JORMASS
Volume 9, Issue 2
December 2023
JOURNAL OF RESEARCH IN MANAGEMENT AND SOCIAL SCIENCES
DOI: To be assigned

The Good, Bad And Ugly Sides To Agribusiness Development In The Developing World: A Focus On Nigeria's Oil Palm

[1]Oko-Isu, Anthony;[2]Njoku, Maria-Stella E.;[2]Onwumere, Joseph;[1]Oko-Isu, Mercy C.
[1]Department of Agribusiness and Management, Alex Ekwueme Federal University Ndufu-Alike, (AE-FUNAI) Ebonyi State, Nigeria
[2]Michael Okpara University of Agriculture Umudike, Abia State, Nigeria

ABSTRACT:
This paper examines the reaction of Nigeria's oil palm output to climate change and international commodity price volatility since its independence. The Fully Modified-ordinary least square (FM-OLS) regression, Generalized Autoregressive Conditional Heteroscedasticity (GARCH), Autoregressive Conditional Heteroscedasticity (ARCH), and Granger causality were employed to analyze secondary data used from January 1961 to December 2015. The GARCH and ARCH results reveal volatility in the international commodity price of oil palm. Consistently, the FM-OLS result showed that temperature, oil palm commodity price, and inflation rate had a significant positive effect on oil palm yield, while the combination of temperature with oil palm commodity price exerted a significant negative influence on it.The FM-OLS result showed that oil palm production was negatively influenced by inflation, real exchange rate, and combination of rainfall with oil palm commodity price and positively by rainfall. Furthermore, the Granger causality test showed that the null hypothesis, which held that rainfall did not Granger cause oil palm output, was accepted, while others were rejected. Ultimately, we present some sound reasons to explain the statistical results and propose policy suggestions to uplift food and environmental security through rubber output. This research is a landmark and pacesetting study. Research combining climate change and commodity price as it reacts to agribusiness is lacking to date.

KEYWORDS: *climate change; commodity price volatility; oil palm output; Nigeria*

MANUSCRIPT TYPE:
Research Paper
PUBLICATION DETAILS:
Received: AUG 2023
Revised: OCT 2023
Accepted: OCT 2023

Publication of College of Management Sciences, Michael Okpara University of Agriculture, Umudike Nigeria

OPEN ACCESS

Crossref

INTRODUCTION

Agribusiness is an important sub-sector of the economy with high potential for employment generation, food security, foreign exchange earnings, and poverty reduction (Federal Ministry of Agriculture and Rural Development Abuja, Nigeria, 2011; Chikaire *et al.,* 2014). In Nigeria, however, these potentials have remained largely untapped, which has led to the dwindling performance of its agricultural sector both domestically and in international trade over years reduction (Federal Ministry of Agriculture and Rural Development Abuja, Nigeria, 2011; Chikaire*et al.,* 2014). Nigeria, faced with an increasing population, heavy dependence on imports, and reliance on crude oil earnings, needs to find a solution to these problems.

Although the recent food price spikes can be attributed to several factors, such as demand growth from emerging economies and the global surge of biofuels production, the role of weather anomalies in recent years is unquestionable (Food and Agriculture Organization (FAO), International Fund for Agricultural Development (IFAD), OECD, World Food Programme (WFP), the World Bank Group (WBG), World Trade Organization (WTO), United Nations Conference on Trade and Development (UNCTAD), International Food Policy Research Institute (IFPRI) and the United Nations High-Level Task Force on Global Food Security (UN HLTF, 2011; Nam *et al.,* 2012). The high inelasticity of demand for commodity crops makes crop prices highly sensitive to yield shocks, and mounting evidence indicates that climate change will continue to influence agricultural crop yields and cause greater year-to-year variability adversely. A rational, forward-looking, and competitive commodity market would account for these anticipated changes, thereby influencing the time path of storage, price level and volatility, and social welfare (Nam *et al.,* 2012).

Climate change will undoubtedly increase pressure on already volatile commodity prices and trading. The consensus is that agricultural productivity and food shortages will decrease in many regions, especially those in the tropics. Additionally, climate may decrease the land available for agricultural production and increase competition for resources with other development needs, such as infrastructure. Food and commodity prices have risen and are expected to increase further because of instability in production quality and quantity due to climate change impacts (Masters, 2010).

Available evidence showed that Nigeria is already plagued with diverse ecological problems directly linked to the ongoing climate change (Odjugo, 2010; Bello *et al.,*2012; Adefolalu, 2007; Ikhile, 2007). The southern ecological zone of Nigeria, largely known for high rainfall, is currently confronted by irregular rainfall patterns, while the Guinea savannah is experiencing gradually increasing temperatures. The Northern zone faces the threat of desert encroachment at a very fast rate per year, occasioned by a fast reduction in the amount of surface water, flora, and fauna resources on land (Bello *et al.,* 2012; Federal Ministry of Environment, Abuja, Nigeria, (FME), 2004; Obioha, 2008). This makes people exploit more previously undisturbed lands, leading to the depletion of the forest cover and an increase in sand dunes/Aeolian deposits in the Northern axis of Nigeria. On the other hand, those in the coastal regions are vulnerable to incessant floods, destruction of mangrove ecosystems, contamination of water, and transmission of waterborne diseases, leading to displacement and communal crisis (Bello *et al*., 2012; Odjugo, 2010). Therefore, resource-poor farmers face tragic crop failures, which reduce agricultural productivity and increase hunger, poverty, malnutrition, and diseases (Bello *et al*., 2012; Zoellick& Robert, 2009; Obioha, 2009).

Climate change has already impacted Nigeria as weather-related disasters have become more frequent in the past four decades, and the trend continues. In 2010, the National Emergency Management Agency (NEMA) reported that over 250,000 Nigerians were displaced by flood disasters that ravaged many communities across the country (NEMA, 2010). Weather-related disasters, especially flooding, are reported almost daily in the country's news media at the peak of the rainy season. Due to these environmental threats resulting in declining crop yields, some farmers in Nigeria are abandoning farming for non-farming activities (Bello *et al*., 2012; Apata*et al*.,2010).

Nevertheless, with the depletion of the ozone layer resulting in the high intensity of climate change coupled with the unstable international commodity prices, the output of some export tree crops like oil palm has not been proven to be affected, and their commodity prices have remained relatively stable or even appreciating. Why, then, has Nigeria, which has the landmass, climate, and population predominated by the youth, not been able to tap this open window of opportunity of the output of some export tree crops not being affected by climate variations? Furthermore, analyses combining rigorous climate science and commodity price volatility have been notably lacking.

METHODOLOGY

The study was carried out in Nigeria. The Federal Republic of Nigeria is in West Africa between Latitudes 4^0 and 14^0 North and Longitudes $2^0 2^I$ and $14^0 30^I$ East. To the North, the country is bounded by Niger Republic (1497km) and Chad (853km), to the West by Benin Republic (773km), to the East by Cameroon Republic (1690km), and to the South by the Atlantic Ocean. Nigeria has a land area of about 923,769 km^2 (FOS, 1989), a North-South length of about 1450km, and a west-east breadth of about 800km, with only 50% of the land proportion presently cultivated. Its total land boundary is 4047km, while the coastline is 853km. Irrigation potential estimates in Nigeria vary from 1.5 to 3.2 million ha. The latest estimate gives about 2.3 million ha, of which over 1 million ha are in the north (World Bank, 2014; FAO, 2009).

Nigeria is comprised of 36 states, and the Federal Capital Territory is in Abuja. It enjoys a humid tropical climate with two clearly identifiable seasons, the wet and dry seasons. The climate condition varies among regions: equatorial in the South, tropical in the center, and arid in the North. Annual rainfall is between 2000 – 3000mm in a year, characterized by high temperatures and relative humidity. Nigeria has four agro-ecological zones with rainfall along the South-North gradient.

Nigeria has a population of over 173.6 million people (NBS, 2013), with diverse biophysical characteristics, ethnic nationalities (more than 250), agro-ecological zones, and socio-economic conditions (FAO, 2009; NIMET, 2008). Popular indigenous languages are Igbo, Hausa, and Yoruba, while English is the official language. Farming is the predominant occupation of the people; about half of the working population is engaged in agriculture, most of whom are smallholder farmers. Cocoa, Coffee, Oil Palm, and rubber are among the major tree crops grown in Nigeria.

The country is faced with an economy characterized by an unstable exchange rate and ecosystems being battered by global warming, while excessive flooding during the past decade has hurt farming in coastal communities, and desertification is ravaging the Sahel. Other environmental issues affecting the country include soil degradation, rapid deforestation, water pollution, desertification, oil spills affecting water, air, and soil, loss of arable land, and rapid urbanization.

Sources of Data

This study was based on time series data from various sources from 1961 to 2015. The monthly national data on climatic variables, selected tree crops' output, and selected tree crop's international commodity prices were collected. The sources of the data collected include various publication editions of the National Bureau of Statistics (NBS), Central Bank of Nigeria (CBN) statistical bulletin, Nigerian Meteorological Agency (NIMET), Food and Agriculture Organization (FAO) statistical website, United Nations (UN) and the World Bank climate data. Data collected include exchange rate, interest rate, commodity prices, rainfall, temperature, exports, gross domestic product (GDP), imports, yield and production of oil palm tree crop, and inflation rate.

Analytical procedures

The study's data were analyzed using graph-form descriptive statistics, the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) and Autoregressive Conditional Heteroscedasticity (ARCH) models, Fully Modified Ordinary Least Square (FM-OLS), and the hypotheses tested using the pair-wise Granger Causality approach.

Estimation procedure for handling time series data

i. Unit root test using Phillips-Perron test**:** The unit root test tests for stationarity of a data series to investigate the presence or absence of unit root.A series is stationary if means and variances stay constant over time. This is done to ensure that variables used in the regression are not subject to spurious regression.
   Non-stationary stochastic series have changing means or variances. We want data to be stationary and, therefore, test the hypothesis of non-stationarity. The adopted Phillips-Perron test tests whether a unit root is present in an autoregressive model and corrects the serial correlation problem.
ii. Procedure: If a series is found to be non-stationary, it is first differenced, that is,

$\Delta Z_t - Z_{t-1}$and the test is repeated for the 1st differentiated series. If the Ho of the test is rejected for the 1st difference, it is concluded as Z_t - 1 (1), etc.

Model specification

Volatility test

In literature, various measures of commodity price volatility have been employed to examine the variability of pair-wise cross-country commodity prices based on the observation that commodity price time series are typically heteroscedastic, leptokurtic and exhibit volatility clustering- that is, varying variance over a specified period (Kenen and Rodrik, 1986, Bailey, George, and Micheal, 1986; Peree & Steinherr, 1989; Cote, 1994; McKenzie & Brooks, 1997). Based on this and in line with the research objectives, this study examined the extent of commodity price volatility between 1961 and 2015. Like other empirical studies, the Autoregressive Conditional Heteroscedasticity (ARCH) model introduced by Engle (1982) and the generalized ARCH (GARCH) model by Bollerslev (1986) were used to capture the extent of tree crop commodity price volatility in Nigeria during the period of study.

The choice of these models was based on their empirical use in various areas of econometric modeling, especially in financial time series analysis (Yinusa, 2004; Akpokoje, 2009; Olowe, 2009), and their approaches to modeling financial time series with an autoregressive structure in that heteroscedasticity observed over different periods may be autocorrelated.

In developing an ARCH model, two specifications were considered - one for the conditional mean and the other for the variance. Generalizing this, the standard GARCH (p,q) specification is expressed in implicit form as:

$$y_t = \alpha + \sum_{i=1}^{k} n_i x_{t-1}\, \varepsilon_t \qquad (1)$$

Where,
y_t = measure of commodity price volatility at time t,
α= mean,
x_{t-1} = exogenous variables,
ε_t = error term

$$\delta = \sqrt{\frac{1}{N} \sum_{i=1}^{k} (x_i - \bar{X})^2} \qquad (2)$$

Where,
δ = variance,
x_i = mean,
$\bar{X}$ = standard deviation

$$\delta t^2 = \omega + \sum_{i=1}^{p} \alpha_i\, \varepsilon_{t-i}^2 + \sum_{i=1}^{q} \beta_i\, \delta_{t-i}^2 \qquad (3)$$

Where;
δt^2 = conditional variance,
P = order of the GARCH,
δ_{t-i}^2 = the GARCH term

The mean equation given in equation (1) was expressed as a function of a constant α-(taken as mean if other exogenous variables were assumed to be zero), exogenous variable(s) x_{t-1}-(majorly in Autoregressive (AR) structure of order k) and with an error term ε_t. Note that y_t was considered a measure of commodity price volatility at time *t*. Since δ_t^2 was the one period ahead forecast variance based on past information, it is called *Conditional Variance.* Equation (3) expresses the normal distribution assumption of the error term. The conditional variance equation specified in (3) represents a function of three components: the mean ω; the information on volatility from the previous period, measured as the lag of the squared residual from the mean equation: ε_{t-i}^2 (the ARCH term); and the last periods forecast variance: δ_{t-i}^2 (the GARCH term).

In Equation (1), the k is the order of the AR term, while in Equation (3), the p is the order of the ARCH term, and q is the order of the GARCH term. According to Gujarati (2004), a GARCH (p,q) model is equivalent to an ARCH (p+q), that is, in our specification ARCH (k), where k=p+q. For instance, a standard GARCH (1,1) refers to the presence of a first-order ARCH term (the first term n parentheses-p, lagged term of the conditional variance).

For this study, the presence of volatility clustering was determined by the significance of the lagged volatility series parameters-y_t. The degree of extent of volatility in the commodity price was determined by the autoregressive root, which governs the persistence of volatility shocks, and thus was the sum of $\alpha+\beta$ and the indication of the degree of volatility was as follows:

If $\alpha+\beta$ is between 0.51 – 1 or =1(i.e. greater than 0.51 to 1 or equal to 1) it indicates that volatility is present and persistent;
If $\alpha+\beta > 1$ (i.e., greater than 1) indicates that volatility is overshooting.
If $\alpha+\beta < 0.5$ (i.e., less than 0.5), it indicates no volatility.

The FM-OLS regression approach
The FM-OLS regression approach is specified following Philips and Hansen (1990), which is formulated and expressed as

$$Yit = f(CPit, Tt, P, IR, TO, ER, CMxCP, \Sigma t) \quad (4)$$

Where,
Yit= yield for crop i at time t (tons/hectare),
CPit= Commodity price for crop i at time t (U.S $),
T = mean annual temperature (^{0}C),
P= total annual rainfall (mm),
IR = total annual Inflation rate (%),
TO = Trade openness (%),
ER = Exchange Rate (Naira)
CMxCP = climate variables x commodity price of crop I at time t (U.S $),
Σt = error term

And

$$Pit = f(CPit, Tt, P, IR, TO, ER, CMxCP, \Sigma t) \quad (5)$$

Where,
Pit= yield for crop i at time t (tons/hectare),
CPit= Commodity price for crop i at time t (U.S $),
T = mean annual temperature (^{0}C),
P= total annual rainfall (mm),
IR = total annual Inflation rate (%),
TO = Trade openness (%),
ER = Exchange Rate (Naira),
CMxCP = climate variables x commodity price of crop I at time t (U.S $),
Σt = error term

The Granger causality test model
The Granger causality test, according to Granger (1969), is specified thus;

$$W_t = \varepsilon^n{}_{y-1}\alpha_1 Z_{y-1} + \varepsilon_j{}^n\text{-}i\beta w_{y-1} + u_{it} \quad (6)$$

$$Z_t = \varepsilon^n{}_{p-1}\alpha_1 Z_{t-1} + \varepsilon_{j-1}{}^n d_1 w_{t-1} + u_{2t} \quad (7)$$

Where,
W_t = yield for selected tree crop (tons/hectare),
Z_t = commodity price for selected tree crop (U.S $),
$_{t-1}$= lag variables,
α_1 and β_1 = parameters to be estimated,
U_{1t} and U_{2t} = error terms

Estimating Trade Openness

The Trade Openness Index is an economic metric calculated as the ratio of a country's total trade, the sum of exports plus imports, to the country's gross domestic product:

$$\text{Trade Openness} = \frac{\text{Exports+Imports}}{\text{GDP}} \quad (8)$$

The interpretation of the Openness Index is that the higher the index, the larger the influence of trade on domestic activities and the stronger the country's economy.

RESULTS AND DISCUSSIONS

Trend of commodity prices of oil palm tree crop from 1961-2015

Considering the international monthly commodity prices of the selected export tree crop (oil palm) for the 648 months (1961-2015), there has been considerable variability and instability in the prices of this commodity. As shown in Figure 1, the general trend pattern for oil palms showed a steady rise in international commodity prices from $216.23 in 1962 to $1125.41 in 2011, when they peaked. The slow growth of oil palm commodity prices could have been necessitated by the trade liberation policy (structural adjustment program SAP), which took effect in 1986 (World Bank, 1994).

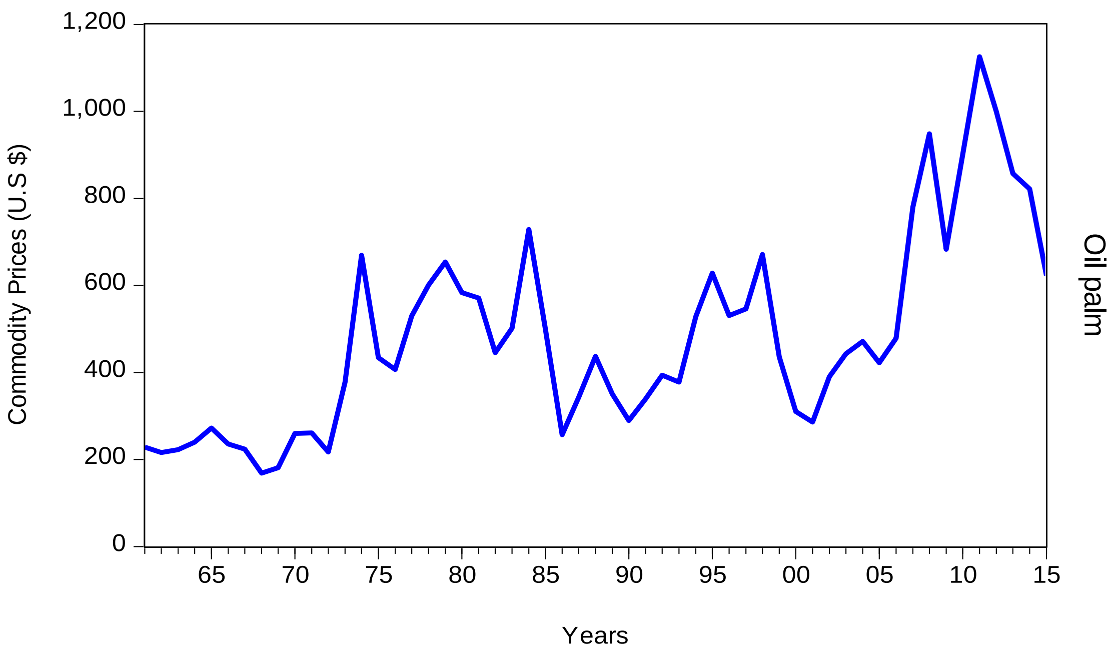

Figure 1: Trend of commodity price of oil palm (1961-2015).
Source: Researchers' calculations

Yield trend of oil palm tree crops in Nigeria (Tons/Ha) from (1961-2015)

The graph of the trend of oil palm tree cropyield (Tons/Ha), as shown in Fig.2, exhibited gradual fluctuations. Nigeria's oil palm maintained a yield value of 25,000 tons/hafrom 1961 to 1984 but has maintained an increase slightly above 25000 tons/ha between 1985and 2015.

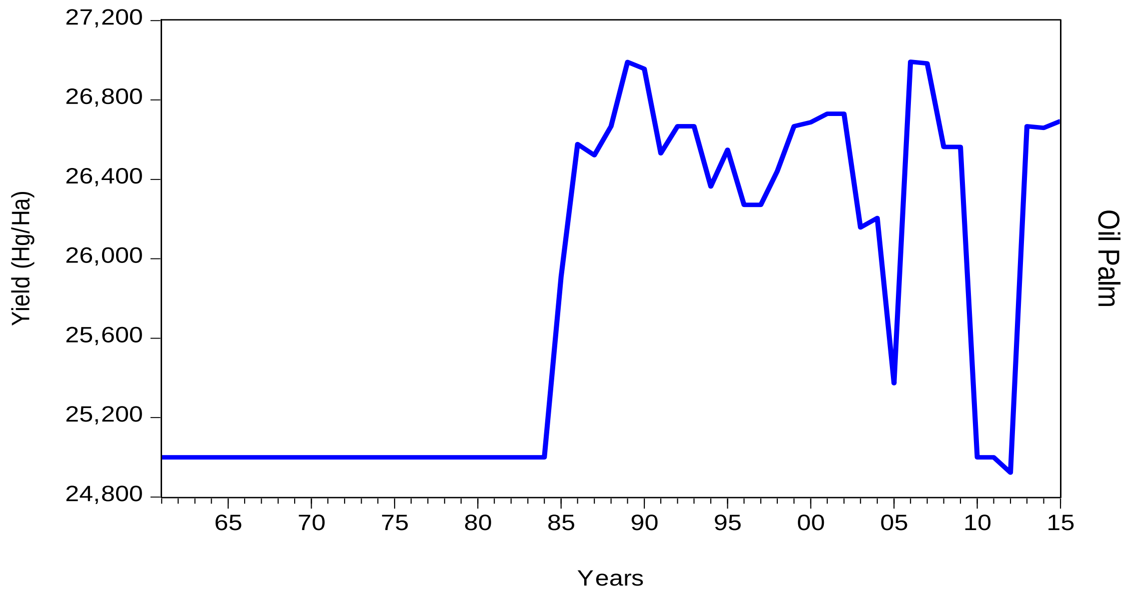

Figure 2: Yield trend of oil palm(Tons/ha) in Nigeria (1961-2015)
Source: Researchers' calculations

Trend of oil palm tree cropproduction (tons) in Nigeria from 1961-2015

Figure 3 presents the graph on the trend of production (tons) recordedby the selected tree crops (oil palm) from 1961 to 2015. The figure shows that the area production ofNigeria's oil palm production for the period under study was observed to increase from 7,200,000 tons in 1993 to 8,495,542 tons in 2015.

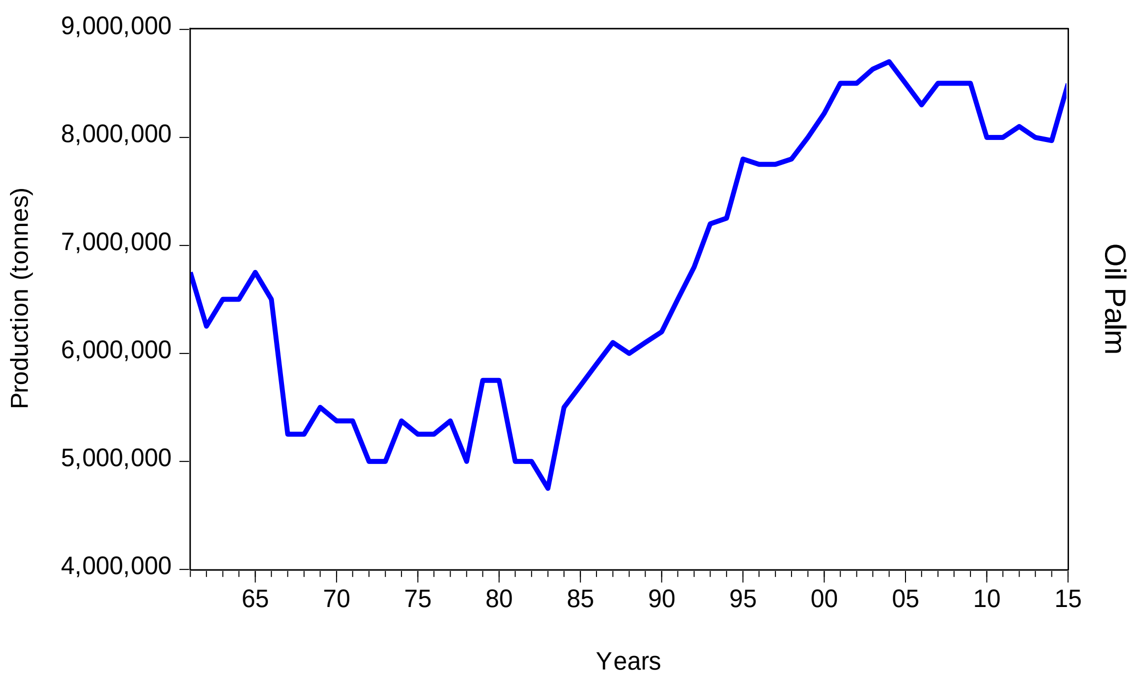

Figure 3: Production trend of oil palm(tons) in Nigeria (1961-2015)
Source: Researchers' calculations

Determination of the time series properties of data employed for analysis

The properties of the time series data used for the analysis were tested. Phillips-Peron's (1988) test (hereafter PP) was used to determine the stationarity of the variables under consideration, and the results are presented in Table 1.

The PP test is non-parametric, but it produced a superior result that corrects for serial correlation and heteroscedasticity. The PP test is also better in regime shifts, a problem usually encountered with macroeconomic data emanating from Africa (Yusuf & Yusuf, 2007). On application of PP, test variables attained stationarity at the level and after differencing once; thus, one may conclude thatthere is a mixed order of integration in the data. Stationarity is confirmed when the test statistic exceeds the critical value in absolute terms.

From Table 1, all the test variables for examining the response of selected export tree crop output (yield and production) to climatic change and international commodity price volatility were stationary at the level and, after first differing for some, based on the PP probability tests. As such, one could reject the null hypothesis of non-stationarity.The occurrence of unit roots at a level in these commodities' price data generation process gives a preliminary indication of shocks having permanent or long-lasting effects, thus not making it easy for traditional price stabilization policies common in African countries to survive (Cashin*et al.,* 2004).

Table 1: Unit Root Test Result

	Phillips-Perron Test		
Variable	**Level**	**1st Difference**	**Order of integration**
Climate change			
Rainfall	-5.045133 (0.0001)		I(0)
Temperature	-4.260020 (0.0013)		I(0)
Commodity prices			
Oil palm	-2.156244 (0.2243)	-8.094708 (0.0000)	I(1)
Output (production)			
Oil palm	-0.580187 (0.8661)	-7.463863 (0.0000)	I(1)
Output (Yield)			
Oil palm	-1.914985 (0.3232)	-8.664360 (0.0000)	I(1)
Others			
Real Exchange rate	1.310611 (0.9984)	-6.287971 (0.0000)	I(1)
Trade openness	-3.007864 (0.1396)	-9.084742 (0.0000)	I(1)
Inflation rate	-3.243140 (0.0228)		I(0)

Source: Researchers' calculationsoutput result from Eviews Version 9**.** *Note: Values in parentheses are probability values.*

Volatility test for oil palm commodity price

The result of the ARCH test for oil palm commodity price is shown in Table 2 below. Engle's LM test indicates that there are ARCH effects in oil palm commodity price. The F-statistic value is significant at the 0.01level, which implies that there isa presence of ARCH, meaning that there is also a presence of heteroskedasticity in the residual.

Table 2: Heteroscedasticity Test of the Residuals for Oil Palm Commodity Price
Heteroskedasticity Test: ARCH

F-statistic	7386.548	Prob. F(1,657)	0.0000
Obs*R-squared	605.1726	Prob. Chi-Square(1)	0.0000

Source: Researchers' calculationsoutput result from Eviews version 9

As shown in Figure 4, the residual plot further strengthens and approves the presence of ARCH and heteroskedasticity in oil palm commodity prices.

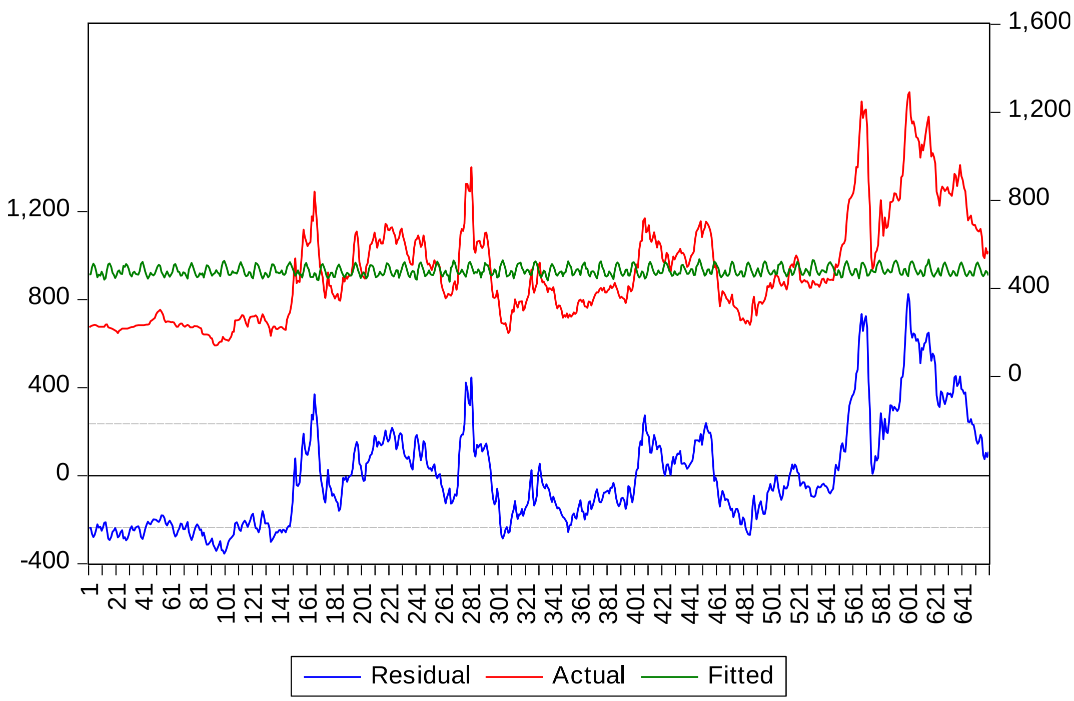

Figure 4: Residuals plot for oil palm commodity price
Source: Researchers' calculationsoutput result from Eviews Version 9

Table 3shows the results of the volatility test for oil palm commodity prices using the GARCH approach to verify the presence of volatility in oil palm commodity prices within the period under study. The results showvolatility in the international commodity price of oil palm. The coefficient of the lagged value of oil palm commodity price (338.620) had a significant positive relationship with its current value (the dependent variable) overtime for the study period at a 1% significant level. In the variance equation, the RESID(-1)^2 value of (1.005) also confirmed the existence of volatility in oil palm commodity prices within the period under study.

This outcome has implications for food security and policy responses by oil palm commodities. This is in contrast to the findings of Zhang and Buongiorno (2010), who found that volatility may not be a major policy issue for forest product exports.

Table 3: Volatility test foroil palm commodity price
GARCH = C(4) + C(5)*RESID(-1)^2

Variable	Coefficient	Std. Error	z-Statistic	Prob.
Intercept	338.6207	40.54288	8.352162***	0.0000
Rainfall	-0.017171	0.032030	-0.536108	0.5919
Temperature	2.017131	1.480713	1.362270	0.1731
		Variance Equation		
C	819.5145	169.1719	4.844271***	0.0000
RESID(-1)^2	1.005237	0.179812	5.590489***	0.0000
R-squared	-0.138251	Mean dependent var		479.9115
Adjusted R-squared	-0.141716	S.D. dependent var		235.8157
S.E. of regression	251.9717	Akaike info criterion		12.69543
Sum squared resid	41712747	Schwarz criterion		12.72946
Log-likelihood	-4184.491	Hannan-Quinn criter.		12.70862
Durbin-Watson stat	0.024418			

Source: Researchers' calculationsoutput result from Eviews Version 9
***, ** significant at the 0.01 and 0.05 probability levels

Effects of Climatic Variations and Commodity Prices Volatility on output ofoil palm

Tables 4 summarize the parameter estimates of the cointegration regression model (Fully Modified Ordinary Least Squares, FM-OLS) applied to analyze the climate variables alongside commodity price and combination of climate variables with commodity price of oil palm tree crop to ascertain their effects on tree crop yield in Nigeria over the period of study. The trend variable was not significant in the model for oil palm production, thus confirming that a linear trend does not exist in these models.

The model's diagnosis found that the model had residuals normally distributed with a JarqueBera statistic of 3.434, thus affirming that the distribution of the residuals of the estimated model was not normal. Similarly, the cointegration test using the Engle-Granger Tau statistic recorded a value of -4.157 ($p<0.10$), implying that we have to reject the null hypothesis, which held that "series are not cointegrated" at 10 percent. Therefore, The series is deemed cointegrated and could be reliably used for forecasting. The test for model fitness gave an R^2 value of 0.56, which implies that 56% of the variations in oil palm yield were accounted for by variability in the independent variables included in the regression model. The fact that the correlogram of the residuals squared did show significant values at 1% implies that the threat of serial correlation at the various lags examined in the study was not severe in the model. All these affirmed that the model had desirable properties of OLS.

For oil palm production, the model estimates diagnosis of residuals indicated that the series was cointegrated with Engle-Granger Tau statistics of -5.617 ($p>0.10$), implying that a long-run stable relationship exists among the series. The model's residuals also exhibited a JarqueBera statistic of 0.938, implying that the residuals were normally distributed. With the estimated correlogram of the residuals squared not significant at 10 percent, it can be adduced that the residuals were not fraught with threats of serial correlation or severe multicollinearity. The R^2 of 0.99 recorded in the model estimates indicated that 99 percent of the variation in oil palm production in the period of study was a result of variations of the independent variables included in the right-hand sides of the model. All the foregoing affirms the desirable properties of the OLS model applied in this research.

The results indicated that temperature, oil palm commodity price, inflation, and the combination of temperature with oil palm commodity price exerted significant effects on the yield of oil palm at the 1% level of significance, respectively, within the period of study. All other included variables showed no significant effect on the yield of oil palm.

The negative significant effect of temperature combined with oil palm commodity price with a slope coefficient of -0.330351 implies thatoil palm commodity price combined with temperature increase by one percent resulted in oil palm yield decrease by 0.330 tons in the study period. More so, the positive significant effect of temperature, oil palm commodity price, and inflation with slope coefficients of 211.29997 ($p<0.01$), 104.0461 ($p<0.01$), and 18.96324 ($p<0.01$), respectively, implies that temperature,oil palm commodity price, and inflation rates increase by one percent resulted in oil palm yield increase by 211.29997, 104.0461 and 18.96324 tons respectively for the period of study. Therefore, these variables are to be paid close attention to harness more yields in oil palm with its attendant benefits to the economy, as shown from the study, which can influence oil palm yield.

It wasfurther observed from the result that rainfall had a positive significant effect on oil palmproduction at a 1% level of significance while three other variables (inflation, real exchange rate, and combination of rainfall with oil palm commodity price) exerted negative significant effects on the production of oil palm in the study. The respective slope coefficients and p values (both in parentheses) are as follows: rainfall (7.968716, $p<0.02$); inflation (-943.5883, $p<0.10$) real exchange rate (-554.4322, $p<0.09$) and rainfall with oil palm commodity price (-0.000758, $p<0.01$).

Inflation and real exchange rate indicatednegative effects on oil palm production with a percentage increase in their values, resulting in a decrease in oil palm productionby 943.5883 and 554.4322tons, respectively, over the period of study. This outcome vindicates the advocates of a balanced economy not dependent on only oil with its consequences of deleterious impacts on food security. It is in agreement with current and past literature on economic theory.

The recorded positive significant effect of rainfall implied that climate variability is an important factor influencing oil palm production in Nigeria. However, this is not consistent with the results on the effects on oil palm yield. It was observed that a percentage increase in rainfall volume during the period in review resulted in an increase in oil palm production by 7.968716tons. This result demonstrates the influence of climate variables on farmers' decision to produce oil palm, showing that weather is important in determining oil palm production in the country.

A combination of climate variables (rainfall) with oil palm commodity price also demonstrated that its increase by one percent could result in oil palm production decrease by 0.000758 tons, and this is against the *a priori* expectation of the study that climate variables and international commodity price increase lead to an increase also in the production of export tree crops.

Table 4: Results of FMOLS Parameter Estimates to Model the Effect of Climate Variables, Commodity price volatility, and Joint Effect of Climatic Variables with Commodity price volatility on the output of Oil Palm in Nigeria (1961-2015)

Dependent variables	**Oil palm yield**		**Oil palm Production**	
Independent variables	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Intercept	-44098.99 (-2.365868)**	18639.67	-747477.1 (-0.474305)	1575943.
Rainfall	0.001639 (0.931057)	0.002	-1463.015 (-1.098531)	1331.793
Temperature	211.2997 (3.582450)***	58.982	7.968716 (58.01758)***	0.137
Commodity price	104.0461 (2.894979)***	35.940	1214.314 (0.245226)	4951.819
Inflation	18.96324 (3.096733)***	6.124	1052.819 (0.366874)	2869.700
Trade openness	0.829438 (0.042105)	19.699	-943.5883 (-1.744221)*	540.980
Real exchange rate	-0.117075 (-0.035513)	3.297	-1392.179 (-0.921831)	1510.232
Rainfall with commodity price	2.73E-06 (0.870642)	3.14E-06	-0.000758 (-3.151103)***	0.001
Temperature with commodity price	-0.330351 (-2.877361)***	0.115	-0.739617 (-0.081154)	9.114
R-squared	0.56		0.99	
Adjusted R-squared	0.47		0.99	
JarqueBera Statistic	3.018		0.938	
Engle-Granger tau-statistic	-4.157		-5.617	
Long Run Variance	147112		2.28E+09	
Remark on Correlogram of Residuals Squared	Significant at 1%		Not Significant at 10%	
Mean dependent var	25795.910		6731777	

Source: output result from Eviews version 9
Note: ***, ** and * = Figures significant at 1%, 5% and 10% probability levels

Test of Hypotheses

H_{O1}: There is no significant relationship between the output of oil palm tree crops and the variation of rainfall in Nigeria

From the results in Table 5, the null hypothesis, which held that rainfall did not Granger Cause oil palm output, gave an F-Statistic of 6.08216 ($p<0.05$), indicating that we have to reject this hypothesis at a significant value of 5%. This enabled us to conclude thatrainfall influenced the output of oil palms in the study.

This is a meaningful result and is in line with *a prior* expectation that oil palmoutput is significantly influenced by the amount of rainfall recorded in any given year. It is usefulin boosting the productivity of theoil palm tree crop in the next year. This is also attributable to the expectations of producers. Positive expectations in the next year's rainfall based on the rising price of the tree crop output in the previous year gave an impetus to improve the management of their farm, hence recording better output in the next year. Our analysis concludes that even the rainfall information in the previous year would still transmit to the present year's oil palm output at a significant level of 5 percent.

H_{O2}: Variation in temperature has no significant effect on oil palm tree crop output in Nigeria
The null hypothesis, which held that temperature did not cause Granger to cause oil palm output and vice versa, was accepted as the F-statistic value was not significant at any probability level. This enabled us to conclude thattemperaturehas no significant effect on the output of oil palm and vice versa.

H_{O3}: Commodity price volatility has no significant effect on Nigeria's oil palm tree crop output.

Table 5: Pairwise Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Prob.
D(Oil palm output) does not Granger Cause Rainfall	52	0.65375	0.5248
Rainfall does not Granger Cause D(Oil palm output)		6.08216***	0.0045
D(Oil palm output) does not Granger Cause Temperature	52	0.17600	0.8392
Temperature does not Granger Cause D(Oil palm output)		1.42235	0.2513
D(Oil palm output) does not Granger Cause D(oil palm commodity price)	52	0.84947	0.4341
D(oil palm commodity price) does not Granger Cause D(Oil palm output)		0.07819	0.9249

Note: ***, ** and * = Figures significant at 1%, 5% and 10% probability levels
Key: X_1=Rainfall, X_2= Temperature, Y_1= cocoa commodity price, Y_2= coffee commodity price, Y_3=oil palm commodity price, Y_4= Rubber commodity price, Z_1=cocoa output, Z_2=Coffee output, Z_3=Oil palm output, Z_4=Rubber output
Source: Researchers' calculationsoutput result from Eviews version 9

The null hypotheses, which held that the international commodity prices of oil palm did not Granger cause oil palm output and vice versa, were accepted as their F-statistic was not significant at any probability level. This enabled us to conclude that the commodity price of the oil palm tree crop has no significant effects on the outputs of oil palm and vice versa.
Therefore, we have observed that climatic change variables (rainfall and temperature) in Nigeria and the international commodity price of export tree crops could Granger cause the output of tree crops, while on the other hand, the output of some crops could equally Granger Cause the future commodity prices of the crops and climate change, as experienced from the results of the hypotheses testing presented in this study.

CONCLUSION AND RECOMMENDATIONS

To our knowledge, this study is the first to explicitly examine the response of export tree crops to a combination of climate change and commodity price volatility. The study concludes that there is volatility in the international commodity price of oil palm. More so, from the FM-OLS results, the study concludes that the yield and output of the commodity were significantly influenced by rainfall, temperature, commodity price, trade openness, exchange rate, and the interaction of climate and commodity prices. The study concludes that rainfall did not cause oil palm and rubber output.

Based on the findings of this study, the following recommendations are proffered;

1. Following the positive trend exhibited by oil palm tree cropyield and production under study, there was a small increase during the study period, as shown in the result. A concerted effort should be made to increase

the yield and production of tree crops. This can be done through the use of improved high-yielding varieties, improved farming techniques, and cultural practices.

2. Based on the variability in climate parameters (temperature and rainfall), there is, therefore, a need for policies formulatedby the government to address these issues of variations *vis-à-vis* their attendant benefits while formulatingthe adaptation and mitigation strategies to forestall the negative impact of climate change that is driven by decreases in precipitation and increase in temperature. This further advocates that adaptation efforts should target more drought-resistant crop varieties and technologies.
3. The government should implement exchange rate and trade policies that promote greater exchange rate stability and trade conditions that promote domestic production in the economythrough the provision of efficient infrastructural services like energy resources.
4. From the indication of the slow process of growth in oil palm production and yield, as observed from the results, it is recommended that short-term and quick remedy efforts be made to reverse the slow growth process in yield and production of thistree crop. This could be through the provision of input support to the farmers engaged in the tree crop through the use of advisory services, which will educate the farmers on the improved varieties and cultural practices that can help improvethe tree crop yield and production.
5. Trade facilitation is needed to reduce inherent marketing risks by reintroducing and re-invigorating the Centre for Agricultural Commodity Marketing (CACMART) by the Government through its institutions.
6. At the global/country level, regional and country-level stock reserves should be coordinated locally or internationally, as it is lacking currently in Nigeria.

ACKNOWLEDGEMENT

We sincerely thank Prof. TankoLikita of the Federal University of Technology Minna, Nigeria, Prof. Abel Ezeoha of AE-FUNAI, and the Late Dr. I.N. Nwachukwu of the Michael Okpara University of Agriculture Umudike, Nigeria, for their helpful comments on this manuscript.

REFERENCES

Adefolalu, D. O. (2007). Climate change and economic sustainability in Nigeria. Paper presented at the *International Conference on Climate Change*, NnamdiAzikiweUniversity, Awka 12-14.

Akpokodje, G. (2009). Exchange rate volatility and External Trade: The Experience of Selected African Countries. In. A. Adenikinju, D. Busari, & S. Olofin (Eds.),*Applied Econometrics and Macroeconomic Modelling in Nigeria*, 79-87.

Apata, T. G., Samuel, K. D., &Adeola, A. O. (2010).Analysis of climate change perception and adaptation among arable food crop farmers in South Western Nigeria. Contributed paper prepared for presentation at the *International Association of Agricultural Economists 2009 Conference, Beijing, China* August 16-22..

Bailey, M., George, T.,&Micheal, U. (1986). Exchange Rate Variability and Trade Performance: Evidence for the big seven industrial countries. *Review of World Economics, 122*(3),467–477.

Bello O. B., Ganiyu O. T., Wahab M. K. A., Afolabi M. S., Oluleye F., Ig S. A., Mahmud J., Azeez M. A., & Abdulmaliq S. Y. (2012). Evidence of Climate Change Impacts on Agriculture and Food Security in Nigeria.*International Journal of Agriculture and Forestry*, 2(2), 49-55. https//doi.org/ 10.5923/j.ijaf.20120202.08

Bollerslev, T. (1986).Generalized autoregressive conditional heteroscedasticity.*Journal of Econometrics, 31*(3),307-327. https//doi.org/10.1016/0304-4076(86)90063-1

Cashin, P.,Céspedes, L., &Sahay, R. (2004).Commodity currencies and the real exchange rate.*Journal of Development Economics, 75*(1), 239–268. https//doi.org/10.1016/j.jdeveco.2003.08.005

Chikaire, J. U., Anyoha, N. O., Ani, A. O., &Atoma, C. N. (2014). Land tenure reform: A vehicle for achieving agricultural transformation agenda in Nigeria. *Merit Research Journal of Agricultural Science and Soil Sciences*, *2*(9), 114-122. http://meritresearchjournals.org/asss/Content/2014/September/Chikaire%20et%20al.pdf

Côté, A. (1994). Exchange Rate Volatility and Trade: A Survey.*Bank of Canada.Working Paper* 94 -95.

Engle, R. F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of Uinted Kingdom Inflation.*Econometrica*: *Journal of Econometric Society*, 50, 987-1008.

Food and Agriculture Organization .(2009).*How to Feed the World in 2050.High Level Expert Forum*.Office of the Director, Agricultural Development Economics Division Economic and Social Development Department. Retrieved fromhttp://www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Investment.pdf (accessed September 7 2016).

Food and Agriculture Organization, International Fund for Agricultural Development, OECD, World Food Programme , the World Bank Group, World Trade Organization, UNCTAD, International Food Policy Research Institute, & United Nations High Level Task Force on Global Food Security. (2011),*Price Volatility in Food and Agricultural Markets: Policy Responses*. Retrieved fromhttp://www.indiaenvironmentportal.org.in/files/G20PriceVolatility.pdf (Accessed September 7 2016).

Food and Agriculture Organization Statistics.(2015). *Database of Food and Agriculture Organization*, Rome.Retrieved from http://faostat.fao.org/(Accessed March 2016).

Federal Ministry of Agriculture and Rural Development Abuja, Nigeria. (2011).*Agricultural Transformation Agenda: We Will Grow Nigeria's Agricultural Sector*. Retrieved from https://www.unaab.edu.ng/attachments/Agricultural%20Transformation%20Blue%20Print.pdf(Accessed September7 2016).

Federal Ministry of Environment. (2004). Abuja. Retrieved from www.nigeria.com.ngcichng.org/ccinfo.php (Accessed September 7 2016)

Federal Office of Statistics.(1989). *Federal Office of Statistics*.

Granger, C.W.J. (1969).Investigating causal relations by economic models and cross-spectral methods.*Econometrica: Journal of Econometric Society,* 37, 424-438.

Ikhile, C. I. (2007). Impacts of climate variability and change on the hydrology and water resources of the Benin-Owena River Basin (Unpublisheddoctoral dissertation).Department of Geography and Regional Planning, University of Benin, Benin City, Nigeria.

Kenen, P. B., &Rodrik, D. (1986). Measuring and Analysing the Effects of Short-term Volatility in Real Exchange Rate. *TheReview of Economics and Statistics, 68*, 311 – 315.

Masters, M. W. (2010). *Testimony before the committee on homeland security and government affairs,* USSenate, Washington.Retrieved from https//www.hsgac.senate.gov//imo/media/doc/052008Masters.pdf?attempt=2.

McKenzie, M. D.,& Brooks, R. D. (1997).The impact of exchange rate volatility on German-US Trade Flows.*Journals of International Financial Markets, Institutions and Money*, *7*(1), 73-87. https//doi.org/10.1016/S1042-4431(97)00012-7

Nam, T. A., Welch, J.R., Lobell, D., Roberts, M. J., &Schlenker, W. (2012). *Commodity Prices and Volatility in Response to Anticipated Climate Change*.Selected Paper prepared for presentation at the Agricultural and Applied Economics Association's 2012 (AAEA) Annual Meeting, August 12-14, 2012, Seattle, Washington. Retrieved fromhttp://ageconsearch.umn.edu/record/124827. doi:10.22004/ag.econ.124827

National Bureau of Statistics.(2013). *National Bureau of Statistics report on Nigerian Population estimate as at 2013*. Retrieved from http://www.nigerianstat.gov.ng/pdfuploads/2014%20Statistical%20Report%20on%20Women%20and%20Men%20in%20Nigeria_.pdf

National Emergency Management Authority.(2010). *Daily Trust newspaper* 14th October 2010.

Nigerian Meteorological Agency .(2008). *Nigerian Meteorological Agency Report*.

Obioha, E. (2008). Climate Change, population drift, and violent conflict over land resources in North Eastern Nigeria. *Journal ofHuman Eco*logy, *23*(4), 311–324.

Obioha, E. (2009). Climate variability, environmental change and food security nexus in Nigeria.*Journal of Human Ecology*, 26(2),107–121.

Odjugo, P. A.O. (2010). General overview of climate change impacts in Nigeria. *Journal of HumanEc*ology, *29*(1), 47-55.

Olowe, R. A. (2009). Modelling Naira/Dollar Exchange Rate Volatility: Application of GARCH and Assymetric Models.*International Review of Business Research Papers*, 5(3),377-398

Peree, E., &Steineir, A. (1989).Exchange Rate Uncertainty and Foreign Trade.*European Economic Review*, 33(6), 1241-1264. https//doi.org /10.1016/0014-2921(89)90095-0

Phillips, P. C. B., & Hansen, B. E. (1990). Statistical inference in instrumental variables regression with I(1) processes. *TheReview of Economic Studies* 57, 99–125. Retrieved from

World Bank.(1994).*Nigeria Structural Adjustment Program Policies, Implementation, and Impact.*http://documents.worldbank.org/curated/en/959091468775569769/pdf/multi0page.pdf(Accessed September 2016).
World Bank.(2014). *Project appraisal document on a proposed credit for transforming irrigation management in Nigeria project.* World Bank, Washington.
Yinusa, D. O. (2004).Exchange Rate Variability, Currency Substitution and Monetary Policy in Nigeria (1986 -2001) [Unpublished Ph.D Thesis].
Yusuf, S. A., & Yusuf, W. A. (2007). Determinants of selected agricultural export crops in Nigeria: An ECM approach. In *Proceedings of African Association of Agricultural Economists* Accra, Ghana, 469 – 472.
Zhang, S., &Buongiorno, J. (2010).Effects of exchange rate volatility on export volume and prices of forest products.*Canadian Journal of Forest Research*, *40* (11), 2069-2081.
Zoellick, R. B., & Robert, B.A (2009).Climate Smart Future.*The Nation* Newspapers, Lagos, Nigeria: Vintage Press Limited.