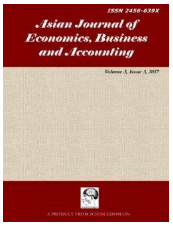

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On Agricultural Performance amidst Macroeconomic Instability in Nigeria; Autoregressive Distributed Lagged Modelling (2010Q1-2017Q4)

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Authors' contributions

This work was carried out in collaboration between the two authors. Author TLG designed the study, wrote the first draft of the manuscript, performed the statistical analysis and results interpretation author OAI managed the literature searches and the protocol. Both authors read and approved the final manuscript.

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ABSTRACT

The interaction among macroeconomic indicators causes shock among themselves and by extension shocks on other macroeconomic variables including agricultural performance. This study investigated agricultural performance amidst macroeconomic instability in Nigeria. Data on the study variables spanning from first quarter of 2010 to the fourth quarter of 2017 was sourced from the Statistical Bulletin of the Central Bank of Nigeria. Diagnostic checks revealed that the variables were integrated of order I(0) and I(1) hence the used of the Autoregressive Distributed Lagged model The cointegration bounds test indicated a long run cointegration consequently the ECM which results showed a correct sign, significant effect and 40.1% speed of adjustment. Empirical, results also indicated that; 91.3% variation in agricultural sector performance was explained by the adopted explanatory variables of the parsimonious model (R^2 =0.913). Particularly, changes in the fourth lag of agricultural sector performance, current period exchange rate, the first, second and third lag of exchange rate were significant determinant of agricultural performance within the period under review.

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1. INTRODUCTION

Tuaneh and Wiri [1] reported that agriculture was the mainstay of the Nigerian economy until the discovery of oil in Nigeria in 1956 and its export in 1958. Agriculture has the inert potentials of; expanding the productive capacities of the agro-allied industries through the provision of industrial raw materials, generation of foreign earnings through increasing the export base of the economy, and provision of employment for a larger percentage of its citizenry than any other sector of the economy. Other important benefits of the agricultural sector to Nigeria's economy include; the provision of food, and contribution to the gross domestic product (GDP).

Ghosh [2] described Agricultural performance as a measure of the changes (positive or negative) in the principal variables that constitute the agricultural sector. Agricultural productivity on the other hand is the measure of the ratio of total farm output to total farm input. The study has adopted agriculture's contribution to gross domestic product as a measure of performance so that the entire scenario of agriculture is included.

Acknowledging that the potential distribution of the effects of non performing agriculture is capable of truncating sectors, regions and national development, successive administrations in the Federal Republic of Nigeria had formulated and implemented various policies and programmes with the target of reviving agriculture considering its enormous significance [3]. Oni et al. [4] noted the dismal performance of the agricultural sector in terms of its contribution to Nigeria's yearly total revenue in the last three decades prompted the government to initiate several agricultural schemes and programs to enhance agricultural productivity in Nigeria, which include: The River Basin Development Authorities, the National Accelerated Food Production Project, the Agricultural Development Project, Operation Feed the Nation, the Green Revolution, the National Directorate of Food, Roads and Rural Infrastructure, the Agricultural Credit Guarantee Scheme Fund, the National Special Programme for Food Security, Root and Tuber Expansion Project, and the National Fadama I and II program. In spite of all these, agriculture's contribution to GDP is still poor, this study consequently seeks to investigate the effects of macroeconomic instability on agricultural performance.

Nigeria like other developing countries traditionally experienced macroeconomic instability resulting from shocks on themselves or other macroeconomic indicators. Tuaneh [5] described economic stability as a major macroeconomic goal for nations all over the world, 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 behaviour of macroeconomic stability indicators particularly their; evolution, interaction and interdependence, obviously cause shocks among themselves. This by extension affects other variables including agricultural performance.

An economy is described as stable when fluctuations in key macroeconomic variables are not excessive. An economy is therefore stable if it shows a fairly constant growth rate, low and fairly stable inflation, low and fairly stable interest rate, adequate and stable exchange rate [5]. The World Bank describes a macroeconomic framework as stable "when the inflation rate is low and predictable, real interest rates are appropriate, the real exchange rate is competitive and predictable and the balance of payments situation is perceived as viable. The term economic stability is described a national economy that has minimized vulnerability to external shocks, which in turn increases its prospects for sustained growth. Macroeconomic stability acts as a buffer against currency and interest fluctuations in the global market. It is however, a necessary, but insufficient requirement for growth. Such that an exposure to currency fluctuations, large debt burdens, and unmanaged inflation can cause economic crises and collapse in GDP (see [6]. Tuaneh [5] conceptualized macroeconomic instability as a volatile macroeconomic condition with a phenomenon that makes the domestic macroeconomic environment less predictable. This is of concern because unpredictability hampers resource allocation decisions and investment. This study identified exchange rates, inflation rate, interest rates, and implicit price deflator as the macroeconomic stability indicator.

2. LITERATURE REVIEW

Macroeconomic policies consists of the fiscal, monetary, exchange rate regimes and trade policies, that determine production outcomes in the real sectors and other sectors including the agricultural sector. Undesirably, macroeconomic policy outcomes differ depending on the policy instruments employed, policy objectives and the operating environment. a low and predictable inflation rate; an appropriate real interest rate; a competitive and predictable real exchange rate, a stable and sustainable fiscal policy, and a balance of payment that is regarded as viable are necessary for economic advancement. The study emphasized on the first three and as the affect the performance of Agriculture.

Empirically, a lot of studies have highlighted the significance of the agricultural sector, others have studied the relationships between macroeconomic variables and agricultural sector.

Several authors; [7,8,9,10], reported the influence of macroeconomic variables fluctuations on agricultural productivity.

Studying the causality between exports and Agricultural output in Pakistan using ARDL [11] found bi-directional Granger-causality relationship between total exports and agricultural GDP.

Sunday et al. [9] adopted the Error Correction model to investigate the causality between Agricultural productivity and macro-economic variable fluctuation in Nigeria. They found out a unidirectional causality from macroeconomic variables to agricultural productivity. This means that total variation in agricultural productivity are induced by changes in macroeconomic variables

Udensi et al. [12] studied the determinants of macroeconomic variables that affect agricultural production in Nigeria between 1977 and 2007. The study found out that total government expenditure on agriculture, nominal exchange rate, interest rate and total credit accessed by farmers from commercial banks were all positively related with the index of agriculture production

Patrick and Prudence [13] investigated which macro factors influence agricultural production in Ghana? modelling with the Cob-Douglas production function and using the ordinary least squares regression technique of statistical analysis. They found out that labour force, real exchange rate, and real GDP per capita were key macro economic factors that influence agricultural production in Ghana

Olarinde and Abdulahi [14] studied Macroeconomic Policy and Agricultural Output in Nigeria: Implications for Food Security. They adopted the Vector Error Correction Model and found out that in the long run, agricultural output was responsive to changes in government spending, agricultural credit, inflation rate, interest rate and exchange rate. The results of impulse response functions suggested that one standard deviation innovation on government expenditure and interest rate reduces the agricultural output thus threatening food security in the short, medium and long term. While results of the variance decomposition indicated that, a significant variation in Nigeria's agricultural food output was due to changes in exchange rate and government expenditure

Oyetade et al. [15] examine the relationship between macro economic factors and agricultural sector in Nigeria. They adopted the Vector error correction mechanism and found out that exchange rate, inflation rate and unemployment were not significant determinant of agricultural output, however, commercial bank loan and interest rate were significant determinant

3. METHODOLOGY

The research design, data collection method and sources, description of variables in the model, data analysis techniques and model specification are presented in this section.

3.1 Research Design

Research design is the overall plan and methods that guide the data collection and analyses and result interpretation. The framework adopted in this study is a quasi-experimental design. The quasi experimental design is a framework that guides the researcher in the process of data collection, analyses and interpretation with a view to arriving at a conclusion. This design is chosen because this research work seeks to explore the effects of the explanatory variables on the dependent variables within a specified period of time (2010Q1-2017Q4). The reason for adopting this period is availability of data and that it is also wide enough to permit good deductions.

3.2 Data Analysis Techniques

The study adopted the Autoregressive Distributed Lag (ARDL) testing approach, developed by Pesaran et al. [16] to examine the long-run relationship between the variables. This approach is adopted because it can be used without considering the order of integration of variables i.e. it can be used with a mixture of variables integrated at I(0), and I(1), or variables integrated at first difference I(I).

3.3 Model Specification

Model specifies that Agricultural performance (proxy by Agricultural Sector Gross Domestic Product) depends on Macroeconomic stability indicators (Implicit Price Deflator, Exchange Rate and Interest Rate,

$$AGDP_t = f(IPD_t, EXR_t, INR_t) \quad (1)$$

$$GDP_t = \lambda_0 + \lambda_1 IPD_t + \lambda_2 EXR_t + \lambda_3 INR_t + U_{t1} \quad (2)$$

The configuration of the ARDL models using the symbols for underlying variables as stated in equations (1), and (2) are provided as follows:

$$Y_t = \lambda_0 + \sum_{i=1}^{p} \lambda_1 Y_{t-i} + \sum_{i=0}^{q} \beta_1 X_{t-i} + U_t \quad (3)$$

$$AGDP_t = \lambda_0 + \sum_{i=1}^{p} \lambda_1 AGDP_{t-i} + \sum_{i=0}^{q} \lambda_1 IPD_{t-i} + \sum_{i=0}^{q} \lambda_1 EXR_{t-i} + \sum_{i=0}^{q} \lambda_1 INR_{t-i} + U_t \quad (4)$$

3.4 Eviews Specification

ARDL AGDP IPD EXR INR or (5)

AGDP = C(1)*AGDP(-1) + C(2)*AGDP(-2) + C(3)*AGDP(-3) + C(4)*AGDP(-4) + C(5)*IPD + C(6)*EXR + C(7)*EXR(-1) + C(8)*EXR(-2) + C(9)*EXR(-3) + C(10)*EXR(-4) + C(11)*INR + (12)*INR(-1) + C(13)*INR(-2) + C(14) (6)

Where:

Y_t = Dependent Variable
X_{ts} = Independent Variables
AGDP = Agricultural Sector Gross Domestic Product
IPD = Implicit Price Deflator
EXR = Exchange Rate
INR = Interest Rate
μ = Disturbance Term
p = Number of lag of the dependent variable
q = Number of lag of the independent variable
λ_0, = Constant term
B_1 = long run coefficients of the explanatory variables.
λ_1- λ_3 = Short run dynamic coefficients of the regressors.
μ_{1t}, = White noise capturing the unobserved characteristics.

3.5 Error Correction Model

The Error Correction Mechanism (ECM) helps to ascertain the short run dynamic to long run equilibrium relationship and as well measure the speed of adjustment from the short run equilibrium to the long run equilibrium state. The greater the co-efficient of the error correction term, the higher the speed of adjustment of the model from the short-run to the long-run. The ECM equation is presented as follows:

$$\Delta AGDP_t = \lambda_0 + \sum_{i=1}^{p} \lambda_1 \Delta AGDP_{t-i} + \sum_{i=0}^{q} \lambda_1 \Delta IPD_{t-i} + \sum_{i=0}^{q} \lambda_1 \Delta EXR_{t-i} + \sum_{i=0}^{q} \lambda_1 \Delta INR_{t-i} + B_1 ECM_{t-1} + U_t \quad (7)$$

This model includes the first differences of all the variables, the long-run and short-run dynamics is also captured. All these differences are lagged p and q number of times, for the depended and independent variables respectively. These first differences represent the short-run dynamics of AGDP (the dependent variable). The parameters represent how changes in the explanatory variables lead to changes in the dependent variable. To control for the fact that there is a long-run relationship among the variable we have included the variable ECM(-1). This variable acts as a control variable, in the sense that it controls the movements in ΔAGD_t over time.

3.6 Unit Root Test

Time series data are often non stationary, however, the Least Squares estimators assume stationarity of the regressors and the regress and Etuk [17] in Tuaneh and Essi [18]. Tuaneh and Essi [18] noted that the Stationarity of a series can strongly influence its behaviour, consequently, the use of non-stationary data can lead to spurious regression.

It is therefore necessary to examine whether the time series in one study is stationary or not. This is because when non-stationary variables are included in a regression model, the outcome is a spurious regression result. Also, statistical test of the coefficient emanating from such regression may be inconsistent, biased and misleading. The unit root test therefore is a standard procedure for investigating the Stationarity properties of a time series variables. Time series data on all variables included in the model are required to be stationary in order to carry out joint significant test on the lags of the variables. Gujarati [19] explained that the various methods often used to test for stationarity; Augumented Dicky Fuller, the Phillips-Perron test, and the graphical method (the correlogram). The study however adopted the; Augmented Dickey Fuller and Phillips-Perron Unit Root Test.

Augmented Dickey-Fuller (ADF) and the Phillips-Perron unit root test were employed to determine the order of integration of the series (i.e. to investigate the stationary status of each variable). The test statistic is t. The following unit root tests regression equations were used for the first difference of the variables;

$$\Delta AGDP_t = \tau_{11} + \tau_{12} \sum_{t-1}^{k} p_i \, \Delta AGDP_{t-1} + \mu_{t1} \quad (8)$$

$$\Delta IPD_t = \tau_{21} + \tau_{22} \sum_{t-1}^{k} p_i \, \Delta IPD_{t-1} + \mu_{t2} \quad (9)$$

$$\Delta EXR_t = \tau_{31} + \tau_{32} \sum_{t-1}^{k} p_i \, \Delta EXR_{t-1} + \mu_{t3} \quad (10)$$

$$\Delta ITR_t = \tau_{41} + \tau_{42} \sum_{t-1}^{k} p_i \, \Delta ITR_{t-1} + \mu_{t4} \quad (11)$$

Where:

Δ is the difference operator, U_t = random terms, t = time, k = number of lagged differences. Δ = first difference ρ_i= coefficient of the preceding observation, $(_{t-1})$ is the immediate prior observation, k is the number of lags, while τ_{11}-τ_{42} are the parameters to be determined.

The null hypothesis is that the series has a unit root, if 'τ' is found to be more negative and statistically significant, we compare the *t*-statistic value of the parameter, with the critical value tabulated in MacKinnon, 1991, We reject the null and conclude that the series do not have a unit root at levels

3.7 ARDL Bound Test for Cointegration

The bound test approach to co-integration, proposed by Pesaran et al. [16] was adopted in this study to determine whether the underlying time series variables had long run relationship. The null hypothesis of no cointegration is tested against the alternative hypothesis of cointegration. The general configuration of the ARDL based cointegration model is provided as:

$$Y_t = \alpha_0 + \sum_{i=1}^{k} \beta_1 x_{t-i} + \varepsilon_t \quad (12)$$

Where

y_t =the dependent variable
x_t = vector of the regressors
α_0 =constant term,
I = number of lags
ε_t = the random disturbance term

Prior to the estimation of the cointegration among the series using ARDL bounds testing procedure, the order of integration of each of the variables in the model is determined to ensure that none of the underlying series is integrated of order two I(2). This ARDL based bounds test procedure approach is based on the assumption that the underlying time series variables are either I(1), I(0) or combinations of I(0) and I(1).

3.8 Second Order Tests

3.8.1 Normality test

The normal distribution of the residuals in the estimated model was examined using the Jarque-Bera test for normal distribution. Specifically, the null hypothesis of normal distribution of the errors was tested against the alternative hypothesis that the errors are not normally distributed at the conventional 5 percent level. If the errors are normally distributed, the corresponding probability value of Jarque-Bera statistics shall exceed 0.05 meaning that at 5 percent level, the null hypothesis of normal distribution cannot be rejected and vice versa. The skewness and Kurtosis are measure in the Jarque –Bera test procedure using the formular below:

$JB = \left[\frac{T}{6} sk^2 + \frac{T}{24} k^2 \right]$ K is distributed as $= N\left[0, \frac{24}{T}\right]$

Where

n or T = number of observations
S = Skewness
K = Kurtosis

This test statistic has a chi-square distribution with two degrees of freedom. The linear combination has a chi-square distribution).

3.8.2 Serial correlation test

The test for serial correlation is important in econometrics analysis as it verifies whether or not the error term is serially correlated i.e. whether the value of the error term in a given period depends on its previous value. The presence of auto correction in the cointegrration regression model is examined using Durbin Watson (D.W). In this regard, the Breush-Godfrey LM test for serial correlation proposed by Breusch [20] and Godfrey [21] is applied given the dynamic nature of ARDL:

$$\dot{\theta}_t = \alpha + \delta_1 \dot{\theta}_{t-1} + \delta_2 \dot{\theta}_{t-2} + \cdots \beta^i X_{t+} U_t \qquad (13)$$

where *ut* is the residual from this OLS regression and *X*t are the explanatory variables used in the regression model from which *et* are taken.

3.8.3 Heteroskedasticity test

This test is applied to determine whether the variance of the residual term is constant or not. This is necessary in order to avoid making erroneous conclusions regarding 't' and 'F' test. The test is carried out using the Autoregressive Conditional Heteroskedasticity (ARCH) test attributed to Engle [22] to test the null hypothesis that the errors are homoschedastic.

A version of the test for autocorrelation in the residual process is the ARCH test (AutoRegressive Conditional Heteroscedasticity). This test works like the one above. The difference is that the regression is performed with squared residuals. A test for ARCH of order *p* is performed by running the regression,

$$\dot{\theta}_t^{\,2} = \alpha + \delta_1 \dot{\theta}^2{}_{t-i} + \delta_2 \dot{\theta}^2{}_{t-2} + \cdots \beta^i X_{t+} U_t \qquad (14)$$

3.8.4 Stability test

The stability of our estimates is examined using the Cumulative Sum (CUSUM) test of the recursive residual. The CUSUM test is used to detect systematic changes in the regression coefficients i.e. examines the stability of the model over the sampled period. Pesaran et al. [16] advocated graphical illustration of the stability of the coefficients of the regressors over the sampled period.

4. RESULTS

4.1 Descriptive Statistics on Variables

The descriptive statistics of the study variables as shown in Table 1 Agricultural Sector Gross Domestic Product ($AGDP_t$) had an average of 3691.4 billion Naira at a standard deviation of 822.4 billion Naira, the highest and lowest levels within the period of the study were 518.5 billion and 2053.8 billion Naira obtained in the third quarter of 2017 and first quarter of 2011 respectively. Implicit Price Deflator (IPD_t) showed an average value of 4,448.9 with a standard deviation of 285.8, it was highest in the third quarter of 2017 and lowest in the first quarter of 2011 at 5028.3 and 3877.04 respectively. Exchange rate and interest rates showed an average of 173.8% and 14.4%, respectively. The probability of Jarque-Bera on all variables as shown in the above table were greater than 5% consequently, the data on the variables followed a normal distribution.

Table 1. Descriptive Statistics on the study variables

Statistics	AGDP	IPD	EXR	INR
Mean	3691.434	4448.908	173.8838	14.48656
Median	3647.950	4364.565	167.9700	15.02000
Maximum	5189.500	5028.320	196.9900	16.56000
Minimum	2053.800	3877.040	152.4900	10.93000
Std. Dev.	822.4427	285.8636	17.31271	1.246491
Skewness	0.030905	0.582850	0.318515	-1.118005
Kurtosis	2.133596	2.959798	1.389461	3.902833
Jarque-Bera	1.005969	1.813962	3.999525	7.753125
Probability	0.604723	0.403741	0.135367	0.020722
Sum	118125.9	142365.1	5564.280	463.5700
Sum Sq. Dev.	20968774	2533258.	9291.632	48.16592
Observations	32	32	32	32

4.1.1 Time plots on agricultural sector GDP and implicit price deflator

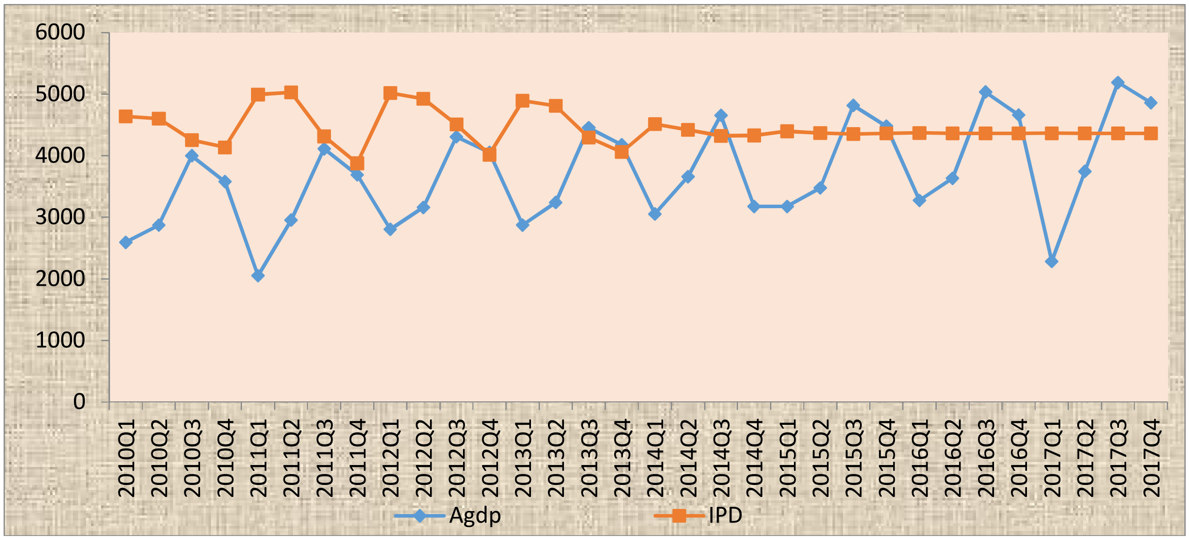

Fig. 1. Time plots on agricultural sector GDP and implicit price deflator

4.1.2 Time plots on interest rate, and implicit price deflator

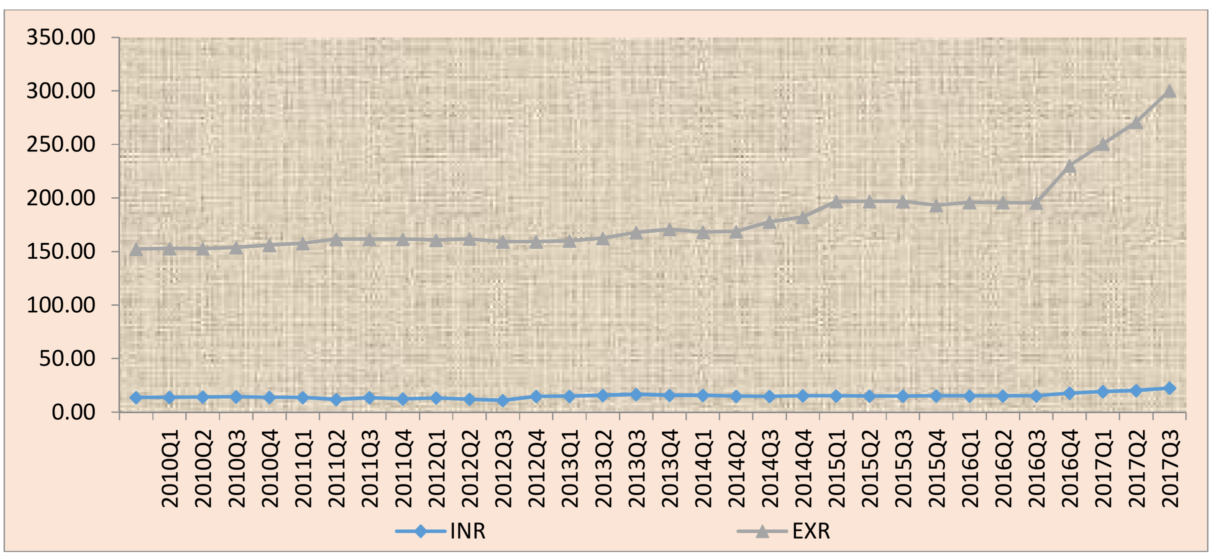

Fig. 2. Time plots on interest rate and exchange rate

4.2 Diagnostic Analysis

4.2.1 The unit root test (Augmented Dickey-fuller (ADF) and Phillip-perron (PP)

The study variables involved time series data as earlier indicated, it is consequently necessary to established that the variables concerned are stationary. Data on each variable were therefore tested for stationarity so as to avoid the problem of spurious regression. For this study, the Augmented Dickey-Fuller (ADF) and Phillip-Perron test (PP) were used. Both tests tested the null hypothesis of a unit root. The null hypothesis of a unit root is rejected in favour of the stationary alternative in each case if the test statistic is more negative than the critical value. A rejection of the null hypothesis means that the series do not have a unit root.

Trend plots on all variables of the study

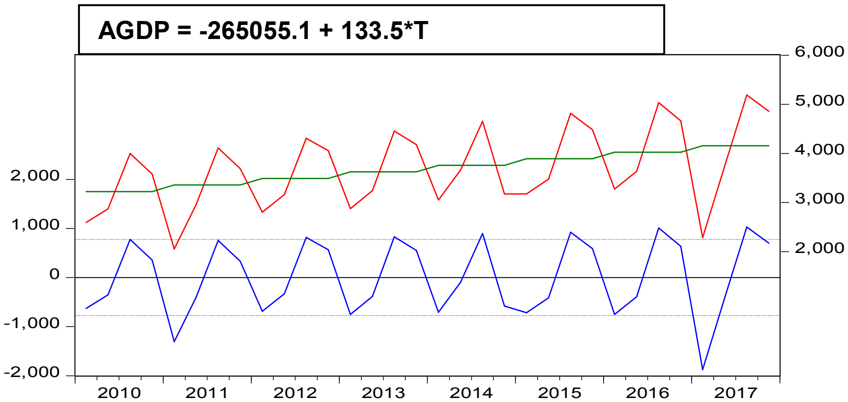

Fig. 3. Trend plot showing actual, fitted and residual of GDP

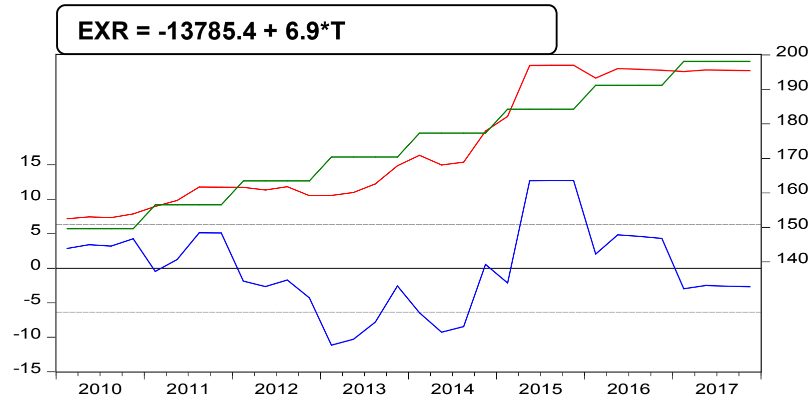

Fig. 4. Trend plot showing actual, fitted and residual of EXR

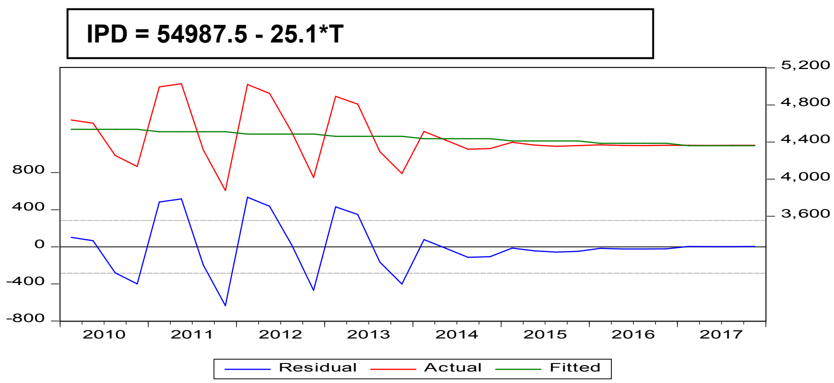

Fig. 5. Trend plot showing actual, fitted and residual of IPD

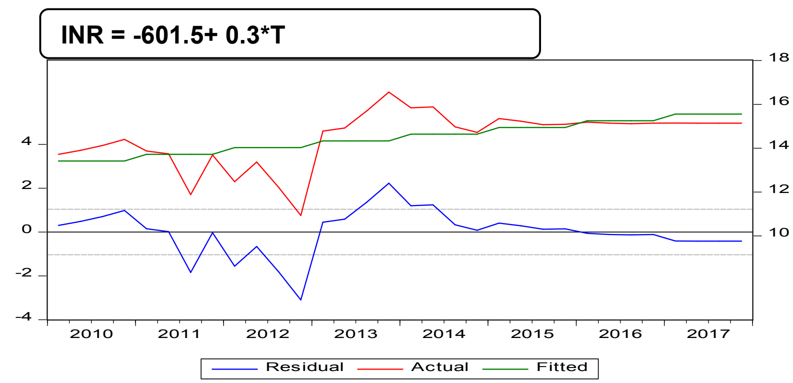

Fig. 6. Trend plot showing actual, fitted and residual of INR

The Augmented Dickey-Fuller and Phillips-Perron unit root results in Table 2 show that only the indicator of agricultural performance (agricultural sector gross domestic product) was stationary at levels, the implicit price deflator, exchange rate and interest rate were had unit root at levels but were stationary at first difference. It is worthy to note that both Augmented Dickey-Fuller and Phillips-Perron Test agreed on all variables except implicit price deflator that was 1(0) from ADF and 1(1) from PP, however the researcher concluded 1(1).

4.2.2 Cointegration test

Performing the cointegration test is necessary to establish the a long run relationship, however, since the unit root test showed that the series were integrated of different order, the Johansen technique of cointegration was no longer valid and could not be applied. The bounds test proposed by Pesaran, Shin and Smith was appropriate, it was therefore necessary to conduct the autoregressive distributed lagged long run form bounds test. The Akaike Information Criteria (AIC) selected ARDL(1, 1, 0, 0) model. The results as shown in Table 3 indicates that the F-value (7.0081) was higher than critical values for the upper bound, hence the null hypothesis of no cointegration is rejected. The results in Table 3 also showed that the t-value (-4.5449) was more negative than critical values for the upper bound hence the null hypothesis of no cointegration is rejected.

The long run Autoregressive Distributed Lagged Over Parameterized Model in Table 4 above showed that 78.5% of the regressors were not significant determinants of response. This implied that only 21.5% were significant. It obvious that some variables were redundant therefore we carried out the Wald test and the likelihood ratio test for coefficient restriction and redundant variables respectively. The Wald test for coefficient restriction as shown in Table 5 indicates that the probability value of F-statistics is 0.708 greater than 0.05 level of significance, hence we cannot reject the null hypothesis that the coefficients are equal to zero.

We can then proceed to estimate the parsimonious model ie model without the restricted variables whose coefficients were equal to zero. Before that, the researchers also subjected the over parameterized model to the likelihood ratio test and found the adjusted R-squared to be 88.2%, t6 this is greater than the 84.4% adjusted R-square from the over parameterized model hence the parsimonious model is preferred.

The result of the bounds test in Table 3 indicated the presence of cointegration (long run relationship). This implied that the series are related and can combine in linear fashion, that is to say that shocks in the short run can affect individual movement which would result to convergence in the long run. Consequently, it was necessary to conduct an ECM analysis to correct the short run adjustment dynamics.

The R-squared of 0.913 implied that the regressors explained 91.3% variations in Agricultural performance. The Durbin Watson statistics of 2.2 indicated absence of autocorrelation. All the regressors significantly explained the response (pv < 0.05 level of significance) except the second lag of exchange rate. The ECM is correctly signed and also significant. Its coefficient of -0.401 indicates 40.1% speed of adjustment from the previous quarter to long run equilibrium.

In order to verify the robustness of the results, diagnostic checking of the estimated model was carried out in terms of conventional multivariate residual-based tests for normality, serial correlation, heteroscedasticity and stability and results from Table 6 indicates that the model also passes the Jarque-Bera normality test at 5% (pv=0.323 > 0.05) therefore we cannot reject the null hypothesis of normality suggesting that the residual was normally distributed in models, see Fig 7. The Lagrange Multiplier (LM) test for serial correlation (pv= 0.565 > 0.05) therefore we cannot reject the null hypothesis of no serial correlation, indicating the absence of serial correlation. ARCH Chi-square test for heteroskedasticity (pv= 0.950 > 0.05) as a result we cannot reject the null hypothesis of homoschedasticity indicating the absence of heteroskedasticity.

The CUSUM test of stability as shown in Fig. 8 shows that it lies within the 5% boundaries, therefore the model was stable. The CUSUM of square test showed that the model is stable it lies within the 5% boundaries.

Table 2. Unit root test result [Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP)]

Variables	Levels constant, linear trend		1st difference constant, linear trend		Order of integration
	ADF	**PP**	**ADT**	**PP**	
Agric. Sector (AGDP)	-13.196(0.000)	-7.390(0.000)			1(0)
Implicit Price Deflator (IPD_t)	-3.317(0.840)	-6.414(0.000)	-12.920(0.000)	-9.960 (0.000)	1(1)
Exchange Rate (EXR_t)	-1.606(0.767)	-1.606(767)	-4.309(0.009)	-4.278 (0.010)	1(1)
Interest Rate (INR_t)	-2.896(0.177)	-2.907(0.174)	-7.394 (0.000)	-7.406 (0.000)	1(1)

Test critical values:	***%level***	***PP***	***ADF***
	1% level	-4.284580	-4.296729
	5% level	-3.562882	-3.568379
	10%level	-3.215267	-3.218382

Table 3. Bounce test for cointegration (Unrestricted constant and no trend model)

Dependent variable	Test statistics	Significant value	1(0) bound	1(1) bound	Conclusion	What next
AGDP	F- =7.0081	10%	2.72	3.77	Reject the null.	Estimate ARDL (Error Correction Model)
		5%	3.23	4.35	There is cointegration	
		2.5%	3.69	4.89		
		1%	4.29	5.61		
	t-= -4.5449	10%	-2.57	-3.46	Reject the null.	Estimate ARDL (Error Correction Model)
		5%	-2.86	-3.78	There is cointegration	
		2.5%	-3.13	-4.05		
		1%	-3.43	-4.37		

Table 4. Results of the long run ARDL over parameterized model

Over parameterized model		
Variable	**Coefficient**	**Prob.***
AGDP(-1)	-0.134229	0.5319
AGDP(-2)	-0.232398	0.3661
AGDP(-3)	-0.049842	0.8228
AGDP(-4)	0.843687	0.0104
IPD	-0.257161	0.4239
EXR	-72.16930	0.0037
EXR(-1)	71.36803	0.0599
EXR(-2)	75.28452	0.0817
EXR(-3)	-92.90504	0.0209
EXR(-4)	23.62545	0.2510
INR	44.62248	0.5994
INR(-1)	71.36811	0.3980
INR(-2)	-111.9436	0.1734
C	2424.153	0.2453
R-squared	0.919257	
Adjusted R-squared	0.844282	
Durbin-Watson stat	1.609633	

$$AGDP_t = -0.13*AGDP_t(-1) - 0.23*AGDP_t(-2) - 0.04*AGDP_t(-3) + 0.84*AGDP_t(-4) - 0.25*IPD_t - 72.16*EXR_t + 71.36*EXR_t(-1) + 75.28*EXR_t(-2) - 92.90*EXR_t(-3) + 23.62*EXR_t(-4) + 44.62*INR_t + 71.36*INR_t(-1) - 111.94*INR_t(-2) + 2424.15$$

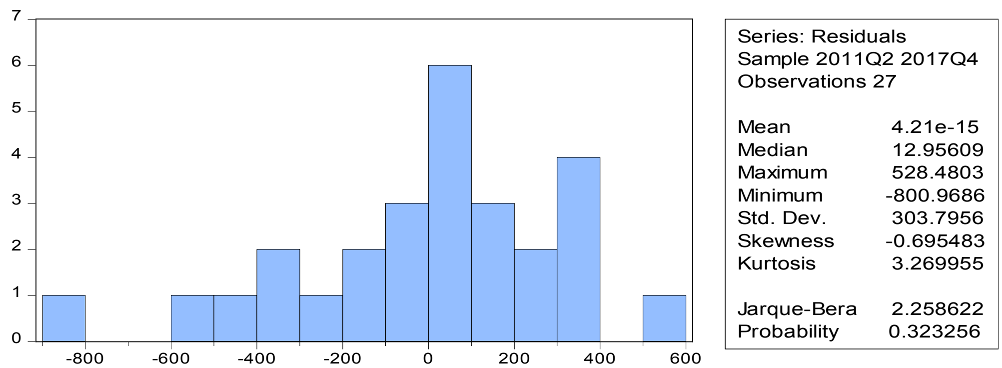

Fig. 7. Jarque-Bera result of normality test

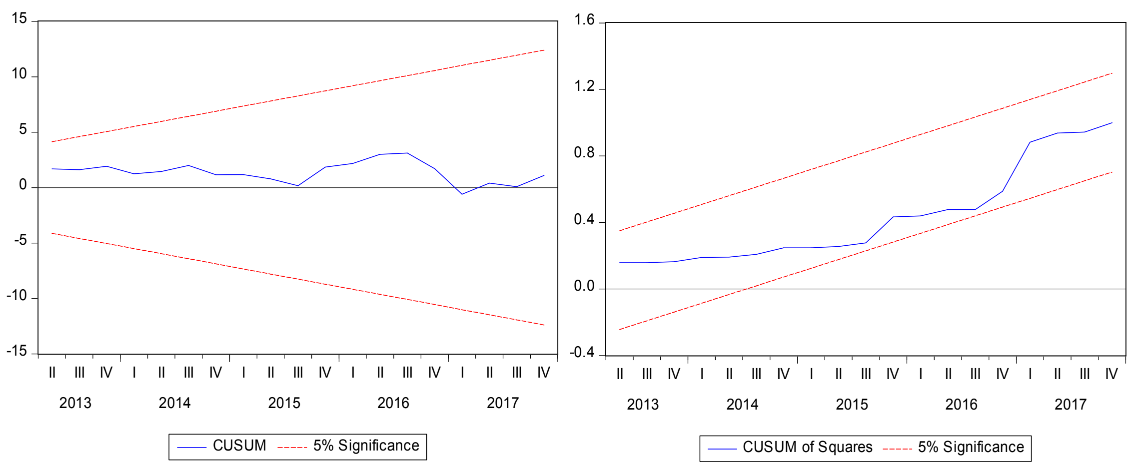

Fig. 8. Plots of CUSUM and CUSUM square test of stability

Table 5. Wald test for coefficient restriction

Wald test			
Test statistic	**Value**	**df**	**Probability**
F-statistic	0.651791	(7, 14)	0.7080
Chi-square	4.562539	7	0.7132

Table 6. Results of the ARDL parsimonious model

Variable	Coefficient	Prob
D(AGDP(-4))	0.982641	0.0000
D(EXR)	-70.05101	0.0031
D(EXR(-1))	45.02863	0.0431
D(EXR(-2))	81.15084	0.0010
D(EXR(-3))	-96.56726	0.0002
D(INR(-2))	-56.51463	0.4394
ECM(-1)	-0.401806	0.0040
C	77.74136	0.3789
R-squared	0.913929	
Adjusted R-squared	0.882218	
Durbin-Watson stat	2.278517	

Diagnostic Test: Jarque-Bera Normality test= 2.25586 (0.323) Breusch-Godfrey Serial Correlation Lagrange Multiplier (LM) test for serial correlation = 0.763 (0.565) ARCH heteroscedasticity Testt = 0.003 (0.953). Pv in brackets; $D(AGDP_t) = 0.98*D(AGDP_t(-4)) - 70.05*D(EXR_t) + 45.02*D(EXR_t(-1)) + 81.15*D(EXR_t(-2)) - 96.56*D(EXR_t(-3)) - 56.51*D(INR_t(-2)) - 0.40*ECM(-1) + 77.74$

5. CONCLUSION

It was concluded that 91.3% variation in agricultural sector performance was explained by changes in its fourth lag, current year exchange rate, the first, second and third lag of exchange rate and the second lag of interest rate. It was also concluded that the current and lagged values of implicit price deflator were not significant determinant of agricultural sector performance. The study has shown that modeling the effects of regressors on criterion variables without the inclusion of the lags of the regressors may not explain how previous values affect the present. The use of autoregressive distributed lagged model is particularly important for this study as agricultural production is undoubtedly affected by past production, consequently, modeling Agricultural performance without the lags of Agricultural performance as regressors would not be comprehensive.

The post estimation or diagnostic test conducted showed that the model was good (normal distribution of the residual, residual was free from auto and serial correlation and the model was stable).

The study as a result recommended that government policies geared towards increasing agricultural performance should simultaneously address appropriate exchange rate regime in order not to inhibit the agricultural sector performance.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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