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Oil Prices and Economic Activity in Nigeria: An Asymmetric Cointegration and Threshold Analysis

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Abstract: Oil price fluctuation greatly affects the economy of oil producing-net-exporting small open economies of developing countries. This study investigates the nonlinear relationship between oil price volatility and economic growth in Nigeria, covering the period 1981 to 2019. The nonlinear autoregressive distributed lag (NARDL) model is adopted to establish the asymmetric cointegration status of oil price volatility and GDP growth. The switching point between the variables is estimated using the threshold regression approach. The results from the NARDL analysis reveal that the relationship between oil price volatility and economic growth is cointegrated in the long run and has an asymmetrical relationship. Furthermore, the threshold regression investigation indicates that the switching point for the oil price in the relationship with economic growth is US$48.263 per barrel. Hence, whenever oil price falls below the threshold, there is a negative effect on the country's economic growth. Therefore, the study recommends that the government take advantage of oil export earnings and make some savings whenever oil price goes above the threshold. The savings can be used to assist in developing the other sources of foreign exchange earnings and sustain the country's development effort.

Keywords: Oil Price; Economic Growth; Nonlinear Autoregressive Distributed Lag (NARDL); Threshold Regression; Asymmetric Cointegration

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1. Introduction

Crude oil has maintained its position as one of the world's most precious commodities. The sudden or unexpected change in oil price often affects the

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economy through household budgets, firms' earnings, and national output. Several factors have been responsible for oil price fluctuations in the global energy market. Some factors include; fluctuations in the world markets, policy changes in countries, conflicts between oil-producing countries, cuts in production quota by cartels like OPEC and natural disasters like the Covid-19, the novel coronavirus and a few others. The fluctuation in oil prices affects the economic activity differently in countries depending on whether a country is a net-exporter or net-importer of petroleum products. Where a country is a net exporter of oil, and there is an increase in oil price, the government may enjoy an increase in revenue from oil sales attendant effect on the country's level of consumer prices, exchange rate and balance of payments (Gershon et al. 2019). On the other hand, where a country is a net importer of oil, a positive oil price fluctuation will increase the cost of importation of oil with attendant effect on production costs, national output, employment, inflation, exchange rate and balance of payments.

Several studies have examined the relationship between oil price fluctuations and the level of economic activity. A pioneering work conducted by Hamilton (1983) showed that the increase in oil price led to the post World War II recession in the United States. Several other scholars have since tried to authenticate the assertion of Hamilton in several other studies (Gisser & Goodwin, 1986; Abel & Bernanke, 2001; Brown & Yucel, 2002; Lardic & Mignon, 2008). The growing body of economic theory suggests the various transmission channels through which oil price changes would affect economic activity. The changes in the world price of oil, through oil price increase or decrease, may relate with the economy via the various stages of the transmission channel. For instance, an increase in the price of oil leads to a rise in the cost of production for firms that rely on oil products as inputs and hence productivity and output for this sector may be slowed (Abel & Bernanke, 2001; Lardic & Mignon, 2008). Also, a rise in oil prices would imply a wealth transfer from the oil-importing countries to the oil exporting countries and hence, a deterioration of the terms of trade for the oil-importing countries.

Furthermore, an increase in oil prices would stimulate a rise in the demand for money which may not be addressed immediately by the monetary authority. A growing money demand situation would trigger an increase in supply and lead to a rise in the interest rate and inflation with negative implications for economic growth (Brown & Yucel, 2002; Lardic & Mignon, 2008). Besides, increasing oil prices could harm consumption through disposable income and investment through increasing production costs. The Dutch Disease theory of economic growth contends that a sustained rise in oil prices for the oil exporting countries tends to sharply alter the production structure of firms in the economy in favour of oil-related activity. The change in investment and labour reallocations would portend long term implications for the level and composition of national output and the unemployment level for the economy (Corden & Neary, 1982). A summary of the discussion so far shows that oil price changes affect macroeconomic performance.

Nigeria is an oil-producing and exporting nation and an importer of oil products. As a net exporter, Nigeria relies heavily on oil revenue to sustain the economy. The country's dependence on oil is so strong that many commentators see it as a mono-product economy. CBN figures (2019) indicate that government revenue from oil exports accounts for over 70% of the total collectable revenue annually. Although several writers have tried to examine the effect of oil price fluctuations on the country's economic performance, not many studies have attempted to investigate the nature of the asymmetric relationship between the variables (Omojolaibi, 2013; Igberaese, 2013; Ogundipe et al. 2014; Osuji, 2015; Ifeanyi & Ayenajeh, 2016; Okonkwo & Mojekwu, 2018). While trying to fill this gap, this study also attempts to establish the threshold between oil price changes and Nigeria's level of economic activity. Estimating the threshold point for oil price changes is essential for policy in the country's financial planning. It establishes the tipping point of oil prices that could trigger negative consequences for its economic performance. Therefore, the study investigates the asymmetric cointegration and threshold for oil price changes and Nigeria's economic activity level.

The remaining part of this research study is organized as follows. Section 2 is devoted to reviewing relevant empirical literature concerning the effect of oil price shocks. Section 3 articulates the methodology, variable definition and data sources. Finally, section 4 discusses the data analysis and empirical results of the study, while Section 5 is committed to the summary of conclusions and policy implications.

2. Literature Review

There are several existing studies on the relationship between oil price and the national output of the economy. While the general notion has been that an increase in oil price would stimulate a decline in national production for the oil-importing countries, a decrease in oil price is accompanied by an improvement in output (Hamilton, 2003). In one of the early studies of the nonlinear relationship between oil price and output growth, Hamilton (2003) concludes that oil price shocks are essential because they disorganize the expenditure patterns of firms and consumers in the critical sectors of the economy. While underscoring the existing evidence of nonlinearities in the variable relationship, he maintains that the increase in oil price has shown more relevance than the oil price decreases; because increases possess significantly less predictive content as they can correct the earlier declines. Also, in a study of six Asian countries between 1975 and 2002 and using quarterly data, Cunado & de Gracia (2005) observed that oil prices significantly affected general costs in the short run. There was significant evidence of asymmetries in the oil price-output growth relationship. In the study of the US, Canada and Japan, Huang et al. (2005) used monthly data covering 1984 to 2004 to examine the relationship between oil price changes and economic activity. Deploying a multivariate threshold model, they found that oil price changes and the volatility at some point beyond the threshold could help to explain the changes in the level of economic activity. In examining Hamilton's claim on the relationship between oil price shock and total output in Japan, Zhang (2008) found evidence of nonlinearities. Specifically, adverse oil price shocks produced more significant effects on aggregate production than the impact of positive shocks. In the same period, Lardic & Mignon (2008) examined the relationship between oil price and economic activity for cointegration and asymmetry over 1970 to 2004 using quarterly data for the US, Europe and the G7 countries. They found no cointegration among the variables for the whole sample, but there is evidence of asymmetric cointegration between oil price and GDP. Also, using quarterly data from 1979:Q1 to 2008:Q2 and adopting the IS-LM model and the Philips curve technique, Malik (2008) examined crude oil prices, monetary policy and output in Pakistan. He found that the relationship between oil prices and national output is nonlinear. Furthermore, when the price of oil goes above the threshold of US$22 per barrel, the economic growth of Pakistan is negatively affected. In a similar study on the G7 countries and utilizing the Markov-switching analysis on quarterly data covering the period 1970 to 2005, Cologni & Manera (2009) concluded that oil price shocks tend to be asymmetrical. They also observed that oil price changes and volatility strongly affect output growth. A similar study on Greece by Papapetou (2009) concludes that the estimated negative correlation between economic activity and oil prices strengthens during high oil price volatility and rapid oil price changes.

While examining the effect of oil price on economic growth in China, Du & Wei (2010) deployed VAR to analyze oil price's linear and nonlinear specification using monthly data over the period 1995:1 to 2008:12. The specified nonlinear model showed that a 100% increase in oil prices negatively affected the GDP by 17% using the Mork Asymmetry transformation. Thus, the study concludes that a nonlinear asymmetric relationship exists between oil prices and economic growth in China. Finally, Apergis et al. (2015) investigated the relationship between oil prices and output covering the United States utilizing a quarterly panel data framework from 1948Q1 to 2013Q4. They confirm the existence of asymmetry among the variables as long-run coefficients with statistical significance, associated favourable oil prices with reducing output. Similarly, hostile oil prices were related to decreasing production for the period.

While investigating the relationship between oil prices and GDP in South Africa, Nzimande & Msomi (2016) adopted quarterly data covering 1980 – 2014. The study utilized the Schorderet approach to asymmetry and recorded evidence of long-run asymmetric cointegration relationship between oil price shocks and GDP. In investigating the asymmetric effects of oil price and exchange rate fluctuations on real GDP for a panel study of ECOWAS countries, Gbatu et al. (2017) observed a linear and asymmetric impact of oil prices on the GDP for the entire sample of countries studied. The asymmetric relationship between actual oil prices and real GDP was investigated by Khalid (2019) for five ASEAN countries using annual data series from 1970 to 2015. While employing the NARDL approach, the empirical findings lend credence to the long-run asymmetry for the variables in ASEAN countries. He further observed that the increase in oil price stimulated positive effects on GDP for all the countries in the sample. While deploying the panel ARDL in a study of selected seven low–income oil-importing countries of sub-Saharan Africa (SSA) and covering the period 1990 - 2018, Akinsola & Odhiambo (2020) examined the nonlinear relationship between oil prices and economic growth. They found that there was an asymmetric nonlinear relationship between the variables. While an oil price increase elicited an adverse impact on economic growth, a decrease in oil price stimulated growth. In a similar study and deploying the panel (NARDL) for ASEAN-4, Rumbia et al. (2020) assessed the effect of household spending on economic growth using data annual data for the period 1967-2018. They found that crude oil prices asymmetrically impacted economic growth and, economic growth increased by 0.42% for every 1% increase in crude oil prices.

In a more recent study, Baek & Young (2020) adopted quarterly data 1998:Q1 – 2017:Q2 and deployed the NARDL approach on an oil exporting country (Alaska) to establish whether oil price changes asymmetrically impacted economic growth. They found that in the short and long run, the country's economic growth was asymmetrically impacted by the changes in oil prices throughout the study. In a survey of Qatar and utilizing quarterly data to cover the period from 2000:Q1 to 2018:Q3, Charfeddine & Barkat (2020) employed the SVAR and NARDL approach to examine the effect of oil prices and gas revenue on real GDP and the economic diversification for both the short run and long run. Their findings reveal that oil prices and gas revenue shocks on real GDP were more negative than positive. Besides, the long-run impact of NARDL analysis confirmed the presence of asymmetry. In other related studies, there is consensus that natural resource abundance, renewable energy and urbanization affect the development of the oil-producing, open and small economy like Nigeria (Nathaniel & Bekun, 2019; Balsalobre-Lorente et al., 2019; Olanipekun & Alola, 2020; Nathaniel et al., 2021)

The review of empirical studies conducted in this article reveals that there is often long-run cointegration between oil prices and economic activity except for the investigation by Lardic & Mignon (2008). Also, most of the examined studies found evidence of an asymmetric effect between oil prices and economic activity. The only research which observed that oil price increase is related to a positive trend in GDP was by Khalid (2019). While most of the studies examined the relationship between oil prices and economic activity for the oil-importing countries, there is scanty evidence on the same research being conducted for oil-importing and exporting countries like Nigeria. Besides, most existing studies on this subject matter did not investigate the threshold price of oil for an oil-producing and importing country like Nigeria. This study, therefore, believes that there is a substantial benefit for economic policy to be derived when the threshold oil price for an importing / exporting country like Nigeria is estimated.

3. Methodology

3.1. The Model and Asymmetric Cointegration

Schorderet (2004) and Lardic & Mignon (2008) argue that the model of oil price changes for the purpose of asymmetric cointegration may find a starting point in the breakdown of the time series components X_t into the positive (X_t^+) and negative (X_t^-) parts:

$$X_t^+ = \sum_{i=0}^{t-1} 1(\Delta X_{t-1} \geq 0)\, \Delta X_{t-1} \; and \; X_t^- = \sum_{i=0}^{t-1} 1(\Delta X_{t-1} < 0)\, \Delta X_{t-1} \quad (1)$$

Generally, time series may broadly be decomposed into two parts, X_{1t} and X_{2t}, therefore, we can define X_{jt}^+ and X_{jt}^- for j=1,2, in line with equation (1). A linear extension z_t may exist between X_{jt}^+ and X_{jt}^- hence:

$$z_t = \beta_0 X_{1t}^+ + \beta_1 X_{1t}^- + \beta_2 X_{2t}^+ + \beta_3 X_{2t}^- \quad (2)$$

In line with the submissions of Schorderet (2004), there is asymmetric cointegration with X_{1t} and X_{2t} if any vector exist in line with $\beta' = (\beta_0, \beta_1, \beta_2, \& \beta_3)$ such that $\beta_0 \neq \beta_1 \; or \; \beta_2 \neq \beta_3$ and $\beta_0 or \; \beta_1 \neq 0$ and $\beta_2 or \; \beta_3 \neq 0$ in such a way that a stationary process exists with z_t in equation (2). It is important to note that whenever the values of the variables decrease or increase, the relationship between them will change. The generality loss might become simplified when only one of each series component is observed in equation (2) as a cointegrating relationship:

$$z_{1t} = X_{1t}^+ - \beta^+ X_{2t}^+ \; \boldsymbol{or} \; z_{2t} = X_{1t}^- - \beta^- X_{2t}^- \quad (3)$$

The nonlinear properties in equation (3) with z_{jt}; j = 1, 2; OLS will be biased in the finite sample. Accordingly, Schorderet (2004) proposes that estimation be conducted the classical regression of the auxiliary model, which follows:

$$\boldsymbol{\varepsilon_{1t}} = X_{1t}^- + \Delta X_{1t}^+ - \beta^- X_{2t}^- \; \boldsymbol{or} \; \boldsymbol{\varepsilon_{2t}} = X_{1t}^+ + \Delta X_{1t}^- - \beta^+ X_{2t}^+ \quad (4)$$

The normal statistical inference can be drawn that equation (4) is asymptotically normal while using the least-squares estimates as the mean of the regressor possesses a linear time trend. It is necessary to estimate the partial sum of positive and negative changes: (ΔX_{1t}^+) and (ΔX_{1t}^-) to test for the existed of asymmetric cointegration. The next step is to estimate equation (4) with the nonlinear error correction mechanism under the NARDL framework. The process entails regression analysis through the Stepwise Least Squares approach. The resulting NARDL output represents the long-run coefficients for the variable relationship. To establish the cointegration status of the variables in the NARDL output entails the estimation of the wald test values for a joint null hypothesis coefficient of the variables in a specification [c(2)=c(3)=c(4)=0]. The value of the F-statistic that is estimated from the Wald test is compared with the critical values of Pesaran et al. (2001). If the value of the estimated F-statistic is larger than the critical value from the Pesaran table, we reject the null hypothesis of no cointegration and conclude that the variables have long run cointegration. Finally, the presence of asymmetry may be ascertained through a second level Wald test to conclude whether the partial sums of negative and positive changes are significantly different from each other through the process [-c(3)/c(2)=-c(4)/c(2)]. Where the partial sums of negative and positive changes are not statistically different from each other in line with the null hypothesis test, we conclude that the variables have asymmetric cointegration. Otherwise, the relationship between the variables has a symmetric cointegration.

3.2. The Model and Threshold Regression

The threshold regression model is a version of the nonlinear regression model, which possesses piecewise linear specifications. The model is regime-switching, and it happens when one of the variables crosses some unknown thresholds. The threshold models are more realistic and closer to practical reality situations, as most behavioural variables are nonlinear. Threshold models have the capacity to generate nonlinearities and are rich in dynamics (Bai & Perron, 2003; Perron & Zhongjun, 2006). A typical multiple linear regression model with t observations and m potential threshold can produce m+1 regimes. Considering the observations in the regime j = 0, 1, 2, …, m hence, the linear regression may be specified as follow:

$$Y_t = X_t'\beta + Z_t'\delta_j + \varepsilon_t \tag{5}$$

Where Y is economic growth (GDPR); X is a vector of the covariates with economic growth where necessary, and Z is the variable with the parameter that is regime specific. Therefore, while the X variables possess parameters which do not vary in the model, the Z variable(s) have parameters that can vary but are regime-specific. A threshold variable q_t would be strictly increasing the threshold values ($\gamma_1 < \gamma_2 < \gamma_3 ... < \gamma_m$) in such a way that regime j exists only if:

$$\gamma_j \leq q_t < \gamma_{j+1}.\gamma_0 = -\infty \ and \ \gamma_{m+1} = \infty \tag{6}$$

Hence, regime j is normally taken into account when the threshold variable is less than or equal to (≤) the j-th threshold value, but less than (<) the (j+1)-th threshold. In a single threshold with two regime model, the following stipulations will hold:

$$Y_t = X_t^{'}\beta + Z_t^{'}\delta_1 + \varepsilon_t \qquad if -\infty < q_t < \gamma_1 \tag{6}$$

$$Y_t = X_t^{'}\beta + Z_t^{'}\delta_2 + \varepsilon_t \qquad if\ \gamma_1 < q_t < \infty \tag{7}$$

If an indicator function k(..) is deployed and takes the values 0 when the expression is false and one when otherwise. In combining to equate $k_j(q_t, \gamma) = k(\gamma_j \leq q_t < \gamma_{j+1})$, it becomes possible to merge the individual regime specifications m+1, into the following single equation:

$$Y_t = X_t^{'}\beta + \sum_{j=0}^{m} k_j(q_t, \gamma) + Z_t^{'}\delta_1 + \varepsilon_t \tag{8}$$

The approach of non-linear least squares is basically to estimate the parameters of the model. Hence, the objective function of the least-squares sum of squares becomes:

$$S(\delta, \beta, \gamma) = \sum_{t=1}^{T} \left[Y_T - X_t^{'}\beta + \sum_{j=0}^{m} k_j(q_t, \gamma) + Z_t^{'}\delta_1\right]^2 \tag{9}$$

The threshold regression estimates can be obtained by minimizing $S(\delta, \beta, \gamma)$ with respect to the parameters.

3.3. Data Sources

This study employs the NARDL model to cover the period 1981 to 2019 to estimate the asymmetric cointegration of oil price changes on the level of economic activities. The study also utilizes the threshold regression approach to establish the critical price of oil that becomes strategic to changes in the level of the country's economic activity. The variables utilized for the study include oil price and economic growth. Secondary data is adopted for the variables and sources from UNCTAD (Oil Price) and WDI (GDP Growth). To standardize the variables, we use the natural logarithm for all variables. The full name, description and source of the data are presented in the table.

Table 1. Data and Variable Description

Variable	Full Name	Description	Source
OILP	Brent Crude Oil Price	UK Brent Crude Oil in US$ per barrel	UNCTAD
GDPR	Economic Growth	The annual percentage growth rate of GDP at market prices: Estimated as $\left(\frac{Y_t - Y_{t-1}}{Y_{t-1}}\right)\%$ for each year	WDI

4. Empirical Analysis and Results

4.1. Time Series Properties: Unit Root Test

This study conducts the test for unit root by adopting the Augmented Dickey-Fuller (ADF) Approach. The test is performed on the two variables in the study, oil price, economic growth, with the results presented in Table 2. From the table, the estimated values of the t-statistics only became greater than the critical values at 1%, 5% and 10% at the first difference I(1). At the first difference, the estimated probability values indicate that all the variables become stationary at the level of integration. At the joint stationarity test of the variables, the Fisher Chi-square value is 57.51 with the associated probability of zero, and the Choi Z-statistic value is -6.73 with the related probability of zero. Therefore, the unit root test shows that all the variables are integrated at the order of the first difference [I(1)].

Table 2. ADF Unit Root Test

Method			Statistic	Prob.*	
ADF - Fisher Chi-square			57.5097	0.0000	
ADF - Choi Z-stat			-6.7333	0.0000	
Series	t-stat	Prob.	Order of Integration	Max Lag	Obs
L(OILP)	-5.2516	0.0001	I(1)	2	36
L(DGDP)	-5.2199	0.0002	I(1)	2	36
Test critical values:	1% level		-3.626784		
	5% level		-2.945842		
	10% level		-2.611531		

Source: Author's Computation

4.2. Asymmetric Cointegration Analysis and Result

To effectively test for the asymmetric cointegration of the variables, we can estimate values for the two auxiliary models that are derived from our equation (4):

$$LGDP_t^- + \Delta LGDP_t^+ = \beta_0^- + \beta_1^- LOILP_t^- + \mathcal{E}_{1t} \quad (10)$$

$$LGDP_t^+ + \Delta LGDP_t^- = \beta_0^+ + \beta_1^+ LOILP_t^+ + \mathcal{E}_{2t} \quad (11)$$

To test for asymmetric cointegration, we proceed to generate values for three new variables:

The difference of GDP which is ΔGDP

The positive cumulative values for OILP ($LOILP_t^+$) which is defined as OILP_p and

The negative cumulative values of OILP ($LOILP_t^+$) which is defined as OILP_n

The variables can now be combined for the purpose of estimation with the use of the stepwise regression analysis in a unidirectional test. The result of the regression test is shown in Table 3. The direct values and their significance are not interpreted directly from this table. However, the long run equation on the relationship between the positive and negative partial sums of oil prices may be derived by relating their coefficients with economic growth by taking the quotients (-c(3)/c(2) and –c(4)/c(2). Therefore, the long-run equation that relates economic growth with oil prices is shown in equation (12)

$$\mathbf{GDPR_t = - OILP\_P*0.00122 + OILP\_N*0.01397 + U_t} \quad \mathbf{(12)}$$

The negative coefficient of OILP_p, which is followed by a positive coefficient of OILP_n gives a prima facie position that the relationship between economic growth and oil price. The nonlinear relationship curve between the variables shown in equation (12), is a minimum turning point that is asymmetric. Although, the coefficient signs in the NARDL analysis for GDPR(-1), OILP_P(1) and OIL_N(-1) give the indicative direction of the switching points between the variable.

While the adjusted R-squared shows that 67% of the variation in economic growth is explained by the variation in oil price, the value of the F-statistic and the probability (0.0028) shows the model is a good fit for the variable relationship. The diagnostic tests for the NARDL regression result show (from the Breusch-Godfrey Serial Correlation LM Test) that the model does not suffer from serial correlation since the probability value of 0.4529 indicates that we cannot reject the null hypothesis that the model is homoscedastic. Also, the probability of 0.8024 from the Breusch-Pagan-Godfrey (heteroscedasticity) test indicates that the model does not suffer from heteroscedasticity.

Table 3. The Regression Result for NARDL Analysis

Dependent Variable: D(GDPR)
Method: Stepwise Regression
Selection method: Uni-directional
Stopping criterion: p-value = 0.1

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
C	2.7025	1.8607	1.4524	0.1605
GDPR(-1)	-0.8209	0.1811	-4.5332	0.0002
OILP_P(-1)	0.0010	0.0290	0.0345	0.9728
OILP_N(-1)	-0.0115	0.0505	-0.2270	0.8225
DGDPR(-2)	0.5343	0.1748	3.0556	0.0058
DOILP_P(-2)	0.1732	0.0951	1.8218	0.0821
DOILP_N(-1)	0.1253	0.0741	1.6922	0.1047
DGDPR(-3)	0.3185	0.1800	1.7695	0.0907
DGDPR(-6)	0.2018	0.1202	1.6788	0.1073
R-squared	0.7145	Mean dependent var		-0.0407
Adjusted R-squared	0.6743	S.D. dependent var		4.4842

F-statistic	4.3834	Durbin-Watson stat	1.8859
Prob(F-statistic)	0.0028		
Breusch-Godfrey Serial Correlation LM Test:			
F-statistic: 0.85196	Prob. F(2,11): 0.4529		
Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic: 0.64693	Prob. F(17,13): 0.8024		
Normality Test:			
Jarque Bera: 0.7852	Probability: 0.6753		

Source: Author's Computation

The stability test for the NARDL model's recursive estimates (Figure 1.0) shows that both the CUSUM and the CUSUM Squared tests support the model's stability at 0.05 level of significance.

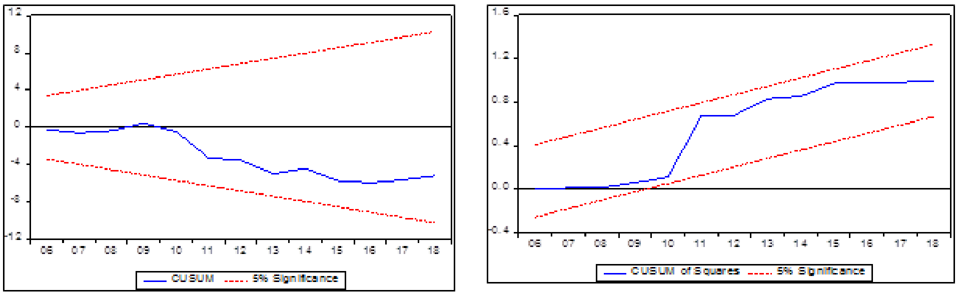

Figure 1. NARDL CUSUM and CUSUMQ Graphs

Next step is to conduct the Asymmetric Cointegration Test. Under NARDL, Shin & Greenwood-Nimmo (2014) recommended the use of joint null hypothesis of level (non-differenced) variables and to be compared with the critical values of bound testing in Pesaran et al. (2001). Therefore, a Wald test is performed to check for the significance of the first lagged term of the dependent variable and the first lagged term of the partial sum positive change in the independent variable (oilp_p).

Table 4. Long Run Cointegration Test

Wald Test:			
Test Statistic	Value	Df	Probability
F-statistic	8.0555	(3, 22)	0.0008
Chi-square	24.1666	3	0.0000
Null Hypothesis: C(2)=C(3)=C(4)=0			

Source: Author's Computation

The Wald Test (Table 4) is also extended to the first lagged term partial sum negative change of the independent variable (oilp_n) using the null hypothesis c(2) = c(3) = c(4) = 0. The results from the cointegration test indicate that the variables are jointly significant at 0.01 and 0.05.

Table 5. Critical Values of Pesaran et al. (2001)

Table CI(iii) Case III: Unrestricted intercept and no trend

	0.100		0.050		0.025		0.010		
k	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)
0	6.58	6.58	8.21	8.21	9.80	9.80	11.79	11.79	3.05
1	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	2.03
2	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	1.69
3	2.72	3.77	3.23	4.35	3.69	4.89	4.29	5.61	1.51

Source: Pesaran et al. (2001)

The value of F-statistic from the Wald test can be compared with the theoretical value from the Pesaran table to decide on the long-run cointegration status of the variables. The decision is that since calculated F-statistic = 8.0555 is greater than the (Pesaran et al. 2001) critical value of F-010 = 7.84 (See Table 5), the null hypothesis of no difference between the coefficients c(2), c(3) and c(4) is rejected. Thus, there is strong evidence in support of long-run equilibrium cointegration at 1% level of significance. The conclusion is that both of the associated positive changes and the negative changes in oil prices have the long-run positive effect on economic growth. However, further examination would be required to confirm whether the coefficients are really (statistically) different.

Table 6. Test for Asymmetry

Wald Test:			
Test Statistic	Value	Df	Probability
t-statistic	2.0270	22	0.0470
F-statistic	4.1087	(1, 22)	0.0502
Chi-square	4.1087	1	0.0427
Null Hypothesis: -C(3)/C(2)=-C(4)/C(2)			

Source: Author's Computation

The Wald test with F-statistic (4.1087) and probability (0.0427) indicates that the null hypothesis of equality between the positive and negative partial sum changes in oil prices in relation to economic growth is rejected. Therefore, the relationship between oil prices and economic growth is asymmetrical (not equal) in the long-run.

The Threshold Regression Analysis is conducted to establish the threshold point between economic growth and oil prices. The essence of this exercise is to establish a threshold oil price to assist the economy to minimize the effect of volatility in the streams of oil revenue. The threshold oil price is important for an oil exporting developing country like Nigeria that depends heavily on oil revenue to survive. Between 1981 and 2019, the revenue from crude oil export in Nigeria accounted for over 70% of the total government collected revenue for the period (CBN, 2019).

Therefore, the country has benefitted immensely from oil price increases as economic growth over the years is fuelled by the proceeds of crude oil exports. Thus, the estimated threshold price of crude oil shows the optimal price of oil such that a lower price will have a negative effect on economic growth. The result of the threshold test is shown in Table 8.

The test is based on the Bai-Perron (2003) critical values for threshold and shows the threshold value of oil price changes with respect to economic growth in terms of sequential and repartition values. The method of discrete regression is adopted to investigate the threshold price of crude oil in Nigeria, and the result is shown in the table. The oil price threshold is US$48.265 per barrel in Nigeria, and it is significant at a 5% level. The threshold of the price of US$48.265 per barrel signals the turning point in the relationship between oil price and economic growth such that oil price below this threshold induces a negative effect on the country's level of economic activity.

Table 8. Discrete Threshold Regression Analysis

Dependent Variable: DGDP				
Method: Discrete Threshold Regression				
Selection: Sequential evaluation, Trimming 0.10, , Sig. level 0.05				
Threshold variable: OILP				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
OILP < 48.264999 -- 22 obs				
OILP	2943.996	7893.962	0.372943	0.7116
C	-2569.98	176179.4	-0.014587	0.9884
48.264999 <= OILP -- 16 obs				
OILP	3411.197	2224.395	1.533539	0.1347
C	515464.7	174796.7	2.948939	0.0058
R-squared	0.7605	Mean dependent var		348576.5
Adjusted R-squared	0.7388	S.D. dependent var		409779.3
F-statistic	34.9346	Durbin-Watson stat		0.915181
Prob(F-statistic)	0.0000			
Breusch-Godfrey Serial Correlation LM Test:				
F-statistic: 0.6166		Prob. F(2,31): 0.5450		
Breusch-Pagan-Godfrey Heteroskedasticity Test:				
F-statistic: 0.8749		Prob. F(3,33): 0.5063		
Normality Test:				
Jarque-Bera: 2.2656		Probability: 0.2828		

Source: Author's Computation

Furthermore, while the upper part of Table 8 shows that for values below 48.265, where the coefficient of oil price is positive, the lower part of the table shows that at values above the threshold, the coefficient of oil price becomes negative. The tipping point on this threshold estimation is 22 observations from the starting point on the data, which makes it the year 2003. The diagnostics on the discrete threshold regression model reveals that it does not suffer from serial correlation taking account of the value of the Durbin-Watson statistic. This position is strengthened by the Breusch-Godfrey Serial Correlation LM Test with the value of the F-statistic (0.275001) and probability (0.7610), indicating that the null hypothesis of no serial correlation cannot be faulted.

Furthermore, the result is free from heteroscedasticity based on the result of the Breusch-Pagan-Godfrey test (with F-statistic: 0.6506 and Probability: 0.6627), which accepts the null hypothesis of homoscedasticity. Similarly, the normality test, which shows that the Jarque-Bera value is 3.5285 with the probability of 0.1713, indicates that the null hypothesis of normality for the data set is not rejected.

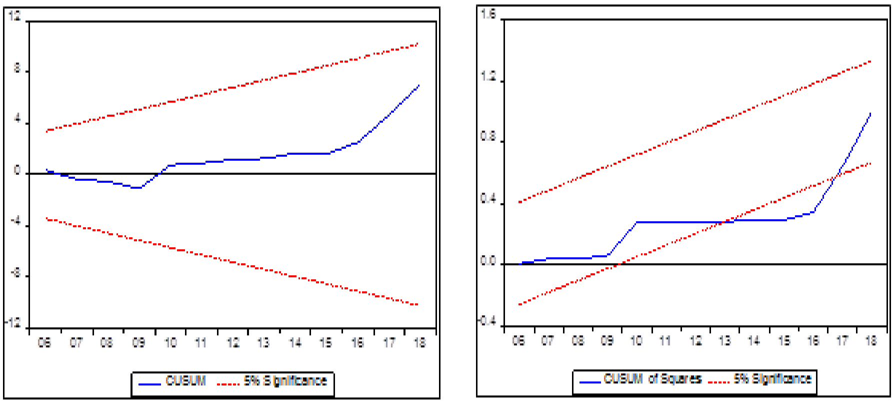

Figure 2. CUSUM Stability Test for Threshold Regression Model

The CUSUM and CUSUM squared test on the recursive estimates for the threshold regression model is shown in figure 2. The test result indicates that while the model is stable at the CUSUM test level at 0.05 per cent level of significance, the CUSUM squared result is unstable at the same level of significance. The instability is traceable to the effect of the global financial crises of 2007 – 2008 on oil prices and global economy.

5. Summary and Conclusions

This study investigates the asymmetric cointegration and threshold for oil prices and economic activity for Nigeria, a small developing economy that exports and imports oil. The study utilises annual time series on data that run from 1981 to 2019. The study deploys the NARDL to analyse the asymmetric cointegration and the Threshold Regression analysis to arrive at the threshold tipping point. The research findings from the study can be concluded as follows:

The variables in the model have long-run cointegration in line with the analysis from the NARDL test, which is in line with the several existing studies like Lardic & Mignon (2008), Nzimande & Msomi (2016) and Khalid (2019). The conclusion from the NARDL investigation shows that the associated positive changes and the negative changes in oil prices have a long-run positive effect on economic growth. This is consistent with the findings of Apergis et al. (2015) and Olanipekun & Alola, 2020.

The asymmetric cointegration test conducted using the NARDL approach shows that the relationship between the oil price fluctuations and economic growth are cointegrated in the long run and has an asymmetrical relationship. The threshold regression investigation result indicates that the turning point for oil prices in the relationship with economic growth is US$48.263 per barrel. The turning point on the threshold estimation records 22 observations from the starting point on the data, which makes it the year 2003. It means that when the oil price falls below the threshold of US$48.263 per barrel, there is a negative effect on the country's economic growth. This result contrasts sharply with the study of Malik (2008), which shows that when oil prices go beyond the threshold of US$22 per barrel, the economic growth of Pakistan is negatively affected. The implication of the estimated threshold of oil price falls in line with the oil-dependent nature of the Nigerian economy. The Nigerian government practically relies on revenue from oil to implement the recurrent and capital expenditures of annual budgets. Thus, when the oil price drops below the threshold of US$48.263 per barrel, the implementation of annual government budgets suffers, and economic growth is adversely affected.

It is recommended that the fiscal authority in Nigeria should take advantage of oil export earnings when the price of oil goes above the threshold mark of US$48.263 to make savings and develop the other sectors of the economy to improve the country's productive capacity in the real sector. The policy to improve the country's productive capacity will also expand the other sources of export earning capability of the country. Therefore, diversifying the economy away from oil production will insulate the export earning capacity of the country from the volatility that is associated with the international price of oil and, more importantly, when it drops below the estimated threshold price. The country can diversify the economy by building more infrastructural facilities, expanding the output from agricultural production, mine and minerals, as well as manufacturing. Therefore, the recommendation of economic policy to diversify away oil dependence should also be applicable to other oil-producing small economies in an effort to achieve more robust economies and sustainable energy in periods of negative oil fluctuations. One limitation of this study is that it does not consider the effect of other control variables like capital formation, population and trade.

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