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Vector Autoregressive Modeling of Exchange Rate, Interest Rate and Agricultural Prices in Nigeria

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Abstract
The study modelled the Interaction among Exchange rate, interest Rate and Agricultural Prices in Nigeria. In details, the study determined the effects of exchange rate and interest rate on agricultural prices (cocoa beans price, cotton prices) the effect of on agricultural prices. The study adopted an ex-post-facto design. The data for the study spanning from May 1991 to May 2022 was sourced from the Central Bank of Nigeria (CBN) statistical bulletin. Sequel to the pretest conducted, the study used the Vector Auto-Regression (VAR) Model. The results of the model estimation showed that all the studied variables had significant own effects (PV < 0.05). However, the lags of the cotton prices, exchange rate and interest rate had insignificant positive and negative effects on cocoa beans price. Exchange rate, interest rate, and cocoa beans price had insignificant positive and negative effects on cotton prices. The Post estimation test showed that the VAR Model was Stable, there was absence of serial correlation, and the normality test confirmed that the residual was multivariate normal. The Variance Decomposition results confirmed the very weak influence of the independent variables in predicting the corresponding dependent variables. The variables were however strongly endogenous. It was recommended that government should ensure policies, which will consequently stabilize exchange rate and interest rate to also stabilize agricultural prices in Nigeria.

***Key words**: Agricultural Prices, Exchange Rate, Interest Rate, Interaction, and VAR modelling*

INTRODUCTION

1.1 Background to the Study

The agricultural sector is one of the leading sectors in Nigeria. Its contributions to the economy in terms of employment, income, foreign exchange earnings, and domestic food supply. According to Mohammed (2020), agricultural output has been the backbone of the Nigerian economy long before the discovery and exploration of crude oil that resulted to the country's dependence on crude oil for the economy's growth. Mohammed (2020) further explained that agriculture provides employment for about 30% of the population as at 2010 and approximately 70% of the population engages in agricultural production at a subsistence level. However, Wiri and Tuaneh (2019) reported that, the major source of income to the Nigerian government is the crude oil production.

According to Tuaneh (2019) 'Macroeconomic stability indicators particularly their; evolution, interaction and interdependence, obviously cause shocks among themselves'. Also, according to Tuaneh and Okidim (2019), Ihe interaction among macroeconomic indicators causes shock among themselves and by extension shocks on other macroeconomic variables including agricultural performance. Agricultural commodities sold outside Nigeria are primarily determined by foreign demand and supply factors like the exchange rate and domestic monetary policy such as interest rate. The nature of agricultural commodities and the imperfections in the markets also influence the price transmission and the final consumer prices (Lack, & Lenz, 2000). This study applied VAR to ascertain the interaction among exchange rate interest rate and agricultural prices. More so, the study determined the effects of exchange rate and interest rate on agricultural prices (cocoa beans price, cotton prices).

2.0 Related Literature

Following the study of Abolagba, Onyekwere, Agbonkpolor, & Umar (2010) exchange rate, interest rate, and price rise of food items have become a major concern for policymakers worldwide and particularly for Nigeria and other developing countries. In Nigeria, the recent fall in Agricultural commodities price largely due to inadequate supply response to increasing demand, aggravated by others factors including coronavirus pandemic, exchange rate, domestic policies such as interest rate, logistic and market-related constraints. The fall in Agricultural commodity prices affects the poor disproportionately and adversely impacts the achievement of eradication (Abolagba, Onyekwere, Agbonkpolor, & Umar, 2010)

Tuaneh (2019) reiterated that exchange rate, interest rate, and commodity prices stability are major economic goals of nations all over the world. This is irrespective of their history, geographical location, or political status, be it underdeveloped, developing, or developed. This informs the desire by macroeconomic managers and investors alike for stable macroeconomic conditions. However, the dynamic behavior of exchange rate, a domestic policy such as interest rate and Agricultural commodities price stability indicators particularly their; evolution, interaction, and interdependence, obviously cause shocks among themselves. Therefore, it becomes necessary to investigate the interaction among Exchange rate, interest rate, and agricultural Prices in Nigeria to identify the causes of price instability in Nigerian Agricultural foreign markets (Adama, & Ohwofasa 2015)

Although, Folawewo, & Olakojo, (2010) revealed that the analysis of the interaction among exchange rate, interest rate, and agricultural commodity prices is complicated but necessary as exchange and interest rate shocks characteristically have real effect on agricultural commodity prices particularly the stability indicators between these variables. The study of the analysis of the interaction among exchange rate, interest rate, and agricultural commodity prices is necessary because there has not been a consensus among academic economists, statisticians, econometricians and policy makers regarding the impact of exchange rate and interest rate variations on agricultural commodity prices variables.

Deebom and Tuaneh, (2019) opined that in Nigeria and the world at large Exchange rate is consider as one of the strongest indicator and instrument used in evaluating economic performance of a nation. However, the traditional view is that fluctuations in exchange rate and interest rate affect relative domestic and foreign prices, causing expenditures to shift between domestic and foreign goods (Adama, & Ohwofasa 2015). Also, there are theoretical reasons why exchange rate, interest rate shock should affect Agricultural commodity prices; firstly, the exchange rate, interest rate shock can lead to lower aggregate demand since the price rise redistributes income between the agricultural commodity import and export countries since higher costs of production in many cases translated into higher prices for goods and services. Secondly, the supply-side effects relate to the fact that crude oil is considered as a basic input in the production process. An increase in the exchange and interest rate reduces aggregate supply increases energy prices reduce energy purchase; consequently, the productivity of any given amount of resource reduces, the potential output will also fall (Adama, & Ohwofasa, 2015)

According to Folawewo, & Olakojo,(2010), since the inception of exchange rate deregulation in Nigeria, there have been fluctuations in the value of the naira. However, exchange rate of the naira to the US dollars was relatively stable in 2010 (CBN, 2010). The average exchange rate of the naira at the Whole Sale Dutch Auction System (WDAS) segment of the foreign exchange market in 2010 was 150.30 per US dollars; a depreciation of 0.9 per cent compared to the level in 2009 (Folawewo, & Olakojo,2010)). A market driven exchange rate and interest rate policy is expected to be important in determining the importation of inputs for agricultural production and also, the export of agricultural produce through its influence on prices but it is worth noting that there exists a dearth of empirical information on the relationship between exchange rate, interest rate and agricultural produced sold outside Nigeria which is in line with Petreski (2009), who posited that the relationship between exchange rate and economic growth remains blurred and requires in depth empirical investigation.

Following from previous studies; Tuaneh (2019) applied the Vector Auto-regression in modeling the interaction among macroeconomic stability indicators in Nigeria, 1981-2016, Tuaneh and Wiri (2019) studied Unrestricted vector autoregressive modeling of the interaction among oil price, exchange rate and inflation rate. Tuaneh and Essi (2021), Tuaneh, Essi, and Etuk (2021), and Tuaneh, Essi, and Ezigbo (2021), respectively used MS-VAR (Intercept Adjusted), MS-VAR (Mean Adjusted) and Vector Error Correction in modelling interaction existing between macroeconomic variables. This study was, designed to fill the gap in research by adopting Vector Autoregressive modeling and incorporating agricultural prices with a view to draw policy inference based on the results obtained from the study.

3.0 METHODOLOGY

3.1 Source of Data

monthly data on exchange rate, Interest rate, Coco Bean and Cotton price spanning from May, 1991 to May, 2022 were sourced from the Statistical Bulletin of the central bank of Nigeria (CBN) www.cbn.ng. The statistical software used was the Eviews version 10.

3.2 Methods of Data Analysis

The study adopted the Vector Autoregression (VAR), however, other statistics/test were conducted

3.2.1 Descriptive Statistics

The summary descriptive statistic is done to examine whether data is normally distributed. This test is carried out using the Jarque- Bera test statistics. According to Deebom & Essi (2017), the

Jarque- Bera test statistic defines the joint test for skewness and kurtosis, and this examine whether the data scores exhibit normal distribution characteristic. The test statistic is defined as thus:

$$\chi^2 = N/6\left[S^2 + \left(\frac{k-3}{4}\right)^2\right] \tag{3.10}$$

Where;

S - Stands for skewness Statistic

K - Stands for kurtosis

N - Stands for the sample size of the data under investigation.

The test statistic under the null hypothesis of normal distribution has a degree of freedom (df) 2 and the hypothesis is stated as thus:

H0: $\alpha_1 = \alpha_2 = ... = \alpha_p = o$, the variable is normally distributed as $\chi^2(\rho) > P - value$ (Standard Probability Value) against the alternative hypothesis

H1: $\alpha_1 \neq \alpha_2 = ... = \alpha_p \neq o$ the variable is not normally distributed. Also, the discussion for the test of the hypothesis will be considered, if the variable under investigation comes from a normal distribution process. If Jarrque-Bera (JB), asymptotically, have a chi-square distribution with degrees of freedom two (2) then the null hypothesis will be accepted while the alternative rejected conversely, if it is on the contrary then the alternative hypothesis will be accepted while the null hypothesis will be rejected. However, after testing the variables and they are not normally distributed then, we proceed to examine the stationary behavior of the variables and this is done using the unit root test.

3.2.2 Unit Root Test

The Unit Root is tested using, the augmented Dickey-Fuller (ADF) unit root test and Phillip Perron (PP) Test which is usually employed in the analysis of random variables to determine the order of integration of a series. This is very vital in time series analysis

The test assumes that the series y_t, is a random walk

$Y_t = \emptyset_1 y_{t-1} + \varepsilon_t$ Random walk (3.1)

$Y_t = \emptyset_o + \emptyset_1 y_{t-1} + \varepsilon_t$ Random walk with drift (3.2)

$Y_t = \emptyset_0 + \emptyset_1 y_{t-1} + \emptyset_2 t + \varepsilon_t$ Random walk with drift and trend (3.3)

Note that to enhance stationarity y_{t-1} is subtracted from both sides of each of equation 3.11 -3.3

$Y_t - Y_{t-1} = \emptyset_1 Y_{t-1} - Y_{t-1} + \varepsilon_t$, $\Delta Y_t = \mathbb{Z} Y_{t-1} + \varepsilon_t$, Random walk (3.4)

$Y_t - Y_{t-1} = \emptyset_0 + \emptyset_1 Y_{t-1} - Y_{t-1} + \varepsilon_t$, $\Delta Y_t = \emptyset_0 + \mathbb{Z} Y_{t-1} + \varepsilon_t$, Random walk with drift (3.5)

$Y_t - Y_{t-1} = \emptyset_0 + \emptyset_1 Y_{t-1} - Y_{t-1} + \boldsymbol{\emptyset_2} t + \varepsilon_t$, $\Delta Y_t = \emptyset_1 + \mathbb{Z} Y_{t-1} + \emptyset_2 t + \varepsilon_t$, Random walk with drift and trend (3.6)

Where $\emptyset_1 Y_{t-1} - Y_{t-1} = (\emptyset_1 - 1) Y_{t-1}$, let $(\emptyset_1 - 1) = \mathbb{Z}$, we have $\mathbb{Z} Y_{t-1}$ and $Y_t - Y_{t-1} = \Delta Y_t$

The null hypothesis is tested as thus: For pure random walk, we have

$\Delta Y_t = \mathbb{Z} Y_{t-1} + \sum_{i=1}^{\rho} \sigma_i \Delta Y_{t-1} + \varepsilon_t$.

H0: $\mathbb{Z} = 0$ and therefore $r = 1$ against the alternative that HO_1: $\mathbb{Z} < 0$ and $r < 1$.
Similarly, Random Walk with drift we have
$\Delta Y_t = b_0 + \mathbb{Z}Y_{t-1} + \sum_{i=1}^{\rho} \sigma_i \Delta Y_{t-1} + \varepsilon_t$
H0: $\mathbb{Z} = 0$ and therefore $r = 1$ against the alternative that HO_1: $\mathbb{Z} < 0$ and $r < 1$
Also, Random Walk with drift and trend
$\Delta Y_t = b_0 + \mathbb{Z}Y_{t-1} + \sum_{i=1}^{\rho} \sigma_i \Delta Y_{t-1} + \emptyset_2 t + \varepsilon_t,$
H0: $\mathbb{Z} = 0$ and therefore $r = 1$ against the alternative that HO_1: $\mathbb{Z} < 0$ and $r < 1$

we compare the t-statistics of the parameter, with the critical value tabulated (Mackinnon, 1991) if Y_t is more negative or statistically significant at a given level of significance, we reject the null hypothesis and accept the alternative and conclude that the series does not have a unit root at levels. However, we accept the null hypothesis and reject the alternate and conclude that the series has a unit root at levels in a situation of the negation of the above result.

3.2.3 Lag Length Order
VAR Lag Length order is selected using some model selection criteria which include: Schwarz information criterion (Sic) or Schwartz Bayesian information, information criterion (SBIC), Final Predator Error (FPE), Akaike Information Criterion (AIC) and Hannan-Quinn Information Criterion (HQ). However, the study adopted the Akaike information criterion since it chooses the value of the length which minimizes the model selection criteria (Sim & Chang,2006). The general specification is to fit VAR models with order L = 0,1,2, … L max whereby models with too few lags could lead to systematic variation in the residual, too many lags come with the penalty of fewer degrees of freedom. Our interest is on the models with the lowest AIC is a good way to select to best one! The lower this value is, the better the model.

3.2.4 Co-integration Test
In testing for cointegration there are several underlying assumptions and this includes: all variables are said to be non-stationary, they are all integrated of the same order and where they are not integrated of the same order then will continue with cointegration analysis using multi cointegration. However, Sim & Chang, (2006) further explained that there exists a Long-run relationship among variables and they include: Engel-Granger's residual-based test and Johansen-Juselius (JJ) test. Since the Engel, Johansen-Juselius (JJ) test is most preferred (Sayed, 2018) in his study adopted the Johansen maximum likelihood approach by using trace and maxeigen value test.

3.3 Model Specification
In line with the objectives for this study, the model adopted was the Vector Auto-Regressive Model (VAR) and a four –variables. VAR (4) with lag could be specified as thus:

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 X_{t-1} + \alpha_3 Z_{t-1} + \alpha_4 M_{t-1} + \varepsilon_{1t} \quad 3.7$$

$$X_t = b_0 + b_1 Y_{t-1} + b_2 X_{t-1} + b_3 Z_{t-1} + b_4 M_{t-1} + \varepsilon_{2t} \quad 3.8$$

$$Z_t = \phi_0 + \phi_1 Y_{t-1} + \phi_2 X_{t-1} + \phi_3 Z_{t-1} + \phi_4 M_{t-1} + \varepsilon_{2t} \quad 3.9$$

$$M_t = d_0 + d_1 Y_{t-1} + d_2 X_{t-1} + d_3 Z_{t-1} + d_4 M_{t-1} + \varepsilon_{4,t} \quad 3.10$$

Where Y_t, X_t, Z_t , *and* M_t , represents exchange rate , interest rate, Cotton price and cocoa Prices respectively. While the apriori expectation: $\alpha_0, b_0, \varphi_0, d_0 > 0$, these represents the intercept $\alpha_1, \beta_2, \lambda_3$, *and* θ_4 = Short-run dynamic coefficients of the model's adjustment long-run equilibrium, $\varepsilon_{i,t}$ = Errors , impulses , shocks or innovations . Each variable is a linear function of the lag 1 values for all variables in the set. In a VAR (2) model, the lag 2 values for all variables are added to the right sides of the equations. The first p lags of each variable in the system would be used as regression predictors for each variable. VAR models are a specific case of more general VARMA models.

3.4 Estimation and Identification

Vector Autogressive Model is estimated using the maximum likelihood method and this is done as thus: Supposing the model is a function of y, the maximum likelihood is defined as ;

$$f(Y_T, Y_{T-1} \ldots\ldots Y_1 | Y_0 . Y_{-1} \ldots\ldots Y_{\_p+1,} V) = \prod_{t=1}^{T} f(Y_t | Y_{t=1}, Y_{t-2} \ldots\ldots Y_{t-p+1}; V)$$

$$Y_t | Y_{t-1}, Y_{t-2} \ldots\ldots \rightarrow N(c + \Phi_1 Y_{t-1} + \ldots\ldots \Phi_1 Y_{t-1} \ldots\ldots \Phi_p Y_{t-p}, \Omega)$$

$$\Pi' \equiv [c\Phi_1 \ \Phi_2 \ldots\ldots \Phi_p]$$

$$X_t \equiv [1Y_{t-1} \ Y_{t-2} \ldots\ldots Y_{t-p}]'$$

$$Y_t = \Pi' \ X_t \ + \ a_t$$

$$\ell(v) = \sum_{t=1}^{T} log\, f\,(Y_t | past; v) =$$

$$= -\frac{Tn}{2} log(2\pi) + \frac{T}{2} log|\Omega^{-1}| - \frac{1}{2} \sum_{t=1}^{T} [(Y1 - \Pi' X_t)' \Omega^{-1} (Y_t - \Pi' X_t)]$$

$$\hat{\prod} mle = \hat{\prod} ols \ \hat{\prod}'_{ols} = \left[\sum_{t=1}^{T} Y_t X'_t\right] \left[\sum_{t=1}^{T} X_t X'_t\right]^{-1}$$

3.5 Model Diagnostic Test

3.5.1 Stability Test for VAR systems

For a set of n time series variables $y_t = (y_{1t}, y_{2t,}, \ldots, y_{nt})'$, a VAR model of order p, (VAR(p)) can be written as: $y_t = A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + u_t$

Where the A_i 's are (nxn) coefficient matrices and $u_t = (u_{1t}, u_{2t}, \ldots, u_{nt})'$ is an unobservable i.i.d. zero mean disturbance term. The stability of the stationary VAR system, according to Halkos and Tsilika, (2012), the stability of a VAR can be examined by calculating the roots of:

$(I_n - A_1 L - A_2 L^2 - \ldots.) y_t = A(L) y_t$

The characteristic polynomial is defined as: $\Pi(z) = (I_n - A_1 z - A_2 z^2 - \ldots.)$

The roots of $|\Pi(z)| = 0$ will give the necessary information about the stationarity or non-stationarity of the process. The necessary and sufficient condition for stability is that all characteristic roots lie inside the unit circle. Then Π is of full rank and all variables are stationary. In this section, we assume this is the case. Later we allow for less than full rank matrices. Following the calculation of the eigenvalues and eigenvectors. We assumed an (nxn) square matrix A, whereby we are looking for a scalar λ and a vector $c \neq 0$ such that $Ac = \lambda c$ then λ is an eigenvalues (or characteristic value or latent root) of A. Then there will be up to n eigenvalues, which will give up to n linearly independent associated eigenvectors such that or $Ac - \lambda Ic = 0 \Rightarrow [A - \lambda I]c = 0$.

For there to be a nontrivial solution, the matrix $[A - \lambda I]$ must be singular. Then λ must be such that $|A - \lambda I| = 0$

Results

4.1 Time Plots on all Variables at Level

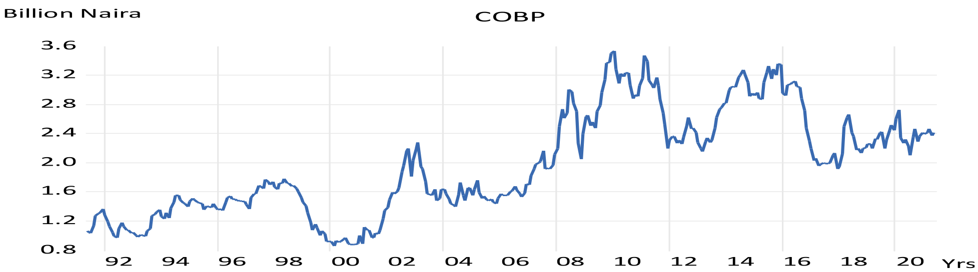


Figure 4.1: Time Plot on Agricultural price (coco Bean Price) at Level

Figure 4.2: Time Plot on Agricultural Price (Cotton Price) at Level

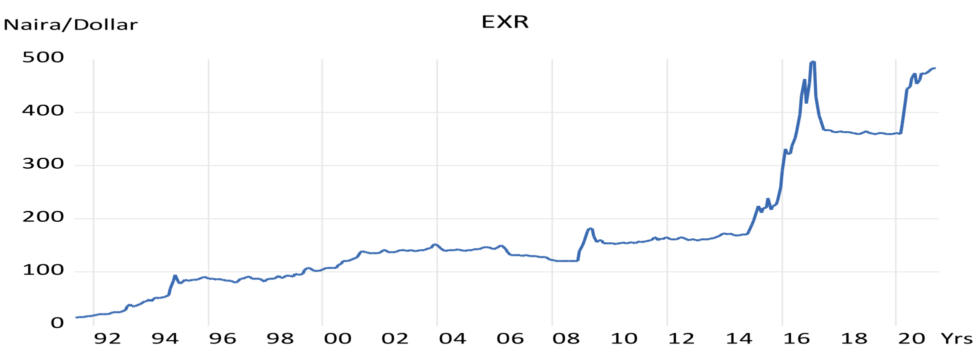


Figure 4.3: Time Plot on Exchange Rate at Level

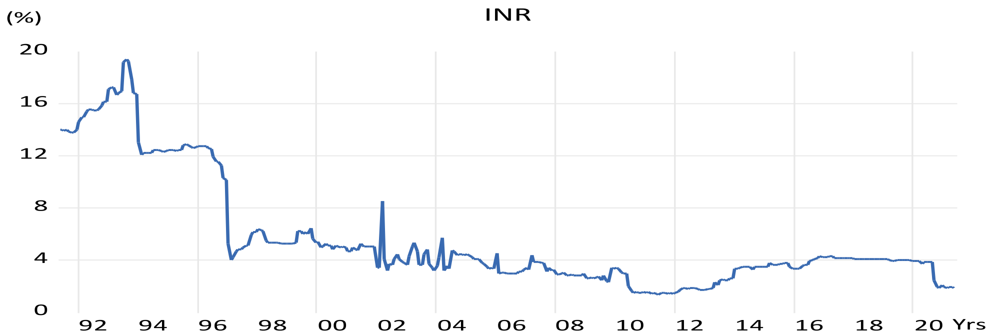


Figure 4.4: Time Plot on Interest Rate at Level

Figure 4.1, 4.2, 4.3, and 4.4 display the time plot on agricultural price (coco Bean Price, cotton price), exchange rate and interest rate at Level. From our visual examinations, the series display trend and other time series properties. This clearly revealed the likelihood of the series having unit roots. Therefore, there is need for differencing to de-trend all the series using appropriate unit root test

4.1.2: Descriptive Test for Normality

Table 4.1 is the result for the descriptive test for normality and this test statistic provides basic information about the variables and highlights potential relationship between variable

Table 4.1 Descriptive Statistics on all Variables

Statistics	COBP	COTP	EXR	INR
Mean	1.974515	1.635900	168.7607	5.585753
Median	1.820000	1.580000	139.8000	4.050000
Maximum	3.530000	5.060000	494.7000	19.38000
Minimum	0.860000	0.820000	12.65000	1.330000
Std. Dev.	0.706697	0.513535	115.5224	4.283809
Skewness	0.346320	2.816022	1.252295	1.536315
Kurtosis	2.014311	16.71628	3.714133	4.138278
Jarque-Bera	21.83044	3307.004	102.0270	161.4984
Probability	0.000018	0.000000	0.000000	0.000000
Sum	712.8000	590.5600	60922.63	2016.457
Sum Sq. Dev.	179.7915	94.93873	4804357.	6606.366
Observations	373	373	373	373

Table 4.1 contains the Descriptive Statistics on all Variables. The result shows that all the series (coco Bean Prices, Cotton Prices, interest rate, and exchange rate) were positively skewed as shown in table 4.1 which implies that all the series were not normally distributed as also shown by the Jarque-bera statistics. The arque-bera test showed that all variables were statistically significant (PV=0.000) therefore, the null hypothesis of normality is not upheld implying that the series were not normally distributed.

4.1.3 Unit Test

The unit test is done to determine the stationary level of the variables under investigations and the results is shown Table 4.2 below.

Table 4.2: Unit Root Test using Augmented Dickey Fuller and Phillip Perron Test

Variables	Stat	Augmented Dickey Fuller Test (ADFT)					Phillip Perron Test (PPT)				
	level	1%	5%	10%	ADFTS	Remarks	1%	5%	10%	PPTS	Remarks
Exchange rate	1(0)	-3.45	-2.87	-2.57	-0.41	NS	-3.45	-2.87	-2.57	0.57	NS
	1(1)	-3.45	-2.87	-2.57	-7.49	S	-3.45	-2.87	-3.45	-13.72	S
Interest rate	1(0)	-3.45	-2.87	-2.57	-1.93	NS	-3.45	-2.87	-2.57	-1.90	NS
	1(1)	-3.45	-2.87	-2.57	-20.42	S	-3.45	-2.87	-2.57	-20.48	S
Cotton Price	1(0)	-2.57	-1.94	-1.62	-2.52	NS	-2.57	-1.94	-1.62	-2.62	NS
	1(1)	-2.57	-1.94	-1.62	-10.24	S	-2.57	-1.94	-1.62	-9.24	S
Coco Bean Price	1(0)	-3.45	-2.87	-2.57	-2.05	NS	-3.45	-2.87	-2.57	-1.90	NS
	1(1)	-3.45	-2.87	-2.57	-15.85	S	-3.45	-2.87	-2.57	-15.64	S

Note: S= Stationary, NS = Not Stationary

Table 4.2 display the result for the unit root test. Most time series are inherently non-stationary and may cause spurious or biased estimation. However, to ascertain the stationarity, the

Augumented Dickey-Fuller and the Phillip-Perron unit root tests was adopted. From the results obtained in Table 4.2 of unit root test, Augumented Dickey-Fuller and Phillips-Perron tests showed that at level, all the variables had unit root (Non-stationary) as the probability value (p-value) is greater than 5% level of significance. At first difference, all the variables had no unit root (stationary) as the probability value (p-value) is less than 5% level of significance.

4.1.4 Time Plots at First Differenced

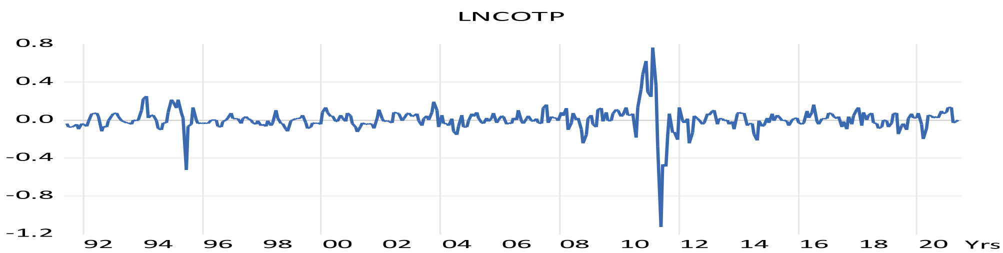
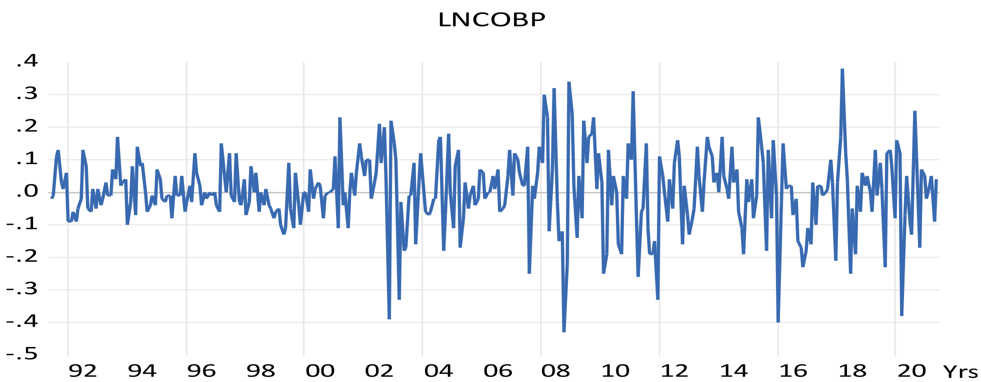


Figure 4.5: Time Plot on Agricultural price (cotton Price) at first differenced Figure



4.6: Time Plot on Agricultural price (coco Bean Price) at first differenced Figure 4.7:

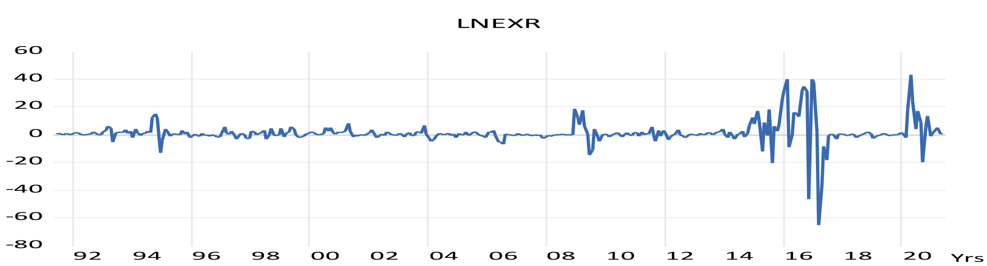


Figure 4.7 Time Plot on Exchange Rate at first differenced

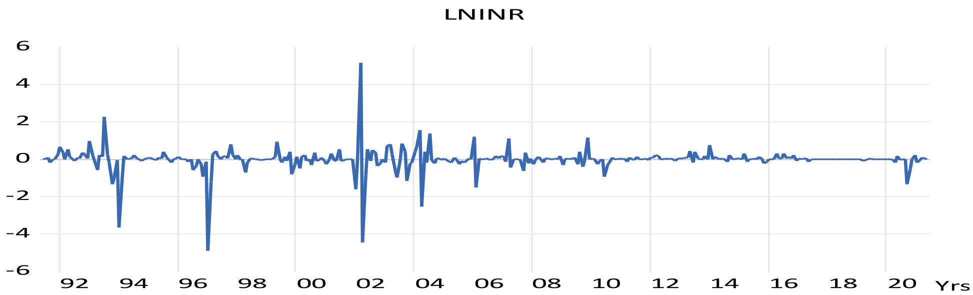


Figure 4.8: Time Plot on Interest Rate at First Differenced

Also, figure 4.5, figure 4.6, figure 4.7 and figure 4.8 shows the time plot for the differenced variables which clearly shows that all the series were de-trended. The variables vary within the zero (O) mean, showing that it is stationary with the evidence of clustering volatility at constant variance.

4.1.5 VAR Lag Length Order Selection

Table 4.3 contains the result for the lag order selection to ascertain the VAR lag length before estimation. This is done to determine the lagged of VAR model parameters of the variables under investigations.

The lag order is selected using statistical information criteria. The result obtained indicates that selection of lag 2, consequently, the VAR analysis is done at lag 2.

4.1.5 Johansen Co-Integration Test

Table 4.3 contains the results of the Johansen co-integration test result to determine the presence of long-run relationship among the study variables and Normalized co-integrating coefficients (standard error in parentheses).

Table 4.3: Johansen co-integration Test Result to Determine the Presence of Long-run Relationship among the Study Variables.

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.074689	40.85386	47.85613	0.1934
At most 1	0.024574	13.21941	29.79707	0.8813
At most 2	0.011470	4.361602	15.49471	0.8723
At most 3	0.000715	0.254782	3.841466	0.6137

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

Similarly, table 4.3 contains the results of Johansen co-integration test using trace and maximum-eigen value. According to Johansen, co-integration exists if two or more variables have a long-run relationship among them. The result presented in Table 4.3 from the Trace statistic indicates that the null hypothesis of no co-integrating relationship was accepted and the alternative hypothesis of co-integration rejected. More so, from the maximum Eigen statistic, the null hypothesis of no co-integrating relationship was accepted against the alternative hypothesis of co-integrating relationship. Therefore, there is no co-integrating (long-run) relationship between exchange rate interest rate, coco bean Prices and cotton rates in Nigeria. The Johansen Normalized co-integrating equation. Normalized cointegrating coefficients (standard error in parentheses)

COBP	COTP	EXR	INR
1.000000	-1.476446	-0.000150	0.071241
	(0.24608)	(0.00123)	(0.03181)

In the above normalized co-integrating equation, coco-bean Prices is positioned as the dependent variable. In the interpretation, the co-efficient of the variables are reversed. This simply means that in the long-run, cotton prices and exchange rate had negative impact on cocoa beans prices while and interest rate had positive impact ceteris paribus. The co-efficient of exchange and interest rate are statistically significant at the 5% level. There is no co-integrating equations, the estimation of the vector autoregressive model was therefore necessary.

4.2 Model Estimation

Table 4.4: Results of the Vector Autoregressive (VAR) Model Estimation

	LNCOTP	LNCOBP	LNEXR	LNINR
LNCOTP(-1)	1.461029	0.062592	-0.042512	-0.123894
	(0.04610)	(0.05591)	(0.03575)	(0.11266)
	[31.6938]	[1.11956]	[-1.18925]	[-1.09967]
LNCOTP(-2)	-0.506921	-0.062083	0.030913	0.136898
	(0.04582)	(0.05557)	(0.03553)	(0.11198)
	[-11.0635]	[-1.11722]	[0.87004]	[1.22249]
LNCOBP(-1)	0.035345	1.094187	-0.032725	0.032304
	(0.04394)	(0.05329)	(0.03407)	(0.10739)
	[0.80438]	[20.5325]	[-0.96044]	[0.30080]
LNCOBP(-2)	-0.014491	-0.124144	0.055137	-0.059657
	(0.04426)	(0.05368)	(0.03432)	(0.10818)
	[-0.32736]	[-2.31250]	[1.60634]	[-0.55145]
LNEXR(-1)	0.015591	-0.022105	1.288041	0.094863
	(0.06522)	(0.07910)	(0.05057)	(0.15939)
	[0.23906]	[-0.27947]	[25.4687]	[0.59515]
LNEXR(-2)	-0.014624	0.021267	-0.297090	-0.111364
	(0.06473)	(0.07850)	(0.05020)	(0.15820)
	[-0.22592]	[0.27091]	[-5.91868]	[-0.70393]
LNINR(-1)	-0.015596	-0.005147	-0.014215	0.854237
	(0.02180)	(0.02644)	(0.01690)	(0.05328)
	[-0.71544]	[-0.19469]	[-0.84091]	[16.0339]
LNINR(-2)	0.017575	-0.006628	0.023155	0.105239
	(0.02173)	(0.02636)	(0.01685)	(0.05311)

	[0.80874]	[-0.25149]	[1.37403]	[1.98143]
C	0.000219	0.042115	0.029413	0.144527
	(0.02920)	(0.03541)	(0.02264)	(0.07136)
	[0.00752]	[1.18927]	[1.29899]	[2.02522]
R-squared	0.968995	0.976556	0.997572	0.968773
Adj. R-squared	0.968286	0.976020	0.997516	0.968059
Sum sq. resids	0.781477	1.149448	0.469918	4.667926
S.E. equation	0.047252	0.057307	0.036642	0.115486
F-statistic	1367.316	1822.394	17973.23	1357.282
Log likelihood	590.9168	521.6563	682.2154	270.0991
Akaike AIC	-3.241876	-2.856024	-3.750504	-1.454591
Schwarz SC	-3.144523	-2.758671	-3.653150	-1.357238
Mean dependent	0.453500	0.616826	4.899565	1.484106
S.D. dependent	0.265339	0.370072	0.735227	0.646183
Determinant resid covariance (dof adj.)		1.30E-10		
Determinant resid covariance		1.17E-10		
Log likelihood		2067.233		
Akaike information criterion		-11.31606		
Schwarz criterion		-10.92665		
Number of coefficients		36		

Table 4.4 shows the results of the vector autoregressive model estimation. The result of the model captured the relationship between exchange rate, agricultural prices and interest rate in Nigeria:

$$\mathrm{LNCOBP_t} = 0.063\mathrm{LNCOTP_{t\text{-}1}} - 0.0621\mathrm{LNCOTP_{t\text{-}2}} + 1.090\mathrm{LNCOBP_{t\text{-}1}} - 0.124\mathrm{LNCOBP_{t\text{-}2}} + \\ - 0.022\mathrm{LNEXR_{t\text{-}1}} + 0.021\mathrm{LNEXR_{t\text{-}2}} - 0.005\mathrm{LNINR_{t\text{-}1}} - 0.007\mathrm{LNINR_{t\text{-}2}} + 0.421$$

$$R^2 = 0.9765, AdjR^{-2} = 0.976$$

The result in Table 4.4 shows a coefficient of determination (R^2) of 0.9765. This implied that 97.65% variation in coco bean prices is explained by variations in the independent variables such as cotton price, interest and exchange rate. The remaining 2.35% are variations expounded by other variables not included in the model. In the long-run, cotton price positively and negatively affected coco bean price at it first and second lag though not significant at 5% level of significance. However, coco bean price had significant positive and negative own effect at first and second lag at 5% level of significance. Similarly, exchange rate had insignificant negative and positive effect on coco bean price at it first and second lag at 5% level of significance while, interest rate had insignificant but negative effects on coco bean price at it first and second lag at 5% level of significance.

$$\mathrm{LNCOTP_t} = 1.461\mathrm{LNCOTP_{t\text{-}1}} - 0.507\mathrm{LNCOTP_{t\text{-}2}} + 1.035\mathrm{LNCOBP_{t\text{-}1}} - 0.014\mathrm{LNCOBP_{t\text{-}2}} + \\ + 0.016\mathrm{LNEXR_{t\text{-}1}} - 0.015\mathrm{LNEXR_{t\text{-}2}} - 0.016\mathrm{LNINR_{t\text{-}1}} - 0.018\mathrm{LNINR_{t\text{-}2}} + 0.0002$$

$$R^2 = 0.968, AdjR^{-2} = 0.968$$

The coefficient of determination (R^2) is 0.9689. This implied that 96.89% variation in cotton prices is explained by variations in the independent variables such as cocobean prices, interest and exchange rate. The remaining 3.11% are variations expounded by other variables not included in the model.
In the long-run, cotton price had significant positively and negatively effect on itself at it first and second lag at 5% level of significance. Also, coco bean price, and exchange rate had positively and negatively effects on cotton price on at it first and second lag respectively though not significant at 5% level of significance. Similarly, interest rate affected cotton price negatively at first and second lag and also not significant at 5% level of significance.

$$\begin{aligned} \text{LNEXR} = {} & \text{-}0.043\text{LNCOTP}_{t\text{-}1} + 0.031\text{LNCOTP}_{t\text{-}2} - 0.033\text{LNCOBP}_{t\text{-}1} + 0.055\text{LNCOBP}_{t\text{-}2} + \\ & + 1.288\text{LNEXR}_{t\text{-}1} - 0.297\text{LNEXR}_{t\text{-}2} - 0.014\text{LNINR}_{t\text{-}1} + 0.023\text{LNINR}_{t\text{-}2} + 0.029 \end{aligned}$$

$$R^2 = 0.997, AdjR^{-2} = 0.997$$

The coefficient of determination (R^2) is 0.997. This implied that 99.7% variation in exchange rate is explained by variations in agricultural Prices (cotton and coco bean price) and interest rate. The remaining 3% are variations expounded by other variables not included in the model. In the long-run, exchange rate had significant positive and negative own effects at its first and second lag at 5% level of significance. Also, exchange rate is negatively affected by coco bean price and interest rate at first and second lag. It is however not significant at 5% level of significance.

The result of the model which captured the relationship between interest rate , exchange rate and agricultural Prices in Nigeria is represented as thus :

$$\begin{aligned} \text{LNINR} = {} & \text{-}0.124\text{LNCOTP}_{t\text{-}1} + 0.1371\text{LNCOTP}_{t\text{-}2} + 0.032\text{LNCOBP}_{t\text{-}1} - 0.060\text{LNCOBP}_{t\text{-}2} + \\ & + 0.095\text{LNEXR}_{t\text{-}1} - 0.111\text{LNEXR}_{t\text{-}2} + 0.854\text{LNINR}_{t\text{-}1} + 0.105\text{LNINR}_{t\text{-}2} + 0.145 \end{aligned}$$

$$R^2 = 0.968, AdjR^{-2} = 0.968$$

The coefficient of determination (R^2) is 0.968. This implied that 96.8% variation in interest rate is explained by variations in agricultural prices such as cotton and coco bean price, and exchange rate. The remaining 3.2% are variations explained by other variables not included in the model.
In the long-run, interest rate had significant positive and negative own at 5% level of significance. Also, cotton prices lag and exchange rate lag 1 & 2 had negative influence on interest rate.
Figure 4.9 is the graph of inverse roots of the characteristic AR polynomial. It satisfies the stability condition of the diagnostic test. The graph shows that all roots lie inside the unit root circle and the detailed result shows that all modulus were less than one. The Inverse roots of a characteristic polynomial satisfy the stability condition (of the diagnostic test) since no root lied outside the unit root circle. Therefore, the estimated VAR is stable. From the result obtained, the model had no serial correlation at lag 1 and lag 2. This is because at lag 1, Rao F-stat equal to 1.579 and the probability value of 0.068 is greater than the 5% level of significance. Also at lag 2, Rao F-stat equal to 11.488836 and the p-value of 0.0566 is greater than 5% level of significance.
Table 4.7 shows the residual heteroskedasticity tests. The result also shows that the residuals were multivariate normal on the interest rate, exchange rate and Agricultural prices (cotton and coco beans) components. The post estimation test carried out on heteroscedasticity revealed that the

value of chi-square (262.8263) and a probability value less than 5% which confirmed the presence of heteroscedasticity

The result of variance decomposition test for interest rate, exchange rate and Agricultural prices (cotton and coco beans) components showed that in the long run, 100% forecast variance in cotton prices is self-explained. Interest rate, exchange rate and Agricultural prices (cotton and coco beans) components and cotton prices however, shows very weak influence in predicting cotton prices, therefore they are strongly exogenous. As we move into the future cotton prices decreases while interest rate, exchange rate and coco bean prices increases but were not strongly exogenous as the percentage forecast variance of interest rate was 97.54% in the long run while the percentage forecast variance of cocoa Bean price, exchange rate and interest rate were 2.394%, 0.026% and 0.0443% respectively. Also**,** the percentage of the forecast error variance shows that in the long run 99.78% forecast variance in Cocoa Bean Price is self-explained. Interest rate, exchange rate and Agricultural prices (cotton and coco beans) components and Cocoa Bean Price however, shows very weak influence in predicting cotton prices, therefore they are strongly exogenous. As we move into the future Cocoa Bean Price decreases while cotton prices , interest rate, and exchange rate increases but were not strongly exogenous as the percentage forecast variance of interest rate was 97.4% in the long run while the percentage forecast variance of cotton prices , interest rate and exchange rate were 1.536%, 1.0002% and 0.048% respectively. Similarly**,** the percentage of the forecast error variance in the long run, 99.82% forecast variance in exchange rate is self-explained. Interest rate, exchange rate and Agricultural prices (cotton and coco beans) components and exchange rate however, shows very weak influence in predicting cotton prices, therefore they are strongly exogenous. As we move into the future exchange rate decreases while interest rate, cotton prices, coco bean prices and interest rate increases but were not strongly exogenous as the percentage forecast variance of exchange rate was 94.86% in the long run while the percentage forecast variance of cotton prices , coco bean prices and interest rate were 3.49%, 11.05% and 0.605% respectively. Also, the percentage of the forecast error variance shows that in the long run 99.10% forecast variance in exchange rate is self-explained. Interest rate, exchange rate and Agricultural prices (cotton and coco beans) components and exchange rate however, shows very weak influence in predicting cotton prices, therefore they are strongly exogenous. As we move into the future exchange rate decreases while interest rate, cotton prices, coco bean prices and interest rate increases but were not strongly exogenous as the percentage forecast variance of exchange rate was 94.86% in the long run while the percentage forecast variance of cotton prices , coco bean prices and interest rate were 3.49%, 11.05% and 0.605% respectively. From the results obtained increase peaks in period one of cotton prices effects cocoa bean Prices', 'when the maximum impact is experienced' effect lasts vice versa. Similarly, for exchange rate to increase peaks in period one" 'when the maximum impact is experienced last effect cotton prices

4.3 Post Estimation Test on the Model

Post estimation test particularly **VAR Model Stability Tests (AR Root Circle),** serial correlation, normality of the residuals and heteroscedasticity were conducted on the Vector Autoregressive (VAR) Model and the results summarized in Table 4.9 as shown below.

4.3 .1 VAR Model Stability Tests (AR Root Circle)

The VAR Model Stability Tests (AR Root Circle) is done to determine how stable is the estimated model. The Model Stability is confirmed if all the points fall inside AR Root Circle. The is further ascertain in the Table 4.7 shown below

Figure 4.9: Graph of inverse roots of the characteristic AR polynomial.

Table 4.5: VAR Model Stability Tests (AR Root Table)

Root	Modulus
0.988598	0.988598
0.965180 - 0.007966i	0.965213
0.965180 + 0.007966i	0.965213
0.892945	0.892945
0.569738	0.569738
0.301694	0.301694
0.122745	0.122745
-0.108585	0.108585

No root lies outside the unit circle.
VAR satisfies the stability condition.

Table 4.6: Summary of Post Estimation Test Result on the VAR Model

S/n	Type of Test Conducted	Null Hypothesis.	Test Statistics	Prob. Value	Decision	Conclusion
1	Residual serial correlation LM test	No serial correlation at lag 1	Rao F-stat (1.579379)	0.0675	Cannot Reject	No serial correlation at lag 1
2	Residual serial correlation LM test	No serial correlation at lag 2	Rao F-stat (1.488836)	0.0960	Cannot Reject	No serial correlation at lag 2

3	Joint Jarque-Bera residual Normality test	Residual is multivariate normal	Jarque-Bera (6244.956)	0.0000	Reject	Multivariate normal
4	Residual Heteroskedasticity test	Residual is Heteroskedastic	Chi-Sq (262.8263)	0.0000	Reject	Residual is Heteroscedastic

The post estimation test conducted on the Vector Autoregressive (VAR) revealed the Stability of the VAR Model, there was absence of serial correlation and the normality test confirmed that the residual is multivariate normal. However, heteroscedasticity was confirmed.

6.1 Conclusion

It is thus concluded the own effects were the most significant determinants. The variance decomposition results confirmed that the variables show very weak influence on the dependent variables

6.2 Recommendations

The recommendations based on the results of the study were: haven seen the significance of own effects, there is the need for the inclusion of the lags of the response variable among the explanatory variables, particularly for multivariate models. There is also the need for policies, which will stabilize exchange rate and interest rate and by extension stabilize agricultural prices in Nigeria. Ther is also need for direct policies to significantly reduce and regulate agricultural prices in Nigeria.

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