



CRUDE OIL PRICE SHOCKS AND AGRICULTURAL PRODUCTIVITY IN NIGERIA (1987-2020): EVIDENCE FROM NON-LINEAR AUTO REGRESSIVE DISTRIBUTED LAG AND GRANGER CAUSALITY ANALYSIS

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ABSTRACT

The study examined empirically the asymmetric relationship between crude oil price shocks and agricultural productivity in Nigeria (1987-2020) from the perspectives of non-linear auto regressive distributed lag (NARDL) and granger causality analysis. The study used an annual time series data from the World development indicators (WDI) data bank for the period of 1987-2020. The newly introduced non-linear auto-regressive distributed lag (NARDL) approach was applied in the model specification and data analysis for the study. The results of the NARDL in both short and long run revealed that decrease in crude oil prices has a negative and significant ($P \leq 0.0011$) impact on agricultural productivity in Nigeria and vice versa. The results of the granger causality test revealed a unidirectional causality from crude oil prices to agricultural productivity with evidence from the current decline of global crude oil prices from December 2019 to April 2020 which is in line with the growth hypothesis. The study recommended the urgent need for the Nigerian government to device possible means of diversifying its economy and the reduction of overdependence on the revenue derived from the oil sector to boost productivity in the agricultural sector of the economy. Also, there is urgent need for the world health organization (WHO) to develop a vaccine that will eliminate the COVID-19 virus that poses a tremendous challenge to the world economy.

Keywords: Agricultural Productivity, COVID-19, Crude oil Price Shock, ECM, NARDL.

INTRODUCTION

Agricultural Productivity has been defined by several scholars with reference to their own views and disciplines. Agriculturalists, agronomists, economists and geographers have interpreted it in different ways. Agricultural productivity is defined in agricultural geography as well as in economics as “output per unit of input” or “output per unit of land area”, and the improvement in agricultural productivity is generally considered to be the results of a more efficient use of the factors of production, such as; physical, socio-economic, institutional and technological. Abdurrahman (2013) suggested that the “yield per unit” should be considered to indicate agricultural productivity. Many scholars have criticized this suggestion pointing out that it considered only land as a factor of production, with no other factors of production. Therefore, other scholars have suggested that agricultural productivity should contain all the factors of production such as labor, farming experiences, fertilizers, availability and management of water and other biological factors. As they widely accept that the average return per unit does not represent the real picture, the use of marginal return per agricultural unit was suggested.

In the decades of 1960s and 1970s, Agricultural sector has been the dominant sector of the Nigerian economy. The sector employs more than 75% of the Nigerian labor force, contributes more than 60% to the GDP and produces over 70% of total food consumption (Reynolds, 1966). Perhaps, more significant was the sector's foreign exchange earning



capacity. In the 60s, Nigeria was the world’s largest exporter of groundnut, the second largest exporter of cocoa and palm produce, and occupied a prominent position in rubber, cotton, and hides and skin export (World Bank, 1975). In spite of the relevance of the agricultural sector to the sustenance and development of the Nigerian economy, the sector suffered a huge neglect which consequently leads to persistent decline in its productivity. The challenge of resuscitating agricultural production and development in Nigeria is an enormous one. This is because of the dramatic shift in the fortunes of the sector over the years; from the dominant sector of the economy (contributed 64.1% to GDP) and supplier of food, income, foreign exchange and employment in the 1960s to a net importer of food contributing less than 5% to total foreign exchange earnings in 2000 (Oyekunle, 2013). Many policy analysts attribute this to the sector’s neglect following the discovery of petroleum resources beginning from the early 1970s and the accompanying foreign exchange fortunes. Farming was not only abandoned, the structure of domestic demand for food and agricultural products was altered in favor of imports of grains, beverages and vegetable oils and fibers which Nigeria was once reputed as a leading world producer (Oyekunle, 2013).

More than production, crude oil price is a key variable in the global oil market. Changes in crude oil prices could have huge impacts on oil- importing and exporting countries, alike at both the macro and micro levels. At the macro-level, sudden changes in oil prices affect macroeconomic variables such as exchange rate, interest rate, and inflation and could lead to fluctuations in current account balance and net foreign assets position, leading to a recession or economic growth (Thomas *et al.*, 2010). Recognizing the huge positive impact of stable crude oil prices in the performance of the Nigerian economy as a net producer/exporter of crude oil and its implication on agricultural productivity, the successive government’s expenditure to the agricultural sector were geared towards improving agricultural productivity. Huge annual allocations were channeled to the agricultural sector in order to boost domestic production from the agricultural sector, reduce the importation of agricultural products, increase the exports of agricultural outputs and provide food security to the teeming Nigerian populace (Njoku, 2005).

Notwithstanding the huge government expenditure (Table 1) to the agricultural sector and series of agricultural reforms introduced in the country, the agricultural productivity measured by its contributions to Nigeria’s gross domestic product (GDP) has been unimpressive over the years. This is due to the fact that Nigerian government expenditure to the agricultural sector depends on huge receipts from the production and sale of crude oil.

Table 1: Government Expenditure to Agricultural Sector from Sales of Crude Oil

Years	Expenditure in ₦ (Billions)
1990	0.01
1993	1.80
2002	9.99
2003	7.54
2008	65.4
2009	22.4

Source: CBN Statistical Bulletin, 2014 **In:** Ulukwu, 2016

According to the table above, Government expenditure on Agricultural sector from oil sales was 0.01 billion in 1990, it rose to 1.80 billion in 1993 and 9.99 billion in 2002, but declined to 7.54 billion in 2003 and thereafter witnessed a steady rise of 65.4 billion in 2008. However, it was short-lived as it declined significantly to 22.4 billion in 2009 and experienced undulating patterns from 2010 and beyond. This indicated inconsistent fund availability to



agricultural sector of the economy (Ulukwu, 2016). This implied that government expenditure, which is the main source of financial and other capital support to agriculture, has remained unstable over time over the years. The implication of this inconsistent and low government funding resulted in inadequate agricultural financing of the small holder farmers which had culminated into the viscous web of low productivity, low income and low capital investment experienced in agricultural sector. This result is consistent with the findings of (Ulukwu, 2016; Iganga *et al.*, 2011; and Nwosu, 2004) who reported that government has been the sole provider of financial and other capital resources to support agriculture over the years. This further conforms to (Osuji *et al.*, 2012) which posited that low funding of the agricultural sector has declined productivity amongst the rural populace.

Nigeria is a net producer/exporter of crude oil ranking 8th in the Organization of Petroleum Exporting Countries (OPEC) and 12th largest producer of oil in the world. Nigeria's economy as a whole and the agricultural sector in particular depends on revenues from the export of crude oil, which constitutes about 70% of export earnings; over 70% of government revenue and 10.45% of GDP (OPEC, 2015; National Bureau of Statistics [NBS], 2015a; and NBS, 2015b). Given its huge reliance on proceeds from oil exports, the Nigerian economy is highly vulnerable to oil price shocks. Consequently, a small change in oil price, be it a rise or fall, can have a large impact on the economy. The crude oil price shock of 2014 has seen the price of crude oil plummeting almost 50% from about US\$115 in June 2014 to about US\$57.47 in April 2015. This has led to lower export earnings and low accretion to external reserves. As a result, there has been a plunge in government oil revenues from ₦602.47 billion in June 2014 to as low as ₦359.73 billion in February, 2015 (Federation Accounts and Allocation Committee [FAA], 2014; and 2015).

The most recent crude oil price shock of 2020 as a result of fall in demand for oil due to the COVID-19 pandemic has crashed the prices of crude oil in the world market from an average closing price of \$56.99 in 2019 to \$36.98 in March 2020 and as low as \$11.30 in April 2020 World Development Indicators (WDI, 2020). This recent global phenomenon has affected the productivity of the world economy at large and the Nigerian economy in particular. With an annual forecast of a percentage fall in crude oil price of -70.67 at the year closing, the negative impact of crude oil price fall will have a deteriorating effect on numerous sectors of the Nigerian economy, most notable the agricultural sector. As stated earlier, agricultural productivity comprised of all output from the agricultural sector which depends on the inputs to be employed. The recent fall in crude oil prices have affected agricultural productivity in Nigeria by cutting down the supply of important inputs such as labor, fertilizer, machinery and so forth.

Given the need to develop the agricultural sector, a considerable number of scholars have studied the effect of crude oil price shock on agricultural productivity (Ikram and Waqas, 2014; Binuomote and Odeniyi, 2013; Udoh and Eghuaikhide, 2012; and Akpan, 2009). However, they end up with mixed and inconclusive findings. Meanwhile, studies on Nigeria have not given much attention to the possibility that the impact of crude oil price shock could have an asymmetry effect on the agricultural sector productivity.

The objective of the study was to examine the impact of crude oil price shocks on agricultural productivity using annual data for the period 1987-2020, and also to assess the causal relationship among the variables of study. The study improved on the existing literature by adopting the non-linear auto-regressive distributed lags (NARDL) model advanced by Shin *et al.* (2014) for its empirical analysis and modelling. The study distinguished itself from past related studies by obtaining and analysing the recent data that relate to crude oil crash up till the current period 2020; it also improved on methodology as most of the existing studies adopts



the ARDL methods. The study would aid in updating past previous studies conducted as there has been on socio-economic changes that occurred from past period to date that required a fresh analysis.

The findings of the study would be of immense benefit to researchers and policy makers as less attention has been given to the impact of recent crude oil price crash on the agricultural sector rather more emphasis on other sectors of the economy. The Nigerian government would focus more on the agricultural sector during these trying times as the entire world battle the dreaded COVID-19 pandemic. The government from the study would, therefore, device means to foster agricultural productivity for its teeming population.

A shock could be defined as a sudden event beyond the control of economic authorities that has a significant impact on the individual or economy (Varangis *et al.*, 2004). Shocks are different from volatility because of their degree, and so shocks may be classified as instances of extreme volatility. A shock could either be positive or negative depending on whether its effect is beneficial or detrimental to the individual or economy. At the individual or household level, shocks can cause changes in household income, consumption and/or their capacity to accumulate productive assets. Similarly, shocks can cause fluctuations in national income, output and employment at the economy level. Shocks are unexpected, unpredictable and exogenous (and most often unexplained by economics) even though they may impact on endogenous economic variables, like income, output, employment, etc. Thus, an oil price shock is an economic shock which could have a significant impact on agricultural productivity as well as aggregate effects on the economy as a whole.

The impact of oil price shocks, whether they come through as positive or negative, essentially depends on whether they are studied in the context of an oil exporting or oil importing country. Once this key distinction is made, the impact of the shock on the agricultural sector and other macroeconomic variables/aggregates can best be understood through their transmission channels. Generally, the key transmission mechanisms for the impact of oil price shocks to be changes in prices (relative prices), employment or inputs (of labor and capital), outputs, incomes, and changes in government expenditures. There is very strong evidence that these three channels, individually or in combination, are pervasive during a crisis (Coffman *et al.*, 2007; Berument *et al.*, 2010; and Mordi and Adebisi, 2010).

The effect of an oil price shock is different for net oil importers and net oil exporting nations. For net importing countries a shock that increases oil prices could lead to a fall in output growth in many economic sectors, particularly in the industrial, Agricultural and transport sectors, largely due to an increase in energy costs. In addition, the high energy costs could lead to increased production costs, which could cause private investment to fall and could further affect the competitiveness of the oil importing country. Moreover, an oil price shock can affect the balance of payments of the net- importing country through changing terms of trade. The extent of this effect will however depend largely on the share of oil in total imports of the country. On the individual and household level, an oil price shock could lead to an increase in food prices as a result of the cost of production of food, like cost of inorganic fertilizers and transportation. Food prices could further increase from this shock due to increased competition for inputs, as a result of the incentive for agriculture and manufacturing to replace crude oil with biofuels, which use crops such as cereals and sugar cane (Mondi *et al.*, 2011).

For oil exporting countries, one of the main transmission channels for the impact of an oil price shock is through their effect on government revenue and expenditure. This is because most of the oil revenue in these countries is earned by the government. In fact, changes in oil prices are reflected in the expenditure patterns of the government of oil exporting countries.



This has translated to procyclical fiscal policy in such countries, in which fluctuations in economic activity intensify in relation to changes in oil prices (Cantore *et al.*, 2012). In spite of the procyclical nature of fiscal policy, there is evidence that while a fall in oil prices leads to economic stagnation in net oil exporting countries, a rise in oil prices does not lead to sustained economic growth. This thus presupposes that the impacts of oil price shocks are asymmetrically linked to fiscal policy, and that transmission mechanisms of positive and negative oil price shocks may be different, due to several factors including poor management and rent-seeking behavior in the allocation of increased resources during a positive price shock (Mordi and Adebisi, 2010; and Moshiri and Banihashem, 2011). A price increase directly increases real national income through higher export earnings, though part of this gain may be later offset by losses from lower demand for exports generally due to the economic recession suffered by trading partners.

Although the body of empirical evidence linking oil price shocks with agricultural productivity is vast, specific studies for Nigeria relating oil price shocks to agriculture are scanty. This review therefore would cover Nigeria and non-Nigerian studies as well as the general impact of oil price shocks. Ikram and Waqas (2014) empirically examined the impacts of crude oil price fluctuations on agriculture productivity growth from 1980 to 2003 in Pakistan. The authors made use of co-integration and error-correction technique in analyzing annual time-series data for the period. The results of the study indicated that oil prices and excess intake of fertilizer have negative impact on agricultural productivity growth.

Binuomote and Odeniyi (2013) carried out a study to empirically assess the effect of crude oil prices on agricultural Productivity in Nigeria between 1981 and 2010 using annual time series data and the co-integration and error correction technique for analysis. The results of the analysis showed that oil prices in Nigeria during the period were negatively related to agricultural productivity as a 10% increase in oil prices led to a 0.4 and 0.34% fall in agricultural productivity in the short- and long-run, respectively. The study concluded that crude oil prices actually had a negative and significant effect on agricultural production in Nigeria.

Udoh and Eghuaikhide (2012) examined the co-movement and causality relationship between oil price fluctuations and domestic food price inflation in Nigeria for the 1970 to 2008 period. The study analyzed annual time-series data for the said period, using tests for stationary, cointegration and Granger causality as well as multivariate regression. Their results provided evidence in support of a causal relationship between oil price distortions and food price instability in Nigeria. Specifically, they found that causality was unidirectional, running from international oil price to domestic food price. Further results showed that a percentage increase in oil price volatility leads to 0.13% increase in the rate of growth of domestic food price inflation. The authors concluded that oil price volatility complements domestic food price inflation in Nigeria.

Assessing the dynamic relationship between oil production and food insecurity in Nigeria, Akpan (2009) used the Vector Auto Regressive (VAR) methodology to analyze quarterly time-series data from 1970 to 2007. The result of the analyses showed a decline in food production, occasioned by the neglect of the agricultural sector. It further indicated that high food imports contributed significantly to shocks in food supply but not significantly in determining food security. In conclusion, the study reiterated the need for policies that will enhance domestic production of staple foods and reduce the over dependence on the oil resource in Nigeria.

Alley *et al.* (2014) examined the impact of oil price shocks on economic growth in Nigeria using annual data from 1981 to 2012 and the Generalized Method of Moments (GMM)



for analysis of the data. Their results indicated that oil price shocks impacted economic growth negatively but not significantly. However, positive oil price shocks significantly benefitted oil exporting countries like Nigeria, which was in line with received wisdom. The authors therefore concluded that oil price shocks created uncertainty and undermined effective management of crude oil revenues hence the negative effect of oil price shocks.

Akinleye and Ekpo (2013) studied oil price shocks and macroeconomic performance in Nigeria using quarterly data which spanned 1973Q1 to 2010Q4 within the VAR framework in order to determine both symmetric and asymmetric impacts of oil price shocks on macroeconomic variables. The main findings of their study indicate that positive oil price shocks have both strong short- and long-run impacts on real GDP, triggering inflation and domestic currency depreciation as imports rise. The findings also reveal that positive oil shocks lead to expansionary fiscal policy stance in the short-term. In conclusion, symmetric shocks do not pose significant inflationary threat to the Nigerian economy but improves the level of GDP in the short-run, while asymmetric effects show that both positive and negative oil price shocks influence real government expenditure in the long-run, among other variables.

Iwayemi and Fowowe (2010) studied the impact of oil price shocks on selected macroeconomic variables in Nigeria using quarterly time series data spanning 1985Q1 to 2007Q4. Granger-causality tests, impulse response functions, and variance decomposition analysis were used in the analysis of data. The results of their analysis showed that different measures of linear and positive oil shocks did not cause output, government expenditure, inflation, and the real exchange rate. Moreover, the results support the existence of asymmetric effects of oil price shocks as negative oil shocks significantly cause output and the real exchange rate. The authors concluded that oil price shocks account only for a small amount of forecast variation for most macroeconomic variables in the model. Also, positive oil shocks contributed less than 2% to the variation in most variables with the exception of net exports, where oil shocks accounted for as much as 6% of the variation in the variable. Finally, there is evidence of the asymmetric effects of oil shocks as negative oil shocks had a more pronounced effect on the macro economy.

From the empirical studies reviewed one can conclude that there are mixed findings on the impact of crude oil price shocks on agricultural productivity. Furthermore, there are few studies that tackle endogeneity of crude oil prices to agricultural output in their analysis. Finally, none of the existing studies captured the relationship between crude oil prices and agricultural productivity within the context of recent global economic challenge posed by the COVID-19 pandemic from 2019-2020. Also, none of the existing studies captured the asymmetric impact of crude oil price shocks on agricultural productivity in Nigeria using the NARDL method of analysis.

MATERIALS AND METHODS

The Study Area

Nigeria is located at the extreme inner corner of the gulf of guinea on the west coast of Africa. The geographical Coordinates of Nigeria is longitude ten degrees north and latitude eight degrees east. Nigeria occupies an area of 923,768 sq. km of which land occupies 910,768 sq. km and water occupies 13,000 sq. km. Nigeria is boarded by Chad on the North East, by Cameroon on the East, by the Atlantic Ocean (Gulf of Guinea) on the south, by Benin on the west and by Niger on the North West with a total boundary length of 4900 km of which 853 km is coastline. Land is in abundance in Nigeria for agricultural, industrial and commercial activities. According to Worldmeter (2020), the current population of Nigeria is 205,472,850 as of Monday, May 18th, 2020 with an annual population growth rate of 2.58% based on the



Worldmeter (2020) elaboration of the latest United Nations data. Nigeria population is equivalent to 2.64% of the total world population, Nigeria is ranked 7th in the list of countries and dependencies by population, the population density in Nigeria is 226 per km sq and lastly, the medium age in Nigeria is 18.1 years (Worldometer, 2020). Natural resources includes; petroleum, tin, columbite, iron ore, coal, limestone, lead, zinc, natural gas, hydro power and arable land.

The Nigeria’s Agricultural sector is vast with numerous branches such as fishery, livestock farming, irrigation farming, crop production and forestry etc. Nigeria is endowed with oil resources which accounts for almost 90% of its revenue source.

Framework for the Study

The study based its framework on following the economic theory of exhaustible resources propounded by Harrod Hotteling in 1931 who design a price path for non-renewable resources known as the hoteling rule. The hoteling theory predicts that the price of an exhaustible resource such as crude oil appreciates at the risk-free rate of interest. Following Taghizadeh-Hesary and Yoshino’s (2014) methodology of a two-country (oil exporter and oil importer) model, the study assumed a simplified multi-input production function agricultural productivity in Nigeria, which can be written as:

$$AP = f (CP_r + EXR) \dots(1)$$

where; AP = Agricultural productivity; CP_r = Crude oil prices; and EXR = Exchange rate

Method of Data Collection

As presented in Table 2, the study employs annual time series data from 1987 to 2020. The data for crude oil prices (Average U.S\$), agricultural productivity and exchange rate were retrieved from the World Development indicators (World Bank data base, 2020) of World Bank database. The data for first quarter of 2020 (January – April) where used for all variables. In all, the data used for the study were obtained from world development indicators WDI World Bank data base (2020) spanning the 1987-2020 period (WDI, 2020). The annual time series data was employed for the period (1987-2020). The definition and measurement of the variables used in the study were presented in Table 2.

Table 2: Definitions and Measurements of Variables Employed

Variable	Definition and Measurement
Agricultural productivity (AP)	Measured by agricultural sectors contribution to GDP.
Crude oil price (CP_r)	Measured by global crude oil average prices as determined by OPEC.
Global exchange rate (EXR)	Proxy by US\$ as benchmark.

Source: Authors Compilations

Method of Data Analysis

The study examined the effect of crude oil price shocks on Agricultural productivity in Nigeria in the face of current global socio-economic challenges: notably, the COVID 19 pandemic. The functional form for the model of the study as:

$$AP_t = f (CP_r_t + EXR_t) \dots(2)$$

All the variables from equation 2 were transformed into natural logarithms for efficient and consistent empirical results. The empirical equation for the model is as:



$$\ln AP_t = \beta_0 + \beta_1 \ln CP_{-r_t} + \beta_2 \ln EXR_t + \varepsilon_t \quad \dots(3)$$

The study's base line long run static econometric model was arrived at by adopting and modifying the Hamilton Model (2003) which shows the relationship between agricultural productivity and crude oil prices in Nigeria as:

$$Y_t^d = f(K_t^d, N_t^d, E_t^d) \quad \dots(4)$$

where;

Ln C_Pr = Stands for the natural logarithm of crude oil prices.

Ln AP = Stands for the natural logarithm of agricultural productivity.

Ln EXR = Stands for the natural logarithm of exchange rate.

β_0 = the constant term.

β_1 and β_2 = the long run parameters to be estimated.

E_t = Stands for random error term with zero mean and constant variance.

Non-linear Auto Regressive Distributed Lag (NARDL) Model

The non-linear auto regressive distributed lag (NARDL) method is employed for this study as a method of data analysis. Shin *et al.* (2014) developed a non-linear ARDL by replacing (Ln CP_r) into its decomposed partial sums in equation 5. Changing the linear model into a non-linear model and using Pesaran *et al.* (2001) bounds testing approach, enables me to establish cointegration between the variables of study. Before developing the full representation of the NARDL model, the study introduces the following asymmetric long-run regression. To examine if the assumption of nonlinearity is valid and detect the asymmetric effects of crude oil price shocks on agricultural productivity in both short- run and long-run. From equation 4, following Shin *et al.* (2014), I decompose fluctuations of (Ln CP_r) into its positive and negative partial sums as:

$$LCP_{-r_t}^+ = \sum_{j=1}^t \Delta LCP_{-r_j}^+ = \sum_{j=1}^t \max(\Delta LCP_{-r_j}, 0)$$

$$LCP_{-r_t}^- = \sum_{j=1}^t \Delta LCP_{-r_j}^- = \sum_{j=1}^t \min(\Delta LCP_{-r_j}, 0) \quad \dots(5)$$

From equation 2, 3 and 4, following Shin *et al.* (2014) I write the NARDL model as:

$$\begin{aligned} \Delta AP_t = & \beta_0 + \beta_1 AP_{t-1} + \beta_2 CP_{-r_{t-1}}^+ + \beta_3 CP_{-r_{t-1}}^- \\ & + \beta_2 EXR_{t-1}^+ + \beta_3 EXR_{t-1}^- + \sum_{i=1}^p \phi_i \Delta AP_{t-i} \\ & + \sum_{i=0}^q (\theta_i^+ \Delta CP_{-r_{t-i}}^+ + \theta_i^- \Delta CP_{-r_{t-i}}^-) + \sum_{i=0}^q (\theta_i^+ \Delta EXR_{t-i}^+ + \theta_i^- \Delta EXR_{t-i}^-) + U_t \quad \dots(6) \end{aligned}$$

ϕ_i = autoregressive parameter.

θ_1, θ_2 , = coefficients of the short-run effects of crude oil price shocks and exchange rates on agricultural productivity.

$\beta_1, \beta_2, \beta_3, \dots, \beta_4$ = coefficients of the long-run effects of crude oil price shocks and exchange rates on agricultural productivity.



These stated equations are a nonlinear ARDL model in which nonlinearity is introduced by creating partial sum components. This model can capture effects of crude oil price shock in a more flexible structure Furthermore, and are partial sums of positive and negative changes in global crude oil prices. The p and q stands for the selected lag order for the dependent and the exogenous variables in distributed lag part, respectively. The lag selection criteria were applied using E-views 10 which are the asymmetric distributed lag parameters. It is the stochastic error term that is independently and identically distributed with zero mean and constant variance.

Error Correction Model

Upon establishing NARDL cointegration between *LAP, LCP_r⁺, LCP_r⁻, and LEXR*, the error correction model (ECM) for the NARDL model is specified as:

$$\Delta LAP_t = \varpi_0 + \sum_{i=1}^{n1} \varpi_1 \Delta LAP_{t-i} + \sum_{i=0}^{n2} \varpi_2 \Delta LCP_{-r^+_{t-i}} + \sum_{i=0}^{n3} \varpi_3 LCP_{-r^-_{t-i}} + \sum_{i=0}^{n4} \varpi_4 LEXR_{t-i} + \sigma ECM(-1) + \psi_t \dots(7)$$

where;

ϖ_0 = constant term;

$\varpi_1, \varpi_2, \varpi_3$ and ϖ_4 = short run coefficients;

σ = coefficient on one period lagged error correction term;

ECM_{t-1} = long run dynamics of agricultural productivity, global crude oil prices and exchange rate.

Stationary Test

A stationary test is also known as the unit root test which is conducted to ascertain the order of integration of each variable employed for the study. Variables are expected to be integrated at either level I (0) or first difference I (1) and none are at second difference I (2). This study will employ the Augmented Dickey-Fuller (ADF) test and the Phillips-Peron (PP) test to ensure reliability of results. The ADF model is specified as:

$$\Delta X_t = \alpha + \beta_t + \psi X_{t-1} + \sum_{i=1}^k \gamma_i \Delta X_{t-i} + \varepsilon_t \dots(8)$$

where; X = the variable being tested; K = the lagged values for change in X.

NARDL Cointegration Test

Assumptions and estimation procedure of the (NARDL) model in equation 6, are similar to the linear (ARDL) model introduced earlier by Pesaran *et al.* 2001. First, I conducted the Stationary tests to ascertain the order of integration of each variable employed for the study. This time for both the two partial sums of LCP_r Pos and LCP_r Neg. Then by using the modified F test and the bounds testing approach, I investigate the long-run relationship between level variables of *LAP, LCP_r⁺, LCP_r⁻, LEXR⁺, and LEXR⁻*.

By employing nonlinear (ARDL) methodologies, I can detect existence of nonlinear cointegration, or no cointegration in these models. In other words, I can determine if there is a long-run equilibrium relationship between agricultural productivity, crude oil prices and exchange rate; and if there is one, I can investigate how crude oil prices affects agricultural productivity (symmetric or asymmetric effects). Furthermore, the model allows me to test for asymmetric impact of crude oil price shocks on agricultural productivity, also asymmetric adjustments of crude oil prices to any short-run deviations from the equilibrium.

This approach has a number of attractions. First, it is applicable to any time series as long as it is not I (2). In other words, it can be applied to I (0) variables or I (1) variables or even a combination of I (0) and I (1) variables. Second, since majority of macroeconomic



variables are either I (0) or I (1), there is no need for pre-unit root testing. Third, short-run and long-run impacts of crude oil price shocks on agricultural productivity can be obtained in one step and simultaneously.

Granger Causality Test

After determining the validity of the long-run relationship using the NARDL methods of analysis, the next step is to examine the Granger causality between the variables of study. A variable, say X_t , is said to Granger cause another variable, say Z_t , if, given the past information or values of Z_t , past values of X_t are useful in predicting Z_t (Granger, 1969). A convenient way for testing Granger causality is to regress Z_t on its own lagged values and on lagged values of X_t and test for the joint significance of the estimated coefficients on lagged coefficients of X_t .

From the Econometric Model of the study specified in equation two, the dependent variable is defined as Agricultural productivity. While the independent variable of interest is defined as CP_r (global crude oil prices) decomposed to CP_r^+ and CP_r^- indicating both positive and negative impact of crude oil price shocks on agricultural productivity. The Granger Causality model is stated as:

$$AP_t = \alpha_0 + \sum_{i=1}^k \alpha_{1i} AP_{t-i} + \sum_{i=1}^k \alpha_{2i} CP_{-r_{t-i}^+} + \sum_{i=1}^k \alpha_{3i} CP_{-r_{t-i}^-} + \varepsilon_t \quad \dots(9)$$

$$CP_{-r_t^+} = \beta_0 + \sum_{i=1}^k \beta_{1i} CP_{-r_{t-i}^+} + \sum_{i=1}^k \beta_{2i} AP_{t-i} + \varepsilon_t \quad \dots(10)$$

$$CP_{-r_t^-} = \theta_0 + \sum_{i=1}^k \theta_{1i} CP_{-r_{t-i}^-} + \sum_{i=1}^k \theta_{2i} AP_{t-i} + \varepsilon_t \quad \dots(11)$$

where; E_t are error terms. It therefore follows that the Granger causality tests are based on the joint significance of the coefficients above, respectively. For example, the null hypothesis that CP_r^+ does not Granger cause AP is rejected if the coefficients are jointly significant.

The equation 9 represents unidirectional granger causality running from agricultural productivity to decomposed partial sums of global crude oil prices, on the other hand equation eight (8) represents unidirectional granger causality running from positive global crude oil prices to agricultural productivity and lastly equation 10 represent unidirectional granger causality running from negative component of global crude oil price to agricultural productivity.

Diagnostic Tests

A diagnostic tests was used in the study to test the hypothesis; $H_0: = 0, = 0, = 0$ (No causality from lagged variables to AP); and $H_1: \neq 0, \neq 0, \neq 0$ (there is at least one causality from lagged variables to AP). In order to ensure that the model used in cointegration analysis is robust, this study employs several diagnostic tests. For serial correlation, the Breusch-Godfrey test is used. The Breusch-Godfrey test is used in place of the popular Durbin-Watson test because it is applicable to use when lagged dependent variables are present in the model and it can take into account higher orders of serial correlation (Asteriou and Hall, 2006).

Symmetry Test

The test for both Short run and long-run symmetry effect employed the Wald statistics. The sort-run (sr) symmetric effect is:



$$H_0 : \sum_{i=0}^q \theta_i^+ \Delta LCP - r_{t-1}^+ = \sum_{i=0}^q \theta_i^- \Delta LCP - r_{t-1}^- \quad \dots(12)$$

The stated hypothesis states that; the overall short-run impacts of increase and decrease in global crude oil prices LCP_r which are equal and therefore LCP_r impact on agricultural productivity LAP are symmetric in the short-run. The long-run Symmetric effect is tested is stated as:

$$H_0 : \beta_2 CP - r_{t-1}^+ = \beta_3 CP - r_{t-1}^- \quad \dots(13)$$

The stated hypothesis states that: the overall long-run impact of increase and decrease in global crude oil prices are equal and therefore, crude oil impact on agricultural productivity is symmetric in the long-run. A non-rejection of the hypothesis of short-run (SR), and long run (LR) symmetric effect means that the original symmetric (ARDL) formulation of Pesaran *et al.* (2001) will hold. Other diagnostic tests conducted includes: Descriptive Statistics, Normality Test, Serial correlation test, Heteroskedasticity test; Ramsey reset test and CUSUM & CUSUM of square tests.

RESULTS AND DISCUSSION

Statistical Analysis of the Study Variables

Table 3 describes the statistics of the variables employed for the study. The standard deviation of all variables shows a minimum variation from their mean ranging from 0.24 to 0.63. This means that their deviation from their mean is minimum. This signifies that the deviation from the mean of all the variables is minimum and also makes them to be good predictors to have a good explanatory power of the behavior of the dependent variable LAP.

In Table 3, all the data series have shown a positive mean value. This justify the upward trend of time series in which global exchange rate average LEXR has recorded highest mean value and (LCP_r_NEG) has observed the lowest mean value among the select variables. All of the selected data series have observed the skewness values to be less than one. Negative shock to global crude oil prices have showed negative skewness value that illustrate left side affinity with longer left tail as compared to right tail, while other data series of crude oil price LAP, and positive shock to global crude oil prices LCP_r_POS have displayed positive skewness indicating longer right side skewed tails against the left side tail. Negative shocks to crude oil prices have expressed kurtosis value greater than 3 indicating leptokurtic natures with heavy peak tails. Remaining data series LCP_r_POS, LEXR and LAP have platykurtic curve with flat top having kurtosis value being less than 3.



Table 3: Analysis of the Variables

Variables	LAP	LCP_r_POS	LCP_r_NEG	LEXR
Mean	3.633665	2.029038	1.226245	3.515663
Median	3.713816	1.923264	-1.059310	4.844187
Maximum	4.601865	3.757493	-0.060981	5.940697
Minimum	2.668616	0.000000	-4.702053	1.677657
Std. Dev.	0.631765	0.392665	0.008755	0.247520
Skewness	0.124700	0.009243	-2.342217	0.640628
Kurtosis	2.580463	1.486196	9.055513	2.133687
Jarque-Bera	2.856269	3.151424	80.59309	3.289160
Probability	0.009756	0.006860	0.000000	0.193094
Sum	119.9110	66.95824	40.46610	142.4169
Sum Sq. Dev.	11.77205	62.06446	32.56280	49.80182
Observations	33	33	33	33

Note: LAP = log of Agricultural Productivity; LCP_r_POS = log of crude oil price positive shock; LCP_r_NEG = log of crude oil price negative shock; LEXR = log of exchange rate.
 Source: Authors Computations from E-views 10

Stationary Test Results

Table 4 presents the results of Augmented Dickey-Fuller (ADF) and the Philip Perron (PP) tests, respectively, for the nonlinear (ARDL) model employed for the study. At level the null hypothesis of unit root is rejected for LCP_r_POS at 10%, while the null hypothesis of unit root is rejected at first difference for LAP, LCP_r_NEG and LEXR at 1%, respectively, for the ADF test. The conduction of conintegration test in the study is independents on the level of stationarity of the variables included in the model. According to Elbourne (2007), Bernanke (2008), and Blanchard and Riggi (2009), to test for the existence of cointegration all variables employed are required to be stationary. Consequently, this study assesses the stationarity of the variables by conducting the ADF and PP unit root test.

Table 4: Unit Root Test Results

Variable	ADF Test Results		PP Test Results	
	Level	1st Difference	Level	1st Difference
LAP		-3.967712***		8.993200***
LCP_r_POS	-4.461582*		-4.363942*	
LCP_r_NEG		-8.687426***	-1.261781*	
LEXR		-7.513321***		-7.983824***

Note: ***significance at the 1%; **significance at the 5%; *significance at the 10%; LAP = log of Agricultural Productivity; LCP_r_POS = log of crude oil price positive shock; LCP_r_NEG = log of crude oil price negative shock; LEXR = log of exchange rate.
 Source: Authors Computations from E-views 10



NARDL Bounds Test for Cointegration Results

Table 5 shows the results of NARDL bounds test for cointegration. The F-statistic for the NARDL equation is (6.053549) which exceed the upper bound critical values at 1%, 5% and 10% significant levels. Accordingly, there is evidence for cointegration based on the Critical values from Pesaran *et al.* (2001).

Table 5: NARDL Bounds Test for Cointegration Results

Model Variable	F-statistics	%	Lower Boundary I (0)	Upper Boundary (1)	Conclusion
AP/CP_r ,EXR		10%	2.21	3.20	
AP/CP_r ,EXR	6.053549	5%	2.97	3.53	Cointegration
AP/CP_r ,EXR		1%	4.15	4.72	

Source: Authors computation from E-views 10

Estimates of Short-Run Models ECM

The estimates in Table 6 reveal that all the short run’s contemporaneous coefficients, except that of decrease in crude oil prices (LCP_r _NEG), are statistically significant at 1%, 5%, respectively. Table 6, however, concentrating our analysis on the main variable of interest (Crude oil prices LCP_r), the results show that the short run coefficient of positive crude oil prices D (LCP_r _POS) is positive and statistically significant at 1%. This means that 1% increase in CP_r will lead to about 1.45% increase in agricultural productivity AP *ceteris-paribus*. Consequently, we can conclude that there is a short run causality running from crude oil prices to agricultural productivity.

Table 6 further reveals that the coefficient of the one period lagged error correction term, ECT (-1) is -1.43 is statistically significant at 1% level. The negative sign on the ECT (-1) and its statistical significance at 1% level are consistent with a priori theory, and confirms the presence of a long run Asymmetric relationship (cointegration) among crude oil prices , agricultural productivity and exchange rate. Moreover, the finding that the ECM-based tests are able to detect the asymmetric long-run relationship is generally consistent with the works of Kremers *et al.* (1992), Hansen (1995), Banerjee *et al.* (1997) and Pesaran *et al.* (2001). This reflects the well-established power-dominance of the ECM-based tests resulting from their inclusion of potentially valuable information relating to the correlation between the regressors and the underlying disturbance.

Estimates of the Long Run Coefficients

Table 7 shows the long run estimates of the NARDL model for the study. The long-run coefficient of global crude oil prices LCP_r _POS is positive and statistically significant at 1%. This means that 1% change or increase in global crude oil prices LCP_r will lead to a corresponding increase of about 0.72% agricultural productivity AP. Similarly, the long-run coefficient of reduction in global crude oil prices (LCP_r _NEG) is negative NEG (1.011) and statistically significant at 1%. This means that a 1% change or fall in crude oil prices will lead to a fall in agricultural productivity AP by 1.011%. This finding clearly depicts the current global economic challenge posed by COVID-19 pandemic which led to the decline of the global economic growth leading to a persistent fall in global crude oil prices leads to a decline in agricultural productivity.



Table 6: Estimates of the short-run models (ECM) (NARDL Model)

Variable	Coefficient	Std. Error	T-value	Prob.
D(LAP(-1))	1.541838***	0.279521	5.122474	0.0001
D(LAP(-2))	0.766576	0.303765	0.943411	0.3701
D(LAP(-3))	0.637238*	0.308346	2.358511	0.0457
D(LCP_r_POS)	1.822711***	0.240695	6.035495	0.0003
D(LCP_r_POS(-1))	-0.328655	0.343021	-0.958120	0.3630
D(LCP_r_POS(-2))	0.584954*	0.279641	2.091799	0.0760
D(LCP_r_POS(-3))	0.351294*	0.214513	1.637636	0.2459
D(LCP_r_NEG)	0.093156	0.070064	1.329597	0.5364
D(LCP_r_NEG(-1))	-1.370819**	0.294071	-4.661519	0.0015
D(LCP_r_NEG(-2))	-0.989808*	0.466212	-2.123087	0.0627
D(LCP_r_NEG(-3))	-0.920744*	0.370172	-2.487344	0.0346
D(LEXR)	0.377588*	0.117080	3.225032	0.0104
D(LEXR(-1))	-0.131846	0.127492	-1.034158	0.3280
D(LEXR(-2))	-0.065034	0.129288	-0.503014	0.6270
D(LEXR(-3))	-0.273054	0.151656	-1.800480	0.1053
CointEq(-1)*	-1.436520***	0.278559	-4.797971	0.0010

Note: ***significance at the 1% level; **significance at the 5%; *significance at the 10%
 Source: Authors computation from E-views 10

The findings of Table 7 also indicate the presence of asymmetric impact of crude oil prices on agricultural productivity. Furthermore, the positive sign and statistical significance of the long run coefficient on crude oil prices (LCP_r_POS) demonstrate the presence of a long run unidirectional causality which runs from crude oil prices to agricultural productivity. Also, the coefficient of exchange rate is positive but not statistically significant. This implies that exchange rate plays a dominant role in crude oil prices.

Table 7: Estimates of the Long- run Coefficient (NARDL Model)

Variable	Coefficient	Std. Error	T-value	Prob.
LCP_r_POS	0.726126***	0.085183	6.998147	0.0001
LCP_r_NEG	1.011752***	0.216114	4.681579	0.0011
LEXR	0.200772	0.133312	1.506028	0.1663
Constant	2.270707***	0.413282	5.494333	0.0004

Note: ***significance at the 1% level; **significance at the 5%; *significance at the 10%
 Source: Authors computation from E-views 10

Granger Causality Test Results

Table 8 shows the results of granger causality test based on the NARDL model. The P-value of causality running from LCP_r_POS to LAP is statistically significant with value less than 0.05. This is an indication of unidirectional causality from positive shock or increase in global crude oil prices to agricultural productivity, this indicates that global economic growth plays a crucial role in determining the global crude oil prices any possible global socio economic effect just like COVID-19 pandemic may affect the demand for crude oil leading to a sharp fall in its prices globally. The result is in line with the growth hypothesis. Similarly, there is a unidirectional causality from agricultural productivity to exchange rate; this implies



that an active global economy supports multinational and international trade among different countries of the world. Exchange rate therefore responds depending on comparative advantages between nations that engage in trade.

Table 8: Granger Causality Test Results NARDL Model

H ₀ Variables	Observations	F-statistics	P-value	Decision
LCP_r_POS ≠ LAP	33	4.53731**	0.0072	Reject H ₀
LAP ≠ LCP_r_POS	33	1.43510	0.2529	Do Not Reject H ₀
LCP_r_NEG ≠ LAP	33	3.86554	0.1460	Do Not Reject H ₀
LAP ≠ LCP_r_NEG	33	3.47191	0.2250	Do Not Reject H ₀
LEXR ≠ LAP	33	5.566712	0.2339	Do Not Reject H ₀
LAP ≠ LEXR	33	16.12428**	0.0029	Reject H ₀

Note: ***significance at the 1% level; **significance at the 5%; *significance at the 10%
 Source: Authors computation from E-views 10

Diagnostic Test Results

The results of diagnostic tests for the NARDL model are reported in Table 9 It shows that the value for Adjusted R² is (0.59) which suggests that global crude oil prices and exchange rates account for about 59% of the total variations or changes in the agricultural productivity during the period of the study. In addition, the probability value (0.000) for the F-statistics, which is less than 5%, implies that all the independent variables (LCP_r_POS, LCP_r_NEG and LEXR) are important determinants agricultural productivity. Lastly, the value (2.06) for the Durbin Watson (D.W) statistics, which is approximately 2, reveals that the model is not having serial correlation challenge. More importantly, the results for the post-estimation diagnostics tests performed on the long run model show that the P-values (0.96, 0.5004 and 0.9140) in respect of the the Jarque- Bera test for normality, Lagrangian Multiplier (LM) test for serial correlation and the Bruesh-Pagan-Gofrey (BFG) test for heteroscedasticity, respectively, are greater than 5%,; hence our decision to accept the null respective hypotheses. Consequently, we conclude that the residuals are normally distributed; they are homoskedastic and they are not serially correlated.

Furthermore to Table 9, the probability value (0.4570) for the Ramsy Reset test which is also greater than 5% reveals that the model is free from specification error. In otherwords, it is correctly specified. Finally, the plots or graphs of the cumulative sum (Cum sum) and cumulative sum squared (Cum sum SQ) shown in the Appendix are within the critical bounds at 5% significance level. These results indicate that all the parameters of the long run model have been stable throughout the period of the study. This situation implies that the long run model is therefore, relevant for policy recommendation.



Table 9: Diagnostic Test Results for NARDL Model

Statistics	Coefficient	P-value
R-square	0.75	
Adj. R-square	0.59	
F-statistics	6.053549***	(0.0000)
Durbin Watson	2.06	
Autocorrelation	0.2653	(0.5004)
Normality	2.94	(0.96)
Heteroskedasticity	1.550841	(0.9140)
Ramsey RESET	1.309275	(0.4570)

Note: ***significance at the 1% level; **significance at the 5%; * significance at the 10%
 Source: Authors computation from E-views 10

Asymmetry Test Result

Table 10 shows the long run asymmetry test on the effect of increase in crude oil prices LCP_r_POS and decrease on crude oil prices LCP_r_NEG on agricultural productivity in Nigeria. The value of T-statistics, F-statistics and Chi-Square statistics are all positive and statistically significant at 1% which is below 0.05%.

Table 10: Asymmetry Test Results NARDL Model

Test Statistics	Value	Difference	Probability
T-statistics	2.723243***	26	0.00071
F-statistics	6.545349***	(1, 26)	0.00071
Chi- Square	8.545349***	1	0.0035
Null Hypothesis	-C(3)/C(2)=-C(4)/C(2)		

Note: ***significance at the 1% level; **significance at the 5%; *significance at the 10%
 Source: Authors computation from E-views 10

The result of Table 10 shows that there is a strong asymmetric relationship between crude oil prices and agricultural productivity. This result is in line with the current fall in the prices of crude oil due to the COVID-19 pandemic. The COVID-19 leads to a fall or negative shock in global economic activities which have a negative resultant effect on key economic stimulants. The result is in line with an early study conducted by Borenstein *et al.* (1997) which investigates short-run dynamic asymmetries in the response of retail gasoline prices to fluctuations in the price of crude oil by implicitly imposing the long-run symmetry restrictions.

CONCLUSION AND RECOMMENDATIONS

The study concluded based on the results of the (NARDL) that in both short and long run, there was an increase in crude oil prices has a positive and significant impact on the agricultural sector in Nigeria, while on the other hand the results indicates that decrease in crude oil prices has a negative and significant impact on the agricultural sector productivity in Nigeria. Also, from the granger causality test, the study concluded revealed a unidirectional causality from crude oil prices to agricultural productivity with evidence from the current sharp decline of global crude oil prices from December 2019 to April 2020 which is in line with the growth hypothesis. Furthermore, was the fall in global economic activities that led to a fall in crude oil prices due to fall in demand for crude oil, which further had a multiplier effect of a



low productivity from the agricultural sector in Nigeria. This is indicated by the long-run NARDL coefficients. In the light of the results of the study, it was recommended as follows:

1. The urgency for the Nigerian government create possible ways for the diversification of the Nigerian economy to prevent overdependence on revenue from the sale of oil, this is because any challenge to the revenue derived from the sale of oil poses an equal challenge to vibrant sectors of the Nigerian economy.
2. There is need for the world health organization (WHO) to foster the development of a vaccine that will eliminate the COVID-19 virus that poses a tremendous challenge to the world economy.

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