011. Their findings  
63 showed that oil price shock had negative and significant impact on the real stock return. Jiranyakul [5]  
64 investigated the impact of oil price uncertainty on the Stock Exchange of Thailand using monthly data  
65 from May 1987 to December 2013. He employed Generalized Autoregressive Conditional  
66 Heteroskedasticity (GARCH) model and pairwise Granger causality test as methods of investigation.  
67 The study found that movement in real oil price did not affect real stock market return but stock price  
68 volatility affect real stock return. The Granger causality test revealed a positive one-directional  
69 volatility transmission running from oil price to stock market. Chittedi [6] investigated the long-run  
70 dynamic relationship between crude oil prices and stock market prices in India over the period April  
71 2000- June 2011. He employed Autoregressive Distributed Lag (ARDL) Model as method of  
72 investigation. Results revealed that volatility of stock market prices in India had a significant impact  
73 on the volatility of crude oil prices. However, a change in the crude oil prices did not have any impact  
74 on stock market prices. Buthaina & Ghazi [7] examined the asymmetric responds of the Amman stock  
75 market returns to oil price fluctuations for the quarterly period of 2000 to 2015 in Jordan using  
76 asymmetric cointegration analysis. Results provided evidence that stock returns react to oil price  
77 variations in an asymmetric manner. Increases in oil prices had a significant effect on the behaviour of  
78 stock market in Jordan. See [8, 9, 10, 11, 12, 13, 14, 15, 16] for similar contributions and more  
79 surveys on the subject matter.

80 In Nigeria [17] examined the long-run and short-run dynamic effects of oil price on stock returns in  
81 Nigeria from January, 1985 to April, 2009 using the Johansen cointegration tests. He specified a  
82 bivariate model and empirical results showed a significant positive stock return to oil price shock in the  
83 short-run and a significant negative stock return to oil price shock in the long-run. The Granger  
84 causality test result showed that oil price shock Granger caused stock returns in Nigeria indicating  
85 that variations in the Nigerian stock prices can be explained by oil price volatility. Ogiri *et al.* [18]  
86 investigated the relationship between oil prices and stock market performance in Nigeria. They  
87 employed Johansen cointegration test, Augmented Dickey-Fuller test, Vector error correction (VEC)  
88 model, as well as the Vector autoregressive (VAR) model as methods of analysis. Results showed a  
89 significant link between oil prices and stock market performance in Nigeria. Iheanacho [19] conducted  
90 a study that employed a multivariate Vector Error Correction Model (VECM) which used Granger  
91 causality test and generalized variance decomposition analysis to study the relationship between  
92 crude oil prices, exchange rate and stock market performance in Nigeria from January 1995 to  
93 December 2014. The study found a short-run positive relationship between crude oil prices and the

94 Nigerian stock market with the direction of causality running from crude oil prices to the Nigerian stock  
 95 market. The short run relationship between exchange rate and Nigerian stock market was also found  
 96 to be positive and the direction of causality was from the exchange rate to the Nigerian stock market.  
 97 Exchange rate was also found to be positively related to the movements in the crude oil prices in the  
 98 short run with the direction of causality running from crude oil prices to exchange rate. However, the  
 99 results of a multivariate Johansen cointegration test indicated the existence of negative relationship  
 100 among the three study variables in the long-run. The variance decomposition analysis showed that  
 101 the Nigerian stock market performance and exchange rate behaviour were strongly influenced by the  
 102 movements in crude oil prices. Lawal *et al.* [20] examined the impact of both the exchange rate  
 103 volatility and oil price volatility on stock market volatility in Nigeria using EGARCH model. The result  
 104 showed that share price volatility is induced by both the exchange rate volatility and oil price volatility.  
 105 See also [21] for more surveys in Nigeria.

### 108 3. MATERIAL AND METHODS

#### 109 3.1 Source of Data

111 This study utilizes monthly data on crude oil prices and all share index from January 2006 to April  
 112 2017 obtained from [www.cbn.org.ng](http://www.cbn.org.ng). The monthly data are converted to monthly returns using  
 113  $r_t = \ln(R_{t-1} - R_t) \times 100$  where  $r_t$  is the log return,  $R_{t-1}$  is the price of the previous month while  $R_t$  is  
 114 the price of the current month.

#### 115 3.2 Dickey-Fuller Generalized Least Squares (DF GLS) Unit Root Test

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

$$\Delta Y_t = \alpha Y_{t-1} + X_t \delta + \beta_1 \Delta Y_{t-1} + \beta_2 \Delta Y_{t-2} + \dots + \beta_p \Delta Y_{t-p} + v_t \quad (1)$$

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

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

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

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

121 Where  $\hat{\alpha}$  is the estimate of  $\alpha$ , and  $se(\hat{\alpha})$  is the coefficient standard error. The null and alternative  
 122 hypotheses may be written as:  $H_0: \alpha = 0$  against  $H_1: \alpha < 0$ . The test rejects the null hypothesis of unit  
 123 root if the DFGLS test statistic is less than the test critical values at the designated test sizes. See  
 124 [22].

#### 125 3.3 Linear Regression Model Specification

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

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

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

128 where  $COP_t$  represents crude oil prices at time  $t$ ,  $ASI_t$  represents all share index used as proxy for  
 129 stock market prices at time  $t$ ,  $\varepsilon_t$  is the error term,  $\beta_0$  is the intercept of the regression model while  $\beta_1$   
 130 is the slope coefficient of the independent variable.

#### 131 3.4 Johansen Cointegration Test

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

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

135 where  $Y_t$  is the  $k$  –vector of non-stationary I(1) variables,  $X_t$  is the  $d$  –vector of deterministic variables  
 136 and  $\varepsilon_t$  is a vector of innovations. We may rewrite this VAR as:

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

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

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

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

142 The maximum eigenvalue test statistic is computed as:

$$143 \quad LR_{max}(r|r+1) = -T \log(1 - \lambda_{r+1}) = LR_{tr}(r|k) - LR_{tr}(r+1|k) \quad (10)$$

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

### 145 3.5 Vector Autoregressive (VAR) Model

146 VAR models are used for analyzing multivariate time series and each variable in VAR model is a  
 147 linear function of past lags of itself and past lags of the other variables. We consider two different time  
 148 series variables in this study denoted by  $ASI_{t,1}$  and  $COP_{t,2}$ . The vector autoregressive model of order  
 149 1, denoted by VAR (1), is expressed as:

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

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

### 152 3.6 VAR Granger Causality Test Based on Toda-Yamamoto Procedure

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

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

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

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

### 162 3.7 The Generalized Autoregressive Conditional Heteroskedasticity (GARCH) Model

163 To investigate the volatility shock persistence of crude oil prices and stock market price and to further  
 164 investigate the dependable relationship between crude oil price and stock market prices log returns,

165 we apply the standard GARCH (1,1) model proposed by [26 & 27]. The time series  $\varepsilon_t$  following a  
 166 GARCH (p,q) model is defined as:

$$\varepsilon_t = \eta_t \sqrt{h_t} \quad (14)$$

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

167 where  $\omega$ ,  $\alpha_i$  and  $\beta_j$  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  
 168 that the conditional variance ( $h_t$ ) is positive and stationary. The GARCH (1,1) is the most popular and  
 169 simplest model for explaining volatility and is expressed as:

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

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

170 where  $\varepsilon_t$  is the underlying process,  $\{\eta_t\}$  are iid random variables with mean zero and variance 1 and  
 171 are assumed to be standard normally distributed. For a standard GARCH (1,1) model to be stationary  
 172 the sum of ARCH term ( $\alpha_1$ ) and GARCH term ( $\beta_1$ ) must be less than one. If  $\alpha_1 + \beta_1 > 1$ , the  
 173 conditional variance becomes unstable, non-stationary and therefore explodes.  
 174

## 175 4. RESULTS AND DISCUSSION

### 176 4.1 Unit Root Test Result

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

181  
 182 **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
$\Delta$ ASI	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
$\Delta$ COP	Constant only	-7.2307**	-2.5823	-1.9432	-1.6151
	Constant & trend	-7.3959**	-3.5392	-2.9960	-2.7060

183 **Note:** \*\*denotes significance of the DF GLS test statistic at 1% and 5% significance levels  
 184

### 185 4.2 Simple Linear Regression Results

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

190  
 191 **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

192  
193  
194

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

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

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

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

### 204 4.3 Johansen Cointegration Test Result

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

208

209 **Table 3:** Johansen Cointegration Test Results on the Study Variables

Rank	Null Hypothesis	Eigen value	Trace Test		Maximum Eigenvalue Test	
			Trace stat.	P-value	$\lambda_{max}$ 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

210

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

### 215 4.4 Vector Autoregressive (VAR) Model Result

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

220

221 **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

222 **Note:** \* indicates lag order selected by the criterion

223

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

226

227 **Table 5:** Unrestricted VAR Model Parameter Estimates

	COP	ASI
COP(-1)	0.973873 (0.02217) [43.9323]	-0.973087 (8.13676) [-0.11959]
ASI (-1)	-0.00008 (0.00005) [-0.14109]	0.971569 (0.02118) [45.8776]



C	2.320598 (2.34188) [0.99091]	1004.570 (859.603) [1.16864]
R-squared	0.939531	0.944286
Adjusted R-squared	0.938614	0.943441
F-statistic	1025.462	1118.611

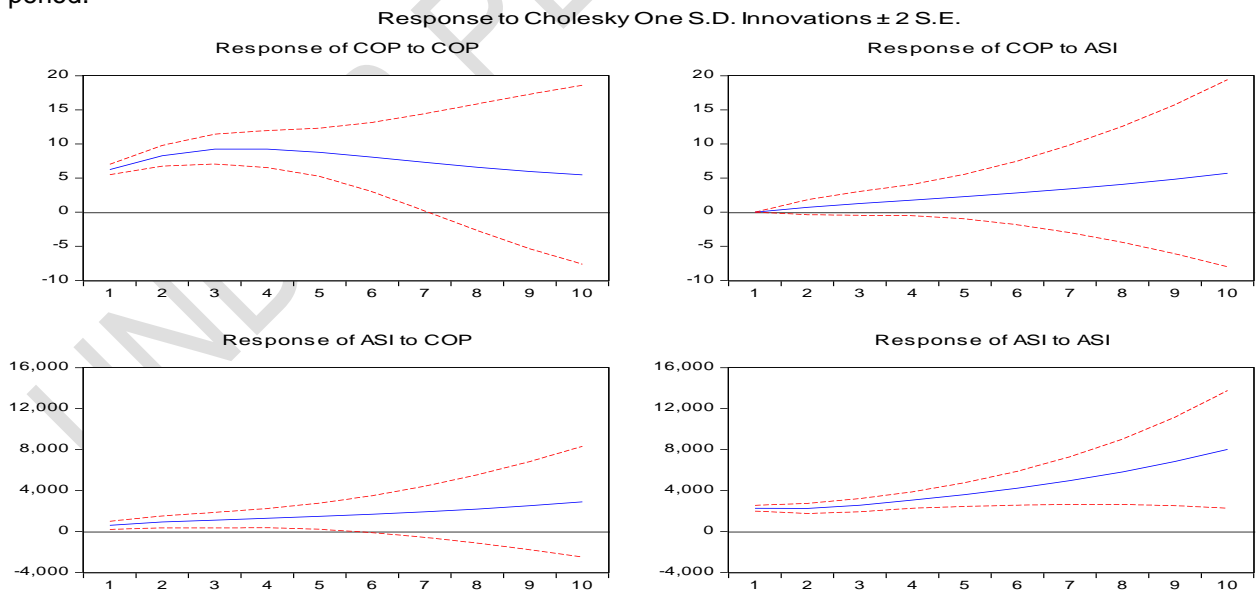
228 **Note:** Standard errors in ( ) & t-statistics in [ ]

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

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

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

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



252  
253

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

255

256 On the other hand, stock market prices have explained about 6 percent, 28 percent and 31 percent of  
 257 the variance of crude oil prices in the first, 20<sup>th</sup> and 24<sup>th</sup> months respectively while 94 percent, 72  
 258 percent and 69 percent of their forecast-error variance is explained by own innovations in the same

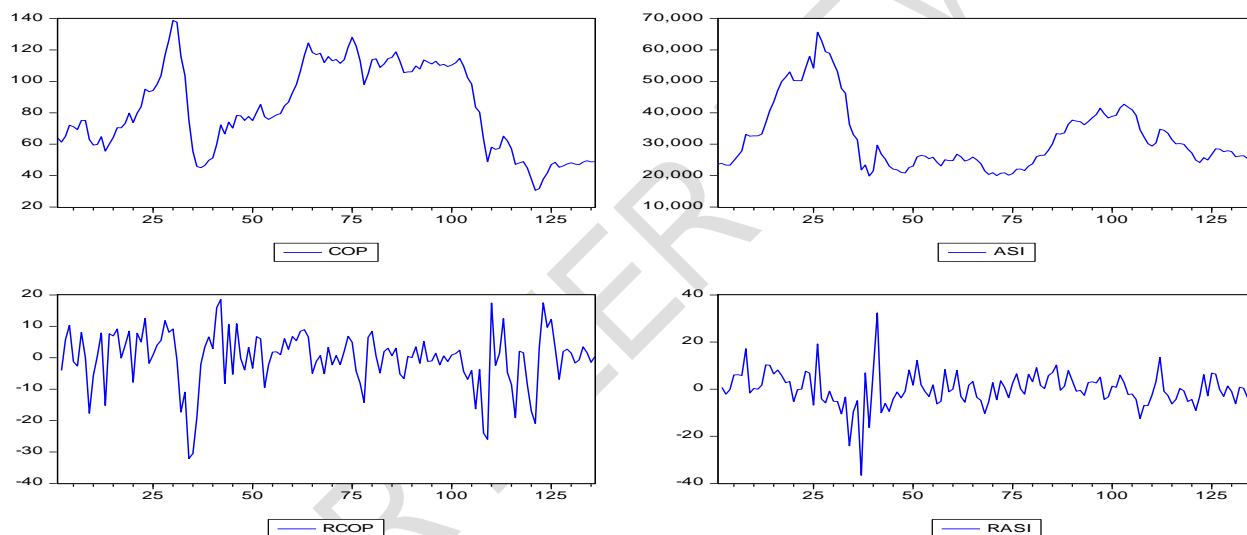
259 respective periods. These results showed that crude oil prices and stock market prices have  
 260 predictive information on one another in the long-run.  
 261

262

**Table 6:** Variance Decomposition for the VAR Model

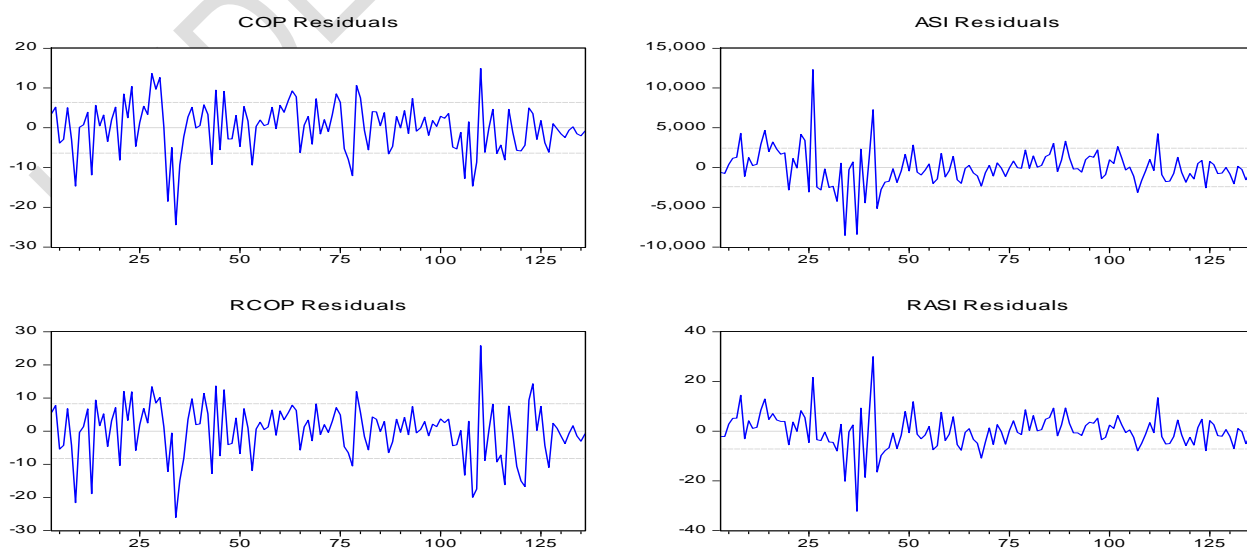
Period	Variance Decomposition of COP			Variance Decomposition of ASI		
	S.E.	COP	ASI	S.E.	ASI	COP
1	6.252805	100.0000	0.000000	2340.105	93.62062	6.379378
2	10.38845	99.51818	0.481821	3366.840	89.41141	10.58859
3	13.96569	98.88966	1.110340	4364.577	87.45393	12.54607
4	16.84012	98.13078	1.869217	5484.178	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

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



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



270 **4.4 VAR Granger Causality Test Result**

271 To investigate the direction of causality between crude oil prices and stock market prices, we employ  
 272 VAR Granger causality test based on Toda-Yamamoto procedure and the result is presented in Table  
 273 7.

274 **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	

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

276

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

282 **4.5 Relationship between Crude Oil and Stock Market Prices from GARCH Models**

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

286

287 **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
<b>Mean Equation</b>				
$\mu$	1.029029	0.339422*	0.745190*	0.399996
RASI(-1)	-----	-----	-----	0.204370*
RCOP(-1)	-----	-----	0.191829*	-----
<b>Variance Equation</b>				
$\omega$	4.317202*	2.390080*	3.612260	4.471335*
$\alpha_1$	0.296012*	0.631016*	0.192692*	0.696597*
$\beta_1$	0.657203*	0.499231*	0.748309*	0.416798*
$\alpha_1 + \beta_1$	0.953215	1.130247	0.941001	1.113395

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

290

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

299 The right panel of Table 8 shows the estimation results of two GARCH (1,1) models when lagged  
 300 crude oil price log return is included in the stock market log return mean equation and when lagged  
 301 stock market log return is incorporated into the crude oil log return mean equation respectively. The  
 302 estimated coefficients of  $\alpha_1$ ,  $\beta_1$  and the lagged variables RASI(-1) and RCOP(-1) are statistically  
 303 significant. This result indicates that incorporating these lagged variables into the respective mean  
 304 equations significantly reduce shock persistence (noise) and this lead us to conclude that crude oil

305 prices explains volatility in the stock market in the same way as stock market returns help in  
306 explaining volatility in crude oil returns. This shows a dependable and dynamic relationship between  
307 crude oil prices and stock market prices in Nigeria. The residuals of the estimated GARCH (1,1)  
308 models are presented in Figure 3.

## 309 5. CONCLUSION

310 This study investigated the dynamic relationship between crude oil prices and stock market price  
311 volatility in Nigeria using monthly data on the study variables from January 2006 to April 2017. The  
312 study employs Dickey-Fuller Generalized least squares unit root test to investigate the order of  
313 integration of the series, simple linear regression model to determine the impact of each variable on  
314 one another, unrestricted vector autoregressive model to determine the predictive power of both  
315 variables on each other, Granger causality test to investigate the direction of causality of each study  
316 variable and standard GARCH models to determine the persistence of shocks and dependable  
317 relationship between the study variables. Results shows that the study variables are integrated of  
318 order one, no long-run stable relationship was found to exist between crude oil prices and stock  
319 market prices in Nigeria. Both crude oil prices and stock market prices were found to have positive  
320 and significant impact on each other indicating that an increase in crude oil prices will increase stock  
321 market prices and vice versa. Both crude oil prices and stock market prices were found to have  
322 predictive information on one another in the long-run. A one-way causality ran from crude oil prices to  
323 stock market prices suggesting that crude oil prices determine stock prices and are a driven force in  
324 Nigerian stock market. Results of GARCH (1,1) models show high persistence of shocks in the  
325 conditional variance of both returns. The conditional volatility of stock market price log return was  
326 found to be stable and predictable while that of crude oil price log return was found to be unstable and  
327 unpredictable although a dependable and dynamic relationship between crude oil prices and stock  
328 market prices was found to exist. **The cointegration test result** of this study agrees with the findings of  
329 [17, 18, 19, 20] among others.

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

336 Ethical: NA

337 Consent: NA

338

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