International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 15 No. 1 Mar. 2016, pp. 191-209

http://www.ijias.issr-journals.org/

Regime-based Causality Analysis of Crude Oil Price - Stock Market and Economic Growth Nexus: Evidence from Nigeria

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ABSTRACT: The purpose of this study is to diagnose the causal relationships between crude oil price and the indicators of the stock market, and on the economic growth in Nigeria, a typical oil-dependent economy during the regime of global financial crisis and regime of no global financial crisis using a dummy-augmented Toda and Yamamoto causality testing procedures. Dummy-augmented model is used to assess the relative causal impacts of the variables on another in the regime of global financial crisis and regime of no global financial crisis. The results of the empirical findings imply that the causal relationship between the oil prices, the stock market indicators and the economic growth may be better in diagnosed if adequate attention is given to the two economic regimes using the augmented T-Y model.

KEYWORDS: Regime-based, Cointegration, Causality, Nigeria.

1 INTRODUCTION

The relation between crude oil price, stock market and economic growth is a topic that has given birth to divergent views and opinions by different authors. Crude oil price being one of the major determinants of how well an oil dependent economy performs, has made many researchers to have interest in studying its effect on the economic variables. Depending on the economic variable, the shocks crude oil price exerts could be short-run and at times long-run and it could be positive or negative. Distortions in the international crude oil price affect both exchange rate and inflation rates of an oil-dependent economy, this in-turn affect prospects of the economy for investors to invest and its direct consequence is reflected on the investability and returns of the stock market and the economy at large. As asserted by Adebiyi, Adenuga, Abeng and Omanukwue (2010), the oil crisis of the 1970s has made the literature to be gorged with oil prices explaining macroeconomic activities, irrespective of whether they are oil resource economies or not. Literatures have identified three measures of oil price. These are: the linear measure of oil price, asymmetric oil price measure and the net oil price increase. The linear or symmetric measure of oil price assumes that effects of oil price movements (increases or decreases) are equal such that a rise in oil price is expected to have a negative impact on the level of economic activity and oil price declines have a positive impact (Afshar, Arabian and Zomorrodian, 2008). This explains the direct proportional relationship between oil price increase and the increase in the production cost of modernized economies that because of their expanded production objectives, their demand for oil increases. Net oil price increase has been identified as the quality by which oil prices exceeds its maximum value over the previous periods. Thus, if by example, the current price of oil is higher than the maximum oil price of previous periods, then the percentage change between the two is computed. This measure of oil price assumes that when oil price is merely increasing to attain its maximum level in the previous period, it would have no impact (Adebiyi, et al., 2010). However, when the current price of oil has increased to a level above its maximum value in the previous periods, it expected to have an impact (Hamilton and Lin, 1998). Asymmetric oil price shocks refer to an oil price measure that differentiates between the positive and negative oil price volatility. In other words, a variable represents a positive percentage changes in oil price and another variable represents the negative percentage change (Mark, 1989, Lee and Ratti 1995). Other works in this area are; Jones and Kaul (1996), Sadorsky (1999), Canova and Nicolo (2002) and Uhliq (2005), Guo and Kliesen (2005), Olusegun (2008), Christopher and Benedikt (2008) and Philip and Akintoye (2006), Anoruo and Mustapha (2007).

Different from these studies, most of them which use traditional Granger-causality testing procedures and other techniques to analyze the nexus between oil price shocks and stock market returns, this study seeks to employ the method of causality test developed by Toda and Yamamoto (1995) popularly known as the T-Y approach, to investigate the causal link between oil price shocks, stock market indicators via Market Capitalization and economic growth via Exchange Rates. It also seeks to dig deeper into the extent to which oil price impact on these economic variables during the period of global financial crisis of 2007/2008 and during the period of no global financial crisis using dummy variables. As asserted by Arouri and Rault (2012), no particular direction of relationship between oil shocks and stock returns could be identified as they are changing per regime. Given the above assertions, it is therefore of empirical importance to investigate the relative causal impact of these variables on another given the two economic regimes. The rest of this paper is structured as follows: section 2 presents data and methods while section 3 presents empirical analysis. Discussion of policy implications of the results is presented in section 4 while section 5 presents summary and conclusion.

2 DATA AND METHODS

2.1 DATA COLLECTION

Monthly data for the crude oil prices, market capitalization and exchange rate were obtained for a period spanning from 1995:1 to 2014: 11. Each of these series consists of 239 observations. Data for the crude oil prices is obtained via www.eia.gov/dnas/pet-pet_pri_spt_sl_d.htm. Monthly data for Market Capitalization was purchased from the Nigeria Stock Exchange (NSE), Stock Exchange House, 2-4 Customs Street, Lagos, Nigeria via contactcentre@nigerianstockexchange.com & www.nse.com.org. Data on Exchange Rate was obtained from the Central Bank of Nigeria statistical database, www.cenbank.org.

2.2 UNIT ROOT TESTS

As a prerequisite for any further analysis in time series modeling, it is pertinent to formally diagnose the characteristics of the series that are used in the study. With respect to this, Crude Oil Price, Market Capitalization as well as the Exchange Rate (proxies for Nigerian stock market indicators and economic growth) shall be tested for the presence of unit root, or putting it differently, the series will be diagnosed to see if they are stationary. This process will also ascertain the order of integration of the variables. Here, by order of integration, we mean the number of times each of the series will be differenced before stationarity is attained. We shall make use of the Augmented Dickey-Fuller (ADF) (1979) test which the null hypothesis is non-stationarity. The three variables will be represented in vector form as

$$\begin{pmatrix} COP \\ MC \\ ER \end{pmatrix} = \begin{pmatrix} x \\ y \\ z \end{pmatrix} \quad (1.0)$$

where COP, MC and ER are respectively the crude oil prices, market capitalization and exchange rate.

2.2.1 THE AUGMENTED DICKEY-FULLER (ADF) TEST

The Augmented Dickey-Fuller (ADF) test is based on the regression equation,

$$y_t = \phi y_{t-1} + \sum_{j=1}^{p-1} \gamma_j \Delta y_{t-j} + \varepsilon_t \quad (2.0)$$

which can also be written as,

$$\Delta y_t = \beta y_{t-1} + \sum_{j=1}^{p-1} \gamma_j \Delta y_{t-j} + \varepsilon_t \quad (3.0)$$

Where y_t is the series being tested and p is the number of lagged differenced terms included to capture any autocorrelation, $\beta = \phi - 1$, $\Delta y_{t-j} = (y_{t-j} - y_{t-j-1})$, the null hypothesis is that the series contains a unit root process.

$H_0: \beta = 0$

against

$H_1: \beta < 0$

Test statistics: $T = \frac{\hat{\beta}}{S.E.(\hat{\beta})} \equiv \frac{\hat{\phi}-1}{S.E.(\hat{\phi})} \sim t_\alpha(n)$ at α level of significance

If the null hypothesis is rejected, we conclude that the series contains a unit root. This implies, however, only that the series y_t is integrated of order $d \geq 1$. To find out the order of required differencing, we repeat the above test on the series Δy_t, $\Delta^2 y_t$, and so on until an order of integration is reached. A nonstationary series may not be homogeneous and no differencing of any order may transform it into a stationary series. In such case, some other transformation procedures may be necessary. In practice, however, for most homogenous nonstationary series the required order of differencing is rarely greater than 2 (Wei, 2006).

2.3 Johansen Cointegration Test

Cointegration is defined as a long run or equilibrium relationship between two series. This definition of co-integration makes the term a very vital and ideal technique for analyzing and ascertaining the existence of a long-run relationship between the Crude Oil Prices and Market Capitalization and between the Crude Oil Prices and Exchange Rate. As asserted by Engle and Granger (1987), if cointegration is found between two variables, then there must be causality between them, either uni-directionally or bi-directionally. Sequel to this, the cointegration test also provides possible crosscheck on the validity of the results obtained from causality test procedures.

According to Engle and Granger (1987), the first step in testing cointegration is to test the null hypothesis of a unit root in each component series y_t individually using the unit test procdures discussed in the preceding section above. If the hypothesis is not rejected, then the next step is to test cointegration among the component series, that is, to test whether

$$\boldsymbol{X_t} = \boldsymbol{\beta}'\boldsymbol{Y_t} \quad (4.0)$$

is stationary for some matrix or vector $\boldsymbol{\beta}'$. Sometimes the choice of the matrix/vector $\boldsymbol{\beta}'$ is based on some theoretical considerations. For example, if

$$\boldsymbol{Y_t} = [Y_{1,t}, Y_{2,t}]' \quad (5.0)$$

where $Y_{1,t}$ represents revenue and $Y_{2,t}$ represents expenditure, we may want to test whether the revenues and expenditures are in some long-run equilibrium relation and therefore whether $X_t = Y_{1,t} - Y_{2,t}$ is stationary. In such case, we choose

$$\boldsymbol{\beta}' = [\mathbf{1} \quad -\mathbf{1}]. \quad (6.0)$$

In testing for cointegration in $\boldsymbol{Y_t}$ with known cointegrating vector $\boldsymbol{\beta}'$, we formulate the null hypothesis to test whether the process $\boldsymbol{X_t} = \boldsymbol{\beta}'\boldsymbol{Y_t}$ contains a unit root so that we can again use the test discussed in preceding section above. We will conclude that $\boldsymbol{Y_t}$ is cointegrated if the null hypothesis is rejected.

When the cointegrating vector is unknown, we can use the following method to test and estimate the cointegration.

2.3.1 The Likelihood Ratio Test

Now we consider a vector autoregressive process of finite order p

$$Y_t = A_1 Y_{t-1} + \cdots + A_p Y_{t-p} + \varepsilon_t \quad (7.0)$$

which can be written as

$$Y_t = \sum_{j=1}^{p} A_j Y_{t-j} + \varepsilon_t \quad (8.0)$$

where ε_t denotes a normally distributed k-dimensional white noise process, A_j, $j = 1,2,\ldots,p$ are the $k \times k$-dimensional parameter matrices. The reparameterization as a vector error-correction model leads to

$$\Delta Y_t = -\Pi Y_{t-1} + \sum_{j=1}^{p-1} A_j^* \Delta Y_{t-j} + \varepsilon_t \quad (9.0)$$

with

$\Pi = A(1) = I - \sum_{j=1}^{p} A_j$ and $A_j^* = -\sum_{i=j+1}^{p} A_i$, $j = 1,2,\cdots,p-1$

For the sake of this study, we will not treat the vector error-correction model deeply.

The matrix Π represents the long-run relations between the variables. Since all components of Y_t are $I(1)$ variables, each component of $\Delta Y_t, \cdots, \Delta Y_{t-p+1}$ is stationary and each component of Y_{t-1} is also integrated of order one. This makes (9.0) unbalanced as long as Π has a full rank of k. In this case the inverse matrix Π^{-1} exists and we could solve (9.0) for Y_{t-1} as a linear combination of stationary variables. However, this would be a contradiction. Therefore, Π must have a reduced rank of $r < k$. Then the following decomposition exists:

$$\underset{(k\times k)}{\Pi} = \underset{(k\times r)}{\Gamma}\underset{(r\times k)}{B'} \tag{10.0}$$

where all matrices have rank r. $B'Y_{t-1}$ are r stationary linear combinations which ensures that the system of equations in (9.0) are balanced. The columns of B contain the r linearly independent cointegration vectors and the matrix Γ contains the so-called loading coefficients which measure the contributions of the r long-run relations in the different equations of the system. The adjustment processes to the equilibria can be derived from these coefficients.

If there is no cointegration, i.e. if $r = 0$, Π is the zero matrix and (9.0) is a VAR of $p - 1$ in ΔY. This system possesses k unit roots, i.e. k stochastic trends. If $r = k - 1$, the system contains exactly one common stochastic trend and all the variables of the system are pair-wise cointegrated. As a general rule, the system (9.0) contains $k - r$ common stochastic trend and r linearly independent cointegration vectors for a contegration rank r with $0 < r < k$.

The approach proposed Johansen (1988) is a maximum likelihood estimation of (9.0) that considers the restriction (10.0). We can write

$$\Delta Y_t + \Gamma B' Y_{t-1} = A_1^* \Delta Y_{t-1} + \cdots + A_p^* \Delta Y_{t-p+1} + \varepsilon_t \tag{11.0}$$

We get the maximum likelihood estimation of $A_j^*, j = 1, \dots, p-1$, by applying ordinary least squares on (9.0) if Γ and B are given. Eliminating the influence of the short-run dynamics on ΔY_t and Y_{t-1} by regressing ΔY_t on the lagged differences and Y_{t-1} on the lagged differences, we get the residuals R_{0t} and R_{1t} respectively for which

$$R_{0t} = -\Gamma B' R_{1t} + \hat{\varepsilon}_t \tag{12.0}$$

holds.

Here, R_0 is a vector of stationary and R_1 a vector of nonstationary processes. The idea of the Johansen approach is to find those linear combinations $B'R_1$ which show the highest correlations with R_0. The optimal values of Γ and the variance-covariance matrix $\sum$ of ε can be derived for known B by ordinary least squares estimation of (11.0). We get

$$\hat{\Gamma}(B) = -S_{01}B(B' S_{11} B)^{-1} \tag{13.0}$$

and

$$\hat{\sum}(B) = S_{00} - S_{01}B(B'S_{11}B)^{-1}B'S_{10} \tag{14.0}$$

with

$$S_{ij} = T^{-1} \sum_{t=1}^{T} R_{i,t} R'_{j,t} \quad \text{for } i,j = 0,1. \tag{15.0}$$

It can be shown that the likelihood function concentrated with (12.0) and (13.0) is proportional to $\left|\hat{\sum}(B)\right|^{-T/2}$. Therefore, the optional values of B result from minimizing the determinant

$$|S_{00} - S_{01}B(B'S_{11}B)^{-1}B'S_{10}|$$

Showed that this is equivalent to the solution of the following eigenvalue problem

$$|\lambda S_{11} - S_{10}S_{00}^{-1}S_{01}| = 0 \tag{16.0}$$

with the eigenvalues λ_i and the corresponding k-dimensional eigenvectors υ_i, $i = 1,2, \dots, k$, for which

$$\lambda_i S_{11} \upsilon_i = S_{10} S_{00}^{-1} S_{01} \upsilon_i \text{s}$$

Using the arbitrary normalization

$$\begin{bmatrix} v_1' \\ \vdots \\ v_k' \end{bmatrix} S_{11} [v_1 \quad \cdots \quad v_k] = I_k \ ,$$

with I_k being the k-dimensional identity matrix, leads to a unique solution. $1 \geq \hat{\lambda}_1 \geq \cdots \hat{\lambda}_k \geq 0$ holds for the ordered estimated eigenvalues. It can be shown that for $k\ I(1)$ variables with cointegration rank r exactly r eigenvalues are positive and the remaining $k - r$ eigenvalues are asymptotically zero. The cointegrating vectors are estimated by the corresponding eigenvectors and combined in the $k \times r$ matrix

$$\hat{B} = [\hat{v}_1 \quad \cdots \quad \hat{v}_r] \ ,$$

The number of significantly positive eigenvalues determines the rank r of the cointegration space. This leads to two different likelihood ratio test procedures:

i. The trace test has the null hypothesis

H_0: There are at most r positive eigenvalues

against the alternative hypothesis that there are more than r positive eigenvalues. The test statistic is given by

$$Tr(r) = -T \sum_{i=r+1}^{k} ln\left(1 - \hat{\lambda}_i\right) \tag{17.0}$$

ii. The λ_{max} test analyses whether there are r or $r + 1$ cointegrating vectors. The null hypothesis is

H_0: There are exactly r positive eigenvalues

against the alternative hypothesis that there are exactly $r + 1$ positive eigenvalues. The corresponding test statistic is given by

$$\lambda_{max}(r, r + 1) = -Tln\left(1 - \hat{\lambda}_{r+1}\right) \tag{18.0}$$

The series of tests starts with $r = 0$ and is performed until the first time the null hypothesis cannot be rejected. The cointegration rank is given by the corresponding value of r. The null hypothesis is rejected for too large values of the test statistic. Since the test statistics do not follow standard asymptotic distributions, the critical values are generated by simulations (Kirchgaessner and Wolter 2007).

2.4 TODA AND YAMAMOTO (T-Y) (1995) PROCEDURE (NON-AUGMENTED)

It is a fact that the standard asymptotic theory is invalid to hypothesis testing in level in as much as the variables are integrated or cointegrated (Sims, Stock and Watson, 1990, Toda and Phillips 1993). To checkmate this problem, Toda and Yamamoto (1995) have proposed an alternative technique for testing coefficient restrictions of a level VAR model for an integrated or cointegrated process. They recommend that modified Wald (MWALD) test should be used in testing a lag augmented VAR (LA-VAR) which has a conventional asymptotic chi-square distribution when a $VAR(p + q_{max})$ is estimated since the testing procedure is robust to the non-stationarity, integrating and co-integrating properties of the process, where q_{max} is the maximum order of integration known to occur in the system, p is the optimal lag length. In carrying out T – Y test procedure, two steps are involved, these include the determination of the lag length (p) and the selection of maximum order of integration (q_{max}) for the variables in the system. The Bayesian Information Criteria (BIC) will be consulted since it is established that it provides a better and more reliable results especially for bigger samples. However, other measures such as Akaike Information Criterion (AIC), Final Prediction Error (FPE) and Hannan-Quinn (HQ) could be used for similar purpose.

Using a bivariate VAR ($p + q_{max}$) comprising of Crude Oil Prices and Market Capitalization

$$x_t = c_1 + \sum_{i=1}^{p+q_{max}} \alpha_i\, x_{t-i} + \sum_{i=1}^{p+q_{max}} \beta_i\, y_{t-i} + \varepsilon_{1t}$$

$$y_t = c_2 + \sum_{i=1}^{p+q_{max}} \vartheta_i\, y_{t-i} + \sum_{i=1}^{p+q_{max}} \tau_i\, x_{t-i} + \varepsilon_{2t}$$

which can be segmented to reflect the integrated parameters of the model.

$$x_t = c_1 + \sum_{i=1}^{p} \alpha_{1i}\, x_{t-i} + \sum_{i=p+1}^{p+q_{max}} \alpha_{2i}\, x_{t-i} + \sum_{i=1}^{p} \beta_{1i}\, y_{t-i} + \sum_{i=p+1}^{p+q_{max}} \beta_{2i}\, y_{t-i} + \varepsilon_{1t}$$

$$y_t = c_2 + \sum_{i=1}^{p} \vartheta_{1i}\, y_{t-i} + \sum_{i=p+1}^{p+q_{max}} \vartheta_{2i}\, y_{t-i} + \sum_{i=1}^{p} \tau_{1i}\, x_{t-i} + \sum_{i=p+1}^{p+q_{max}} \tau_{2i}\, x_{t-i} + \varepsilon_{2t}$$

where x_t and y_t corresponds to crude oil price and Market Capitalization at time t respectively, while α, β, ϑ and τ are the coefficients to be estimated. c and ε are respectively the constants and white noise (residuals) of the models,

$\varepsilon_1 \sim N(0, V_1), \varepsilon_2 \sim N(O, V_2)$ where V_1 and V_2 are the variance-covariance matrices of ε_1 and ε_2 respectively. q_{max} is the maximum order of integration known to occur in the system, p is the optimal lag length.

The null hypothesis of non-causality from Crude Oil Prices to Market Capitalization can be expressed as:

H_{01}: $\tau_i = 0, \forall\, i = 1, 2, \ldots \ldots . p$

and the null hypothesis of non-causality from Market Capitalization to Crude Oil Price can be expressed as:

H_{02}: $\beta_i = 0, \forall\, i = 1, 2, \ldots \ldots . p$.

Using another bi-variate VAR ($p + q_{max}$) comprising of Crude Oil Prices and Exchange Rate;

$$x_t = k_1 + \sum_{i=1}^{p+q_{max}} \pi_i\, x_{t-i} + \sum_{i=1}^{p+q_{max}} \omega_i\, z_{t-i} + \varepsilon_{1t}$$

$$z_t = k_2 + \sum_{i=1}^{p+q_{max}} \xi_i\, z_{t-i} + \sum_{i=1}^{p+q_{max}} \eta_i\, x_{t-i} + \varepsilon_{2t}$$

which can be segmented into two equations to reflect the integrated parameters of the model.

$$x_t = l_1 + \sum_{i=1}^{p} \pi_{1i}\, x_{t-i} + \sum_{i=p+1}^{p+q_{max}} \pi_{2i}\, x_{t-i} + \sum_{i=1}^{p} \omega_{1i}\, z_{t-i} + \sum_{i=p+1}^{p+q_{max}} \omega_{2i}\, z_{t-i} + \varepsilon_{1t}$$

$$z_t = l_2 + \sum_{i=1}^{p} \xi_{1i}\, z_{t-i} + \sum_{i=p+1}^{p+q_{max}} \xi_{2i}\, z_{t-i} + \sum_{i=1}^{p} \eta_{1i}\, x_{t-i} + \sum_{i=p+1}^{p+q_{max}} \eta_{2i}\, x_{t-i} + \varepsilon_{2t}$$

where x_t and z_t corresponds to crude oil price and Exchange Rate at time t respectively, while π, ω, ξ and η are the coefficients to be estimated. l and ε are respectively the constants and white noise (residuals) of the models, $\varepsilon_1 \sim N(0, V_1), \varepsilon_2 \sim N(O, V_2)$ where V_1 and V_2 are the variance-covariance matrices of ε_1 and ε_2 respectively. q_{max} is the maximum order of integration known to occur in the system, p is the optimal lag length.

The null hypothesis of non-causality from crude oil prices to Exchange Rate can be expressed as:

H_{01}: $\eta_i = 0, \forall\, i = 1, 2, \ldots \ldots . p$

and the null hypothesis of non-causality from Exchange Rate to Crude Oil Price can be expressed as:

H_{02}: $\omega_i = 0, \forall\, i = 1, 2, \ldots \ldots . p$.

2.5 TODA AND YAMAMOTO (T-Y) (1995) PROCEDURE (AUGMENTED)

The global financial crisis of 2008 has created a major impact on the crude oil prices, the stock market returns as well as other economic variables across the globe. Most of these variables have experienced either downward or upward trends because of the said financial situation. Its effects vary from country to country, the economic impacts include: weaker export revenues; further pressures on current accounts and balance of payment, lower investment and growth rates, and loss of employment (Adama, 2010). Nigeria is not exempted from the impact of this crisis either directly or indirectly due to its global economic affiliations. These impacts have caused a deep and subtle change in the course (structural break) of progression of these economic variables.

This structural break in the series because of the global financial crisis has raised questions to whether it is appropriate to analyze the variables as it is without giving cognizance to implications of its consequences. Putting it differently, performing Granger-causality test traditionally in particular, with the presence of this break may yield inconsistent results (Castles, Doornik and Hendry, 2013). Hence, in order to have a consistent outcome and ensure the robustness of the results, it is pertinent to take appropriate measures so as to carter for this break and its impending negative effects. Here we will introduce dummies of 0's and 1's as exogenous variable to the model. Two categories shall be considered: the period of no financial crisis and the period of financial arsis. The period of no financial crisis (1995:1 – 2007:7, 2009:1-2014:11) shall be coded with 1's while the period of financial crisis, (2007:8 – 2008:12) shall be coded with 0's so that it accounts for this sharp drift in the trend for the Crude Oil Price, Market Capitalization and Exchange Rate.

The augmented model that will carter for the break in Crude Oil Price and Market Capitalization takes the following form:

$$x_t = c_1 + \sum_{i=1}^{p} \alpha_{1i}\, x_{t-i} + \sum_{i=p+1}^{p+q_{max}} \alpha_{2i}\, x_{t-i} + \sum_{i=1}^{p} \beta_{1i}\, y_{t-i} + \sum_{i=p+1}^{p+q_{max}} \beta_{2i}\, y_{t-i} + \delta d_{2t} + \varepsilon_{1t}$$

$$y_t = c_2 + \sum_{i=1}^{p} \vartheta_{1i}\, y_{t-i} + \sum_{i=p+1}^{p+q_{max}} \vartheta_{2i}\, y_{t-i} + \sum_{i=1}^{p} \tau_{1i}\, x_{t-i} + \sum_{i=p+1}^{p+q_{max}} \tau_{2i}\, x_{t-i} + \omega d_{1t} + \varepsilon_{2t}$$

where x_t and y_t corresponds to crude oil price and Market Capitalization at time t respectively, while $\alpha, \beta, \vartheta\ \tau, \delta$ and ω are the coefficients to be estimated. c, d and ε are respectively the constants, dummies and white noise (residuals) of the models, $\varepsilon_1 \sim N(0, V_1), \varepsilon_2 \sim N(O, V_2)$ where V_1 and V_2 are the variance-covariance matrices of ε_1 and ε_2 respectively. q_{max} is the maximum order of integration known to occur in the system, p is the optimal lag length.

The null hypothesis of non-causality from Crude Oil Prices to Market Capitalization can be expressed as:

H_{01}: $\tau_i = 0, \forall\, i = 1, 2, \dots \dots . p$

and the null hypothesis of non-causality from Market Capitalization to Crude Oil Price can be expressed as:

H_{02}: $\beta_i = 0, \forall\, i = 1, 2, \dots \dots . p$.

For crude oil price and Exchange Rate relationship in the two economic regimes is given as;

$$x_t = l_1 + \sum_{i=1}^{p} \pi_{1i}\, x_{t-i} + \sum_{i=p+1}^{p+q_{max}} \pi_{2i}\, x_{t-i} + \sum_{i=1}^{p} \omega_{1i}\, z_{t-i} + \sum_{i=p+1}^{p+q_{max}} \omega_{2i}\, z_{t-i} + \Theta d_{1t} + \varepsilon_{1t}$$

$$z_t = l_2 + \sum_{i=1}^{p} \xi_{1i}\, z_{t-i} + \sum_{i=p+1}^{p+q_{max}} \xi_{2i}\, z_{t-i} + \sum_{i=1}^{p} \eta_{1i}\, x_{t-i} + \sum_{i=p+1}^{p+q_{max}} \eta_{2i}\, x_{t-i} + 3 d_{1t} + \varepsilon_{2t}$$

where x_t and z_t corresponds to crude oil price and Exchange Rate at time t respectively, while $\pi, \omega, \xi, \eta, \Theta$ and 3 are the coefficients to be estimated. l, d and ε are respectively the constants, dummies and white noise (residuals) of the models, $\varepsilon_1 \sim N(0, V_1), \varepsilon_2 \sim N(O, V_2)$ where V_1 and V_2 are the variance-covariance matrices of ε_1 and ε_2 respectively. q_{max} is the maximum order of integration known to occur in the system, p is the optimal lag length.

The null hypothesis of non-causality from crude oil prices to Exchange Rate can be expressed as:

H_{01}: $\eta_i = 0, \forall\, i = 1, 2, \dots \dots . p$

and the null hypothesis of non-causality from Exchange Rate to Crude Oil Price can be expressed as:

H_{02}: $\omega_i = 0, \forall\, i = 1, 2, \dots \dots . p$.

3 Results

3.1 Unit Root Test for Stationarity

Tables 1and 2 presents the result of the unit root test from ADF test procedure.

Table 1: ADF unit root test at level

Null Hypothesis: Variable has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=14)

lnCOP			lnMC			lnER		
		t-Statistic		-0.029030	t-Statistic			t-Statistic
ADF test statistics		-1.872623	ADF test statistics		-0.830265	ADF test statistics		-0.830265
Test critical values:	1% level	-3.457865	Test critical values:	1% level	-3.457747	Test critical values:	1% level	-3.457865
	5% level	-2.873543		5% level	-2.873492		5% level	-2.873543
	10% level	-2.573242		10% level	-2.573215		10% level	-2.573242

Table 2: ADF unit root test at first difference

Null Hypothesis: Difference of the variable has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=14)

DlnCOP			DlnMC			DlnER		
		t-Statistic			t-Statistic			t-Statistic
ADF test statistics		-10.19347	ADF test statistics		-6.467114	ADF test statistics		-10.76239
Test critical values:	1% level	-3.457865	Test critical values:	1% level	-3.457747	Test critical values:	1% level	-3.457865
	5% level	-2.873543		5% level	-2.873492		5% level	-2.873543
	10% level	-2.573242		10% level	-2.573215		10% level	-2.573242

From the result as presented in Tables 1 and 2, the variables are seen to be non-stationary at levels but stationary at first difference which means that highest order of integration known to occur among them is 1.

3.2 JOHANSEN COINTEGRATION TEST

The Johansen (1991) cointegration test result is presented in the Tables 3 and 4 for Crude Oil Price- Stock Market Capitalization and Crude Oil Price- Exchange Rate respectively.

Table 3: Johansen (1991) Cointegration Test for COP and MC

Sample (adjusted): 1995M05 2014M11
Included observations: 235 after adjustments
Trend assumption: Linear deterministic trend (restricted)
Series: COP MC
Lags interval (in first differences): 1 to 3

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.087029	25.47838	25.87211	0.0559
At most 1	0.017217	4.081309	12.51798	0.7303

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.087029	21.39707	19.38704	0.0252
At most 1	0.017217	4.081309	12.51798	0.7303

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 4: Johansen (1991) Cointegration Test for COP and ER

Sample (adjusted): 1995M05 2014M11
Included observations: 235 after adjustments
Trend assumption: No deterministic trend
Series: COP ER
Lags interval (in first differences): 1 to 3

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.051355	17.18063	12.32090	0.0071
At most 1 *	0.020182	4.791260	4.129906	0.0340

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.051355	12.38937	11.22480	0.0311
At most 1 *	0.020182	4.791260	4.129906	0.0340

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

3.3 TODA AND YAMAMOTO (T-Y) (1995) CAUSALITY TEST PROCEDURE (NON-AUGMENTED)

Table 5 and 6 presents the causality test as prescribed by Toda and Yamamoto (T-Y) (1995) for the two relationships, i.e. COP-MC and COP-ER.

Table 5: Toda and Yamamoto (T-Y) (1995) Causality Test for COP-MC Relationship

VAR Granger Causality/Block Exogeneity Wald Tests
Sample: 1995M01 2014M11
Included observations: 234

Dependent variable: CRUDEOILPRICES

Excluded	Chi-sq	Df	Prob.
MARKETCAPITALIZATION	7.069257	4	0.1323
All	7.069257	4	0.1323

Dependent variable: MARKETCAPITALIZATION

Excluded	Chi-sq	Df	Prob.
CRUDEOILPRICES	16.00457	4	0.0030
All	16.00457	4	0.0030

Table 6: Vector Autoregression Estimates for COP-MC Relationship

Sample (adjusted): 6 239
Included observations: 234 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	CRUDEOILPRICES	MARKETCAPT
CRUDEOILPRICES(-1)	1.297449	13.59387
	(0.06876)	(7.57592)
	[18.8704]	[1.79435]
CRUDEOILPRICES(-2)	-0.231824	5.139217
	(0.11133)	(12.2674)
	[-2.08224]	[0.41893]
CRUDEOILPRICES(-3)	-0.184743	-9.263684
	(0.11196)	(12.3364)
	[-1.65009]	[-0.75093]
CRUDEOILPRICES(-4)	0.017492	-14.25399

	(0.11196)	(12.3360)
	[0.15624]	[-1.15548]
MARKETCAPT(-1)	0.000644	0.963912
	(0.00061)	(0.06752)
	[1.05028]	[14.2756]
MARKETCAPT(-2)	0.000717	0.083072
	(0.00080)	(0.08851)
	[0.89310]	[0.93858]
MARKETCAPT(-3)	-0.000566	0.192897
	(0.00080)	(0.08792)
	[-0.70902]	[2.19398]
MARKETCAPT(-4)	-0.000634	-0.438980
	(0.00081)	(0.08923)
	[-0.78231]	[-4.91956]
C	1.638567	-3.813626
	(0.74231)	(81.7924)
	[2.20738]	[-0.04663]
CRUDEOILPRICES(-5)	0.057934	6.381586
	(0.07120)	(7.84522)
	[0.81369]	[0.81344]
MARKETCAPT(-5)	-2.50E-05	0.193907
	(0.00062)	(0.06780)
	[-0.04060]	[2.85986]
R-squared	0.981316	0.992896
Adj. R-squared	0.980478	0.992577
Sum sq. resids	4499.668	54630034
S.E. equation	4.491980	494.9523
F-statistic	1171.207	3116.576
Log likelihood	-677.9348	-1778.242
Akaike AIC	5.888332	15.29267
Schwarz SC	6.050762	15.45510
Mean dependent	53.97769	5002.340
S.D. dependent	32.14935	5744.767
Determinant resid covariance (dof adj.)		4691305.
Determinant resid covariance		4260609.
Log likelihood		-2450.059
Akaike information criterion		21.12871
Schwarz criterion		21.45357

Table 7: Toda and Yamamoto (T-Y) (1995) Causality Test for COP-ER Relationship

VAR Granger Causality/Block Exogeneity Wald Tests
Sample: 1995M01 2014M11
Included observations: 234

Dependent variable: CRUDEOILPRICES

Excluded	Chi-sq	Df	Prob.
EXCHANGERATES	1.309888	4	0.8597
All	1.309888	4	0.8597

Dependent variable: EXCHANGERATES

Excluded	Chi-sq	Df	Prob.
CRUDEOILPRICES	37.75615	4	0.0000
All	37.75615	4	0.0000

Table 8: Vector Autoregression Estimates for COP-ER Relationship

Sample (adjusted): 6 239
Included observations: 234 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	CRUDEOILPRICES	EXCHANGERATES
CRUDEOILPRICES(-1)	1.295111	-0.017304
	(0.06730)	(0.02404)
	[19.2444]	[-0.71967]
CRUDEOILPRICES(-2)	-0.213300	-0.086296
	(0.10974)	(0.03921)
	[-1.94376]	[-2.20107]
CRUDEOILPRICES(-3)	-0.175875	0.067013
	(0.11191)	(0.03998)
	[-1.57160]	[1.67605]
CRUDEOILPRICES(-4)	0.042811	-0.025264
	(0.11274)	(0.04028)
	[0.37973]	[-0.62720]
EXCHANGERATES(-1)	0.056394	1.232709
	(0.18540)	(0.06624)
	[0.30417]	[18.6095]
EXCHANGERATES(-2)	0.122031	-0.367406
	(0.29639)	(0.10589)
	[0.41172]	[-3.46956]

EXCHANGERATES(-3)	-0.195681	0.100397
	(0.30080)	(0.10747)
	[-0.65053]	[0.93419]
EXCHANGERATES(-4)	-0.018421	0.065611
	(0.28955)	(0.10345)
	[-0.06362]	[0.63424]
C	-4.114185	0.750498
	(1.73819)	(0.62102)
	[-2.36694]	[1.20850]
CRUDEOILPRICES(-5)	-0.007076	0.063159
	(0.07161)	(0.02558)
	[-0.09882]	[2.46878]
EXCHANGERATES(-5)	0.095935	-0.034910
	(0.17581)	(0.06281)
	[0.54566]	[-0.55577]
R-squared	0.981544	0.996507
Adj. R-squared	0.980716	0.996350
Sum sq. resids	4444.723	567.3590
S.E. equation	4.464470	1.595058
F-statistic	1185.961	6361.344
Log likelihood	-676.4974	-435.6551
Akaike AIC	5.876046	3.817565
Schwarz SC	6.038475	3.979995
Mean dependent	53.97769	122.7452
S.D. dependent	32.14935	26.40176
Determinant resid covariance (dof adj.)		50.49772
Determinant resid covariance		45.86167
Log likelihood		-1111.662
Akaike information criterion		9.689418
Schwarz criterion		10.01428

3.4 TODA AND YAMAMOTO (T-Y) (1995) CAUSALITY TEST PROCEDURE (DUMMY-AUGMENTED)

Table 9: Toda and Yamamoto (T-Y) (1995) Causality Test for COP-MC Relationship

VAR Granger Causality/Block Exogeneity Wald Tests
Sample: 1 239
Included observations: 234

Dependent variable: CRUDEOILPRICES

Excluded	Chi-sq	df	Prob.
MARKETCAPT	6.996680	4	0.1361
All	6.996680	4	0.1361

Dependent variable: MARKETCAPT

Excluded	Chi-sq	df	Prob.
CRUDEOILPRICES	15.51802	4	0.0037
All	15.51802	4	0.0037

Table 10: Vector Autoregression Estimates for COP-MC Relationship

Vector Autoregression Estimates
Sample (adjusted): 6 239
Included observations: 234 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	CRUDEOILPRICES	MARKETCAPT
CRUDEOILPRICES(-1)	1.295922	13.57335
	(0.06899)	(7.60451)
	[18.7840]	[1.78491]
CRUDEOILPRICES(-2)	-0.232250	5.133481
	(0.11155)	(12.2955)
	[-2.08205]	[0.41751]
CRUDEOILPRICES(-3)	-0.184840	-9.264981
	(0.11217)	(12.3641)
	[-1.64784]	[-0.74935]
CRUDEOILPRICES(-4)	0.015987	-14.27421
	(0.11223)	(12.3706)
	[0.14245]	[-1.15388]
MARKETCAPT(-1)	0.000651	0.964014
	(0.00061)	(0.06771)
	[1.06021]	[14.2383]
MARKETCAPT(-2)	0.000701	0.082852
	(0.00081)	(0.08882)

	[0.86987]	[0.93278]
MARKETCAPT(-3)	-0.000568	0.192866
	(0.00080)	(0.08812)
	[-0.71058]	[2.18865]
MARKETCAPT(-4)	-0.000636	-0.439016
	(0.00081)	(0.08943)
	[-0.78412]	[-4.90878]
C	2.137018	2.885379
	(1.44864)	(159.676)
	[1.47519]	[0.01807]
DUMMIES	-0.424715	-5.708017
	(1.05925)	(116.756)
	[-0.40096]	[-0.04889]
CRUDEOILPRICES(-5)	0.058143	6.384395
	(0.07134)	(7.86303)
	[0.81506]	[0.81195]
MARKETCAPT(-5)	2.17E-06	0.194272
	(0.00062)	(0.06836)
	[0.00351]	[2.84173]
R-squared	0.981329	0.992896
Adj. R-squared	0.980404	0.992544
Sum sq. resids	4496.412	54629446
S.E. equation	4.500456	496.0631
F-statistic	1060.741	2820.576
Log likelihood	-677.8501	-1778.241
Akaike AIC	5.896155	15.30120
Schwarz SC	6.073351	15.47840
Mean dependent	53.97769	5002.340
S.D. dependent	32.14935	5744.767
Determinant resid covariance (dof adj.)		4730200.
Determinant resid covariance		4257491.
Log likelihood		-2449.974
Akaike information criterion		21.14507
Schwarz criterion		21.49946

Table 11: Toda and Yamamoto (T-Y) (1995) Causality Test for COP-ER Relationship

VAR Granger Causality/Block Exogeneity Wald Tests

Sample: 1 239
Included observations: 234

Dependent variable: CRUDEOILPRICES

Excluded	Chi-sq	df	Prob.
EXCHANGERATES	1.688810	4	0.7927
All	1.688810	4	0.7927

Dependent variable: EXCHANGERATES

Excluded	Chi-sq	df	Prob.
CRUDEOILPRICES	28.41656	4	0.0000
All	28.41656	4	0.0000

Table 12: Vector Autoregression Estimates for COP-ER Relationship

Sample (adjusted): 6 239
Included observations: 234 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	CRUDEOILPRICES	EXCHANGERATES
CRUDEOILPRICES(-1)	1.275793	-0.010963
	(0.06776)	(0.02424)
	[18.8293]	[-0.45234]
CRUDEOILPRICES(-2)	-0.215511	-0.085570
	(0.10916)	(0.03905)
	[-1.97430]	[-2.19150]
CRUDEOILPRICES(-3)	-0.166289	0.063866
	(0.11143)	(0.03986)
	[-1.49226]	[1.60225]
CRUDEOILPRICES(-4)	0.036279	-0.023120
	(0.11220)	(0.04013)
	[0.32335]	[-0.57607]
EXCHANGERATES(-1)	0.085269	1.223232
	(0.18508)	(0.06620)
	[0.46071]	[18.4766]
EXCHANGERATES(-2)	0.105858	-0.362097
	(0.29494)	(0.10550)
	[0.35891]	[-3.43213]

EXCHANGERATES(-3)	-0.187978	0.097869
	(0.29923)	(0.10704)
	[-0.62821]	[0.91436]
EXCHANGERATES(-4)	-0.017171	0.065201
	(0.28800)	(0.10302)
	[-0.05962]	[0.63289]
C	-3.429445	0.525749
	(1.76843)	(0.63257)
	[-1.93926]	[0.83113]
CRUDEOILPRICES(-5)	-0.007890	0.063426
	(0.07123)	(0.02548)
	[-0.11077]	[2.48948]
EXCHANGERATES(-5)	0.092951	-0.033931
	(0.17489)	(0.06256)
	[0.53150]	[-0.54240]
DUMMIES	-2.160278	0.709058
	(1.17258)	(0.41944)
	[-1.84232]	[1.69050]
R-squared	0.981822	0.996551
Adj. R-squared	0.980921	0.996380
Sum sq. resids	4377.791	560.1483
S.E. equation	4.440696	1.588455
F-statistic	1090.030	5831.478
Log likelihood	-674.7221	-434.1586
Akaike AIC	5.869420	3.813322
Schwarz SC	6.046615	3.990518
Mean dependent	53.97769	122.7452
S.D. dependent	32.14935	26.40176
Determinant resid covariance (dof adj.)		49.62443
Determinant resid covariance		44.66525
Log likelihood		-1108.569
Akaike information criterion		9.680078
Schwarz criterion		10.03447

4 Discussion

The results from both the ADF test procedure shows that the variables are nonstationary at level (Table 1) but stationary at first difference (Table 2) which imply that the maximum order of integration known to occur in the system is one, i.e. $q_{max} = 1$

The Johansen test results (Tables 3 and 4) above suggest that there exist a viable cum long run equilibrium relationships among these variables. The results above show that the two sets of variables are cointegrated, the first relationship having just one cointegrating relationship, that is, the maximum eigenvalue test at 5% significant level and the second relationship having 2 cointegrating relationships at 5% significant level, that is, both the maximum eigenvalue and the trace test. By this we mean that there exist sustainable relationships within the two sets of variables in the system except the dummy variable which is exogenous to the model. The existence of long run equilibrium relationships among these variables suggests that there exist causality among them in at least one direction (Engle and Granger, 1987). This result helps us to be sure that there will be causation among these two sets of variables in at least one direction.

The results obtained from VAR Granger Causality/ Block Exogeneity Wald Test as developed by Toda and Yamamoto (1995) (Tables 5and 7) and the dummy-augmented T-Y model (Tables 9 and 11) indicate that the Crude Oil Price Granger-causes the Market Capitalization and Exchange Rates and the reverse cases are not true. From the dummy-augmented VAR model, we see the relative causal impacts of each variable on another in the two economic regimes as they reflect on the coefficients of the dummy variable (Tables 10 and 12). Comparing the estimates from the two relationships (COP-MC and COP-ER); though the information criteria for the dummy-augmented and the non-augmented models (in Table 6 and8, 10 and 10 respectively) are almost the same, the dummy-augmented model would be preferred since it is able to show in the average, by how much the variables will increase or decrease in these two economic regimes given the other variable.

5 Summary and Conclusion

A causal nexus between the Crude Oil Prices, Nigerian Stock Market Indices and economic growth was investigated. Market Capitalization and exchange Rate were used as proxies for the Nigerian Stock Market Indices and economic growth respectively. In exploring theses causal relationships, various steps and aspects were pre-investigated in making sure that the causal relationships among these variables are properly perused.

Firstly, to diagnose the nature of the variables in terms of stationarity and order of integrated, Augmented Dickey-Fuller ADF (1979) was employed. It was discovered that the variables were non-stationary at levels but stationary at first difference which implies that their order of integration is 1.

As indicated in our cointegration results, the variables in the two sets (the COP-MC and COP-ER) have a long run and sustainable equilibrium relationships. The oil price is shown to exert enormous effects on the macroeconomic activities especially in the stock market/financial sector of an oil dependent economy like that of Nigeria, a result seen from the causality tests. The dummy-augmented Toda and Yamamoto model provides a better framework for the analyses of these kinds of time series with structural breaks as it provides a clear impact of these variables on another in the various regimes. And as such will guide the policy makers and stock brokers on how to achieve better results in their policy making and stock brokerages in period of economic crisis and period of no economic crisis.

Acknowledgement

God Almighty

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