Investigating the Asymmetric Effect of Exchange Rate on Agricultural Output in Nigeria,1981-2017

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Abstract
Understanding the relationship between exchange rate and agricultural output has drawn the attention of researchers, since exchange rate has been found to be pertinent in valuing agricultural production and equipments. This paper examines the effects of real exchange rate increases (appreciation) and decreases (depreciation) on aggregate and sectoral agricultural output in Nigeria. Using the nonlinear Auto-Regressive Distributed Lag (ARDL) cointegration framework, the paper analyses the long-run and short-run asymmetric relations between real exchange rate and aggregate and sectoral agricultural output. The findings indicate the existence of cointegration between real exchange rate and aggregate and sectoral agricultural output. In the long-run, real exchange rate appreciation has significant positive effect on aggregate and sectoral agricultural output, while the effect of real exchange rate depreciation is negative and significant. The long run estimates also indicate that the effects on agricultural output of real exchange rate increases are greater than that of real exchange rate decreases. Findings from this empirical analysis indicate the need for an appropriate exchange rate policy to promote agricultural sector development.

Keywords: Agricultural output, Real exchange rate appreciation and depreciation, Nonlinear ARDL, Nigeria
JEL Classification: F31, O13, Q10, C5

I. Introduction

Agricultural output is the quantity and value of agricultural products produced in a country for domestic consumption and export. Nigeria is endowed with an enormous variegated agroecological condition, wide arable land, water and labor, which makes agriculture one of the most important sectors of the Nigerian economy. It is particularly important in terms of its export revenue earnings, employment generation and its value addition to gross domestic product (GDP).

Although the agricultural sector still remains the largest sector of the Nigerian economy, it has lost billions of dollars in annual export earnings from cocoa, groundnut, cotton and palm oil alone due to continuous decline in the production of these commodities as a result of the direct and indirect impacts of fluctuations. "The indirect effects of currency fluctuations dwarfs the direct effect because of the huge influence it exerts on agricultural production and

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on the entire economy both in the short and long run since Nigeria is the world's largest cassava producer and Africa's largest rice importer" (IFPRI- Policy Note No. 32, 2012).

The recent concerted policies of the Nigerian government in the agricultural sector have led to consistent growth of output in the sector in the last half decade. Output from the agricultural sector has recorded an annual growth rate of 8.94 per cent, on the average, between 2012 and 2016. Sectorally, during this same period, average annual growth rate of output for crops, fishing, forestry and livestock were 4.4, 5.7, 3.8 and 3.5 per cent, respectively (CBN Statistical Bulletins, 2016, 2017). If this development is sustained, the agricultural sector would no doubt achieve its full potentials in terms of employment generation, increased income and foreign exchange earnings through enhanced export competitiveness. The progress in the agricultural sector could place the economy on a sustained path of non-oil growth if the agricultural value chain is significantly improved.

Exchange rate is very useful in valuing agricultural production and equipments according to Schuh (1974), as cited by Kristinek and Anderson (2002); changes in exchange rates, nonetheless, will have effect on output of the agricultural sector. Since Nigeria depends largely on importation of capital goods used in agriculture production process, it can be argued changes in exchange rates will have implications on agricultural sector output. Therefore, it becomes pertinent to empirically determine whether exchange rate appreciation or depreciation fosters agricultural sector output in Nigeria. Thus, the purpose of this paper is to examine the effects of exchange rate appreciation or depreciation on aggregate and sectoral agricultural output.

The direction of the relationship between exchange rate and output is not clear cut; thus, no consensus has been reached in the literature. Findings on the relationship between exchange rates and output are also mixed in the empirical literature. Exchange rate depreciation has contractionary effect on output as shown by Kandil (2004), Yaqub (2010), Bakare (2011) and Adelowokan, Adesoye and Balogun (2015) to mention but a few. In contrast, Edwards (1992), Lyons (1992), Odusola and Akinlo (2001), Adewuyi (2005) and Bahmani-Oskooee and Kandil (2007) reveal an expansionary effect of exchange rate depreciation on output. Findings from Yaqub (2013) reveal that output of different sub-sectors of the agricultural industry respond differently to changes in exchange rate for Nigeria. Exchange rate changes have negative effect on output from crop and fishery sub-sectors, whereas the effects on the output of the livestock and forestry are found to be positive. However, while Yaqub (2013) only examined exchange rate changes, other studies on Nigeria only captured exchange rate depreciation.

This paper applies the nonlinear Autoregressive Distributed Lag (ARDL) developed by Shin, Yu and Greenwood-Nimmo (2011) because it allows us not only to model the effects of both negative and positive changes in exchange rates on agricultural sector output, but also to examine the responses of agricultural output to exchange rate shocks. The nonlinear ARDL is found suitable because it is simple and capable of modelling asymmetries both in the underlying long-run relationship and in the patterns of dynamic adjustment simultaneously (see Shin et al., 2011). The study, thus, analysed the long-run and short-run asymmetric relations between agricultural output (both aggregate and sectoral output) and real exchange rate appreciation and depreciation. This is important because of the need to determine the appropriate exchange rate regime that can sustain the observed development in the agricultural sector in Nigeria and consequently improve agricultural value chains.

The rest of this article is structured as follows: Section 2 is literature review, section 3 addresses data and methodology, while section 4 contains results and discussion. Section 5 gives the conclusion.

II. Literature Review

In the theoretical literature, there is no clear-cut relationship between exchange rate and output. The traditionalists opine that exchange rate depreciation would improve balance of trade by making export cheaper and import more expensive, reduce balance of payments problems and accordingly increase output and employment provided the Marshall-Lerner conditions hold.

The monetarists on the other hand conclude that exchange rate shocks have no effect on real variables in the long run (Domac, 1977), provided that the assumption of purchasing power parity (PPP) holds.

The structuralists however posit that exchange rate depreciation affects output through the interaction of demand and supply channels. Accordingly, the combination of demand and supply channels indicate that real output depends on unanticipated movements in the exchange rate, the money supply, and government spending. Also, supply-side channels establish that output varies with anticipated changes in the exchange rate. Given demand-side channels, aggregate demand increases with an increase in government spending or the money supply, increasing output and price in the short-run.

This paper anchors the empirical model on a standard IS-LM framework proposed by the Structuralists. Exchange rate is seen to affect output through the interactions between aggregate demand (AD) and aggregate supply (AS) (see Kandil & Mirzaie, 2003 as cited by Yaqub, 2013). It states that appreciation is expected to affect export negatively as domestic goods become more expensive to foreign consumers.

The position of the empirical literature on the effect of exchange rate shocks on agricultural output has been mixed. This disparity could be attributed to the theory adopted in the study, methodology used, assumptions about the model and type of data used.

Agenor (1991) focuses on real exchange rate, using the Ordinary Least Squares (OLS) technique and data from twenty-four developing economies; and found contractionary effects of real exchange rate depreciation. Bautista (1993), found that a 10 per cent increase in real exchange rate boost the price of agricultural products by slightly less than 4 per cent. The study also estimated the elasticity of relative prices of agricultural products with respect to export tax variable and import tariff variable. While foreign exchange port tax variable is slightly more than 3 per cent that of import tariff is slightly more than 4 per cent. The sign in either case is positive showing that relative agricultural prices respond positively to a rise in both export tax and import tariff.

In Nigeria, Adubi and Okumadewa (1999) showed that exchange rate volatility has a high level of negative impact on export, but positively affect export earnings.

Bahmani-Oskooee and Kandil (2007) used annual data on real and nominal measures of the effective exchange rate for Iran between 1959 and 2003, within a cointegration analysis framework to examine the effects of exchange rate fluctuations on output. The study found no evidence of cointegration between output growth and the parallel rial-dollar exchange rate (for both real and nominal exchange rates). Currency appreciation was also found to be contractionary in the long run but expansionary in the short-run.

Obayelu and Salau (2010) found that food and export prices, as well as the real exchange rate jointly explained 57 per cent of the variation in the Nigeria aggregate agricultural output in the short run and 87 per cent variation in the long run. Total agricultural output responded positively to increases in exchange rate and negatively to increases in food prices both in the short and long run. The statistical significance of food crop prices and exchange rate both in the short-and long-run suggest that changes in these variables are passed immediately to agricultural output.

Omojimite and Akpokodje (2010) found a negligible positive impact of exchange rate depreciation on non-oil exports and concluded that exchange rate reforms are not sufficient to diversify the economy. Yaqub (2013), found output of different sub-sectors responded to the exchange rate changes differently. While the exchange rate changes had negative effects on crop and fishery output, they had positive effects on livestock and forestry.

Abiola (2017), showed that real exchange rate, average price of the agricultural commodity and degree of commercial openness were found to be positively related to agricultural supply. Also, nominal exchange rate was negatively related to agricultural supply.

As the review suggests, many researchers have found evidence for the contractionary effect of exchange rate depreciation on output, while other studies found evidence for expansionary effects of exchange rate depreciation on output.

III. Data and Methodology

The data used for the empirical analysis in this study are yearly aggregate and sectoral agricultural output, real exchange rate (*EXCH*), total government expenditure (*GVEX*) and money supply (*MS*). The yearly series span from 1981 to 2017, based on the availability of data. The agricultural output variables are aggregate agricultural output (*AGOP*), crop output (*CROP*), livestock output (*LVOP*), fishery output (*FSOP*) and forestry output (*FROP*). All the variables are in real terms except total government expenditure and money supply which are measured by federal government expenditure and monetary aggregate, M2, respectively. For ease of interpretation of results, the variables are log transformed. The agricultural output variables are measured by agricultural Gross Domestic Product (GDP) and the real exchange rate is the naira to US dollar exchange rate. The data for agricultural output variables and total government expenditure are sourced from the Central Bank of Nigeria

Statistical Bulletins (2016 and 2017 editions), while data for real exchange rate and money supply are from the World Bank Development Indicator (WDI) and International Financial Statistics (IFS).

The empirical model in equation (1) is anchored on the standard IS-LM framework proposed by the Structuralists; it has been argued in the literature that exchange rate affects output through the interactions between aggregate demand (AD) and aggregate supply (AS) (see Kandil & Mirzaie, 2003; and Yaqub, 2013). This however justified the inclusion of government expenditure and Money supply in the equation.

$$AGROP_t = \alpha_0 + \alpha_1 GVEX_t + \alpha_2 MS_t + \alpha_3 EXCH_t + u_t \quad (1)$$

where $AGROP_t$ is agricultural output variable, $GVEX$ is total government expenditure, MS is money supply, $EXCH$ is real exchange rate, u is the error term while $\alpha = (\alpha_0, \alpha_1, \alpha_2, \alpha_3)$ are the parameters. A priori, government expenditure and money supply are expected to be positively related to output. Since the study is focused on aggregate and sectoral output there are five variants of equation (1) which are total agricultural output equation ($AGOP$), crop output equation ($CROP$), livestock output equation ($LVOP$), fishery output equation ($FSOP$) and forestry output equation ($FROP$). The paper adopts the nonlinear ARDL cointegration approach advanced by Shin et al. (2011) which allows us to examine both long-run and short-run asymmetries of the response of agricultural output to real exchange rate ($EXCH$).

The long-run asymmetric equation for the agricultural output variable is specified as follows:

$$agop_t = \beta_0 + \beta_1 gvex_t + \beta_2 ms_t + \beta_3 exch_t^+ + \beta_4 exch_t^- + e_t \quad (2)$$

where the variables are as defined, $\beta = (\beta_0, \beta_1, \beta_2, \beta_3, \beta_4)$ are long run parameters to be estimated. $exch_t^+$ and $exch_t^-$ in equation (2) are the partial sums of positive and negative changes in real exchange rate (these capture real exchange rate appreciation and depreciation, respectively), $exch_t$ and which are expressed as:

$$exch_t^+ = \sum_{i=1}^{t} \Delta exch_t^+ = \sum_{i=1}^{t} \max(\Delta exch_t, 0) \quad (3)$$

$$exch^+{}_{t-1}{}^- = \sum_{i=1}^{t} \Delta exch^-{}_{t-1} = \sum_{i=1}^{t} \min(\Delta exch_t, 0) \quad (4)$$

Following Shin et al. (2011), equation (2) can be situated in an ARDL framework (see Pesaran and Shin 1999 and Pesaran et al. 2001) as:

$$\Delta agop_t = \alpha + \lambda_0 agop_{t-1} + \lambda_1 gvex_{t-1} + \lambda_2 ms_{t-1} + \lambda_3 exch^{+}{}_{t-1} + \lambda_4 exch^{-}{}_{t-1} + \sum_{i=0}^{p}\omega_i \Delta agop_{t-1} + \sum_{i=0}^{q}\phi_i \Delta gvex_{t-1} + \sum_{i=0}^{r}\mu_i \Delta ms_{t-1} + \sum_{i=1}^{s}(\rho_i^{+}\Delta exch^{+}{}_{t-1} + \rho_i^{-}\Delta exch^{-}{}_{t-1}) + u_t \quad (5)$$

Where all variables are as earlier defined, *p*, *q*, *r* and *s* are lag orders and $\beta_1 = -\lambda_1 \backslash \lambda_0$ $\beta_2 = -\lambda_2 \backslash \lambda_0$, $\beta_3 = -\lambda_3 \backslash \lambda_0$ and $\beta_4 = -\lambda_4 \backslash \lambda_0$, are the long run effects of government expenditure, money supply, exchange rate increase and exchange rate decrease on agricultural output variable, respectively. Real exchange rate increase (appreciation) is expected to have positive relationship with agricultural output while a negative relationship is expected between real exchange rate decrease (depreciation) and agricultural output.

$\sum_{i=0}^{s}\rho_i^{+}$ captures the short run effects of real exchange rate increase on agricultural output variable, while $\sum_{i=0}^{s}\rho_i^{-}$ also measures the short run effects of real exchange rate decrease on agricultural output variable. The asymmetric short-run effects of real exchange rate changes on agricultural output variable is also captured in addition to the asymmetric long run relation.

The empirical analysis of the nonlinear ARDL framework requires the following steps (see Ibrahim, 2015). Foremost, the ARDL cointegration approach is applicable irrespective of whether the variables are I(0) or I(1); and the study applies ADF and NG-Perron unit root tests. The presence of an I(2) variable makes the computed F-statistics for testing the existence of cointegration invalid. Thus, orders of integration of the variables are established to ensure that none of the variable is I(2). For the second step, we estimate equation (5) using the standard OLS estimation technique. Following Katrakilidis and Trachanas (2012) and Ibrahim (2015), we employ the general-to-specific procedure in order to arrive at a parsimonous specification of the nonlinear ARDL by trimming the insignificant lags. Third, from the estimated nonlinear ARDL, we carry out a test to examine the presence of cointegration among agricultural output variable, government expenditure, money supply and real exchange rate increases and decreases using a bounds testing approach of Paseran et al. (2001) and Shin et al.(2011). The bounds test requires the use of Wald F test of the null hypothesis, $\lambda_0 = \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0$ Finally, having established the existence of cointegration, the long-run and short-run asymmetries between the agricultural output and exchange rate are examined and inferences are drawn. We can also derive the asymmetric cumulative dynamic multiplier effects of a one percent change in $exch^{+}_{t-1}$ and $exch^{-}_{t-1}$

accordingly as:

$$m_h^+ = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial exh^+_{t-1}} , m_h^- = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial exh^-_{t-1}} , \quad h = 0,1,2..... \qquad (6)$$

Note that as $h \to \infty$, $m_h^+ \to \beta_3$ and $m_h^- \to \beta_4$.

IV. Results and Discussion

Unit root tests were conducted for all the variables using ADF and NG-Perron to ascertain the stationarity level of the variable in order to avoid spurious results and also to ensure that none of the variables is I(2). The results of the ADF and NG-Perron are presented in Tables1a and 1b, respectively, and they are based on 5 percent level of significance. The test equations for the unit root tests are constant and constant, linear trend. The results of the unit root tests for aggregate agricultural output, crop output, livestock output, fishery output, forestry output and exchange rate are consistent for both the ADF and NG-Perron while others are not. However, going by the results of NG-Perron unit root tests the variables are integrated of order 0 and 1; total government expenditure and money supply are integrated of order 0. Having established that none of the variable is I(2) we proceed to the bounds testing procedure to examine the existence of cointegration among the variables of the models.

Equation (5) is estimated and the general-to-specific procedure was applied to give us a final model specification. There are five variants of equation (5) namely the aggregate agricultural output equation, crop output equation, livestock output equation, fishery output equation and forestry output equation. The maximum lag order considered is 3 for all equations estimated except for livestock output equation which is 2. The maximum lag orders are selected based on AIC information criteria. The bounds F-statistics for nonlinear cointegration are reported in Table 2 while Table 3 presents the results of the non-linear estimates of the agricultural output equations.

Table 1a: ADF Unit Root Tests

	Level				First difference				Order of Integration
Variables	Intercept		Trend & Intercept		Intercept		Trend & Intercept		
	ADF Statistics	5% critical value	ADF Statistics	5% critical Value	ADF Statistics	5% critical value	ADF Statistics	5% critical value	
	0.145	-2.946	-2.097	-3.54	-5.796	-2.948	-5.74	-3.544	I(1)
	-0.022	-2.946	-2.201	-3.54	-5.821	-2.948	-5.743	-3.544	I(1)
	0.71	-2.948	-1.261	-3.544	-4.124	-2.948	-4.263	-3.544	I(1)
	0.237	-2.957	-2.102	-3.558	-9.07	-2.957	-8.629	-3.558	I(1)
	0.967	-2.948	-1.106	-3.544	-6.087	-2.948	-6.489	-3.544	I(1)
	-1.731	-2.948	0.403	-3.548	-1.298	-2.957	-4.629	-3.548	I(1)
	-1.303	-2.951	-0.733	-3.548	-2.607	-2.951	-2.721	-3.548	-------
	-2.122	-2.946	-1.912	-3.54	-2.471	-2.948	-4.491	-3.544	I(1)

Source: Author's computation

Table 1b: NG-Perron Unit Root Tests

	Levels				First difference				Order of Integration
Variables	Intercept		Trend and Intercept		Intercept		Trend and Intercept		
	MZt statistics	5% critical value	MZt statistics	5% critical value	MZt statistics	5% critical value	MZt statistics	5% critical value	
	1.919	-1.98	-1.599	-2.91	-2.955	-1.98	-2.949	-2.91	I(1)
	1.712	-1.98	-1.733	-2.91	-2.955	-1.98	-2.95	-2.91	I(1)
	0.945	-1.98	-1.275	-2.91	-2.71	-1.98	-2.745	-2.91	I(1)
	-1.347	-1.98	-0.664	-2.91	-2.46	-1.98	-2.088	-2.91	I(1)
	0.68	-1.98	-1.263	-2.91	-2.887	-1.98	-2.92	-2.91	I(1)
	-9.768	-1.98	-13.012	-2.91	-0.639	-1.98	-0.788	-2.91	I(0)
	-1.044	-1.98	-4.04	-2.91	-1.837	-1.98	-2.9	-2.91	I(0)
	-1.383	-1.98	-1.66	-2.91	-2.864	-1.98	-2.873	-2.91	I(1)

Source: Author's computation

Table 2: Bound Test for Nonlinear Cointegration

Total agricultural output equation			
F-Statistic	**95% lower bound**	**95% upper bound**	**Conclusion**
10.4463	2.863	4.077	Cointegration
Crop output equation			
F-Statistic	**95% lower bound**	**95% upper bound**	**Conclusion**
7.5519	2.863	4.077	Cointegration
Livestock output equation			
F-Statistic	**95% lower bound**	**95% upper bound**	**Conclusion**
5.9640	2.863	4.077	Cointegration
Fishery output equation			
F-Statistic	**95% lower bound**	**95% upper bound**	**Conclusion**
26.9216	2.863	4.077	Cointegration
Forestry output equation			
F-Statistic	**95% lower bound**	**95% upper bound**	**Conclusion**
8.1181	2.863	4.077	Cointegration

Notes: The lower bound and upper bound critical values are from Narayan (2005) because of the small sample size.

Source: Authors' Computation

The bounds tests indicate the existence of long run relationship between total government expenditure, money supply, exchange rate and the agricultural output variables in all the five variants of agricultural output equations. The F-Statistic of 10.45 (total agricultural output equation), 7.55 (crop output equation), 5.96 (livestock output equation), 26.92 (fishery output equation) and 8.12 (forestry output equation) exceed the critical upper bound at 5 percent significance level. From the results of the bounds test we come to the conclusion that there is long-run relationship between total government expenditure, money supply, real exchange rate and agricultural output variables (that is agricultural output, crop output, livestock output, fishery output and forestry output). With these findings on the existence of long-run relationships, we proceed to examine agricultural output dynamics and its relation to total government expenditure, money supply and positive and negative changes in real exchange rate.

The estimated nonlinear equations for which results are presented in Table 3 are correctly specified having passed the various diagnostic tests. The results of Jacque-Bera statistics for normality, LM statistics for autocorrelation and ARCH test for conditional heteroskedasticity are reported at the lower part of Table 3. The results of the diagnostic test show error normality, absence of autocorrelation and ARCH effects at 5 percent level. Lag orders 1 and 2 are considered for the LM and ARCH effects tests. Structural stability test is conducted for the estimated equations using the CUSUMSQ and CUSUM statistics. All the estimated equations pass the structural stability test except the livestock output equation, (see Figure 1).

We compute the long-run estimates for the five equations from the estimated results in Table 3, these are reported in Table 4. The long-run estimates of total government expenditure are negative and significant at 1 per cent level (aggregate agricultural, crop, livestock, fishery and forestry output equations) and 10 per-cent (forestry output equation). These are in contrast with a priori expectation. The effects of total government expenditure on total agricultural output, crop output, livestock output, fishery output and forestry are -0.85, -0.78, -0.71, -1.67 and -0.14 accordingly. The implication of the result is that total government expenditure increases (decreases) cause aggregate and sectoral agricultural outputs to fall (rise), this may be that prívate investment in the agricultural sector is crowded out by government expenditure. The long-run estimates of money supply are positive and significant at 1 percent in all the agricultural output equations; these results conform with a priori expectation. The estimates are 0.65 (aggregate agricultural output), 0.62 (crop output), 0.56 (livestock output), 0.89 (fishery output) and 0.34 (forestry output). In the short-run, the relationships between changes in government expenditure and agricultural output are mixed. Similarly, the relationships between changes in money supply and agricultural output also indicate mixed results.

Table 3: Nonlinear ARDL Estimation Results

Total Agricultural Output Equation			Crop Output Equation		
Independent variable			Independent variable		
	Coefficients	p-value		Coefficients	p-value
Constant	4.180767	0	Constant	3.368146	0
AGOP(-1)	-0.521715	0	CROP(-1)	-0.428897	0.0001
GVEX(-1)	-0.444819	0	GVEX(-1)	-0.335311	0.0001
MS(-1)	0.341362	0	MS(-1)	0.265069	0.0001
EXCH_P(-1)	0.227181	0.0001	EXCH_P(-1)	0.166198	0.0005
EXCH_N(-1)	-0.170511	0.0014	EXCH_N(-1)	-0.135144	0.0053
DAGOP(-3)	0.207623	0.0441	DCROP(-3)	0.254765	0.0139
DGVEX	-0.14091	0.0068	DGVEX	-0.17565	0.0035
DGVEX(-1)	0.165608	0.0319	DGVEX(-2)	-0.08984	0.0604
DMS	0.159747	0.0417	DMS	0.161526	0.0747
DMS(-2)	-0.1172	0.1565	DEXCH_P(-1)	-0.17171	0.0412
DEXCH_P(-1)	-0.1118	0.1274	DEXCH_N(-1)	0.132846	0.0018
DEXCH_P(-2)	-0.1453	0.083	DEXCH_N(-2)	0.133249	0.0056
DEXCH_N(-1)	0.164999	0.0005	DEXCH_N(-3)	-0.09681	0.0113
DEXCH_N(-2)	0.150104	0.0005	R-squared	0.8633	
DEXCH_N(-3)	-0.06151	0.0928	Adjusted R-squared	0.7698	
R-squared	0.883095		Jacque-Bera	0.4287	0.8071
Adjusted R-squared	0.779944		LM(1)	0.6264	0.439
Jacque-Bera	0.0879	0.957	LM(2)	0.7035	0.5087
LM(1)	0.4184	0.5269	ARCH(1)	0.9159	0.3462
LM(2)	1.2314	0.3198	ARCH(2)	0.5174	0.6017
ARCH(1)	0.5502	0.464			
ARCH(2)	0.6453	0.5321			

Notes: Jacque-Bera test is for normality test, LM is the serial correlation test, and the ARCH is the test for autoregressive conditional heteroskedasticity. Both the LM and ARCH tests are up to lag order 2.
Source: Authors' Computation

Table 3 Contd: Nonlinear ARDL Estimation Results

Livestock Output Equation			Fishery Output Equation		
Independent variable			Independent variable		
	Coefficients	p-value		Coefficients	p-value
Constant	0.887186	0.0223	Constant	2.727082	0
LVOP(-1)	-0.149638	0.0304	FSOP(-1)	-0.76493	0
GVEX(-1)	-0.106055	0.0015	GVEX(-1)	-0.893865	0
MS(-1)	0.084074	0.0061	MS(-1)	0.679747	0
EXCH_P(-1)	0.069544	0.0009	EXCH_P(-1)	0.479107	0.0005
EXCH_N(-1)	-0.016904	0.1706	EXCH_N(-1)	-0.327899	0.0001
DGVEX(-1)	0.049716	0.0517	DFSOP(-2)	0.279008	0.0225
DMS	0.064888	0.0635	DFSOP(-3)	0.562357	0.0002
DEXCH_P(-1)	0.056071	0.1181	DGVEX	0.285661	0.0085
DEXCH_P(-2)	-0.0741	0.0506	DGVEX(-1)	1.15847	0
R-squared	0.604631		DGVEX(-2)	0.850757	0
Adjusted R-squared	0.456367		DGVEX(-3)	0.242954	0.0098
Jacque-Bera	3.4379	0.1793	DMS(-1)	-0.65585	0.0069
LM(1)	1.1665	0.2913	DMS(-2)	-0.34769	0.1336
LM(2)	1.1408	0.3378	DMS(-3)	-0.51682	0.0086
ARCH(1)	--------	---------	DEXCH_P(-2)	0.318895	0.0244
ARCH(2)	0.4677	0.6311	DEXCH_P(-3)	-0.41786	0.0086
			DEXCH_N(-1)	0.157426	0.0239
			DEXCH_N(-3)	-0.10504	0.112
			R-squared	0.935891	
			Adjusted R-squared	0.853466	
			Jacque-Bera	0.8462	0.655
			LM(1)	0.1489	0.7058
			LM(2)	1.5183	0.2583
			ARCH(1)	0.0322	0.8588
			ARCH(2)	2.0589	0.1465

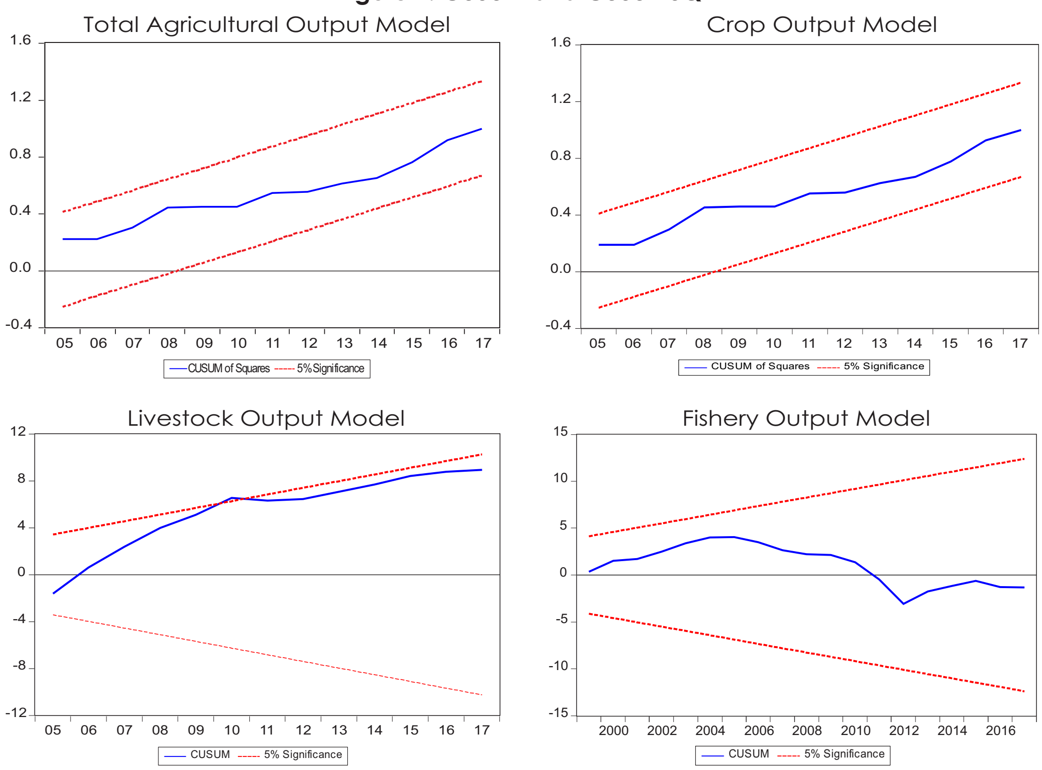
Notes: Jacque -Bera test is for normality test, LM is the serial correlation test, and the ARCH is the test for autoregressive conditional heteroskedasticity. Both the LM and ARCH tests are up to lag order 2.
Source: Authors' Computation

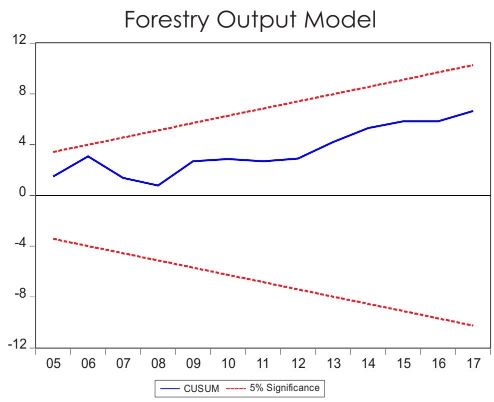
Table 3 Contd: Nonlinear ARDL Estimation Results

Forestry Output Equation		
Independent variable		
	Coefficients	p-value
Constant	2.70888	0
FROP(-1)	-0.713447	0
GVEX(-1)	-0.100913	0.0586
MS(-1)	0.242941	0.0001
EXCH_P(-1)	-0.090233	0.0157
EXCH_N(-1)	0.075634	0.0035
DMS(-2)	-0.21943	0.0128
DEXCH_N(-1)	-0.12409	0.0006
R-squared	0.6099	
Adjusted R-squared	0.5049	
Jacque-Bera	2.2135	0.3306
LM(1)	0.2676	0.6095
LM(2)	0.9329	0.4072
ARCH(1)	3.9279	0.0564
ARCH(2)	1.9663	0.1582

Notes: Jacque-Bera test is for normality test, LM is the serial correlation test, and the ARCH is the test for autoregressive conditional heteroskedasticity.

Figure 1: CUSUM and CUSUMSQ





The results of the tests of symmetry in the long-run and short-run are reported in Table 5. For the long-run relationship, the null hypothesis of symmetry in the long-run against the alternative of asymmetry are tested for all the five models using the Wald statistic. The reported results in Table 5 indicate the rejection of the null hypothesis of long-run symmetry in all the estimated models. The findings show that long-run effects of real exchange rate appreciation (increases) and depreciation (decreases) on aggregate agricultural output, crop output, livestock output, fishery output and forestry output are not the same (see the long-run estimates in Table 4). For the asymmetry relationship in the short-run, the null hypothesis of summative symmetric adjustments was rejected for the total agricultural output and crop output models, while the null hypothesis could not be rejected for fishery output model using the Wald statistic (see Table 5).

These findings indicate asymmetric relationships between real exchange rates and aggregate agricultural output and crop output in the short-run. From the results in Table 4, we observe long run asymmetries between aggregate agricultural output, crop output, livestock output, fishery output, forestry output and real exchange rate shocks- increase and decrease. Real exchange rate increase (appreciation) has significant positive or expansionary effect on aggregate agricultural output, crop output, livestock output and fishery output while, real exchange rate decrease (depreciation) has significant negative (contractionary) effect on the same agricultural output variables. These findings reveal that real exchange rate appreciation has expansionary effect on aggregate agricultural output, crop output, livestock output and fishery output while the effect of real exchange rate depreciation on the same agricultural output variables is contractionary.

For the forestry output, the effect of a positive shock to real exchange rate is negative and significant while that of a negative shock to real exchange rate is positive and significant. This means that real exchange rate appreciation has a contractionary effect on forestry output whereas the impact of depreciation in real exchange rate is expansionary on forestry output. The long-run effects of real exchange rate shocks on agricultural output variables are in conformity to the predictions by theory except for forestry output. The long-run estimates in Table 4 indicate greater asymmetric impact of increases in real exchange rate on aggregate and sectoral agricultural outputs. There are also evidences in support of short-run asymmetries in Table 3.

The one period-lagged changes in real exchange rate increase is negatively related to agricultural output but not significant while that of exchange rate decrease is positive and significant. The three period-lagged changes in real exchange rate increase and decrease are negative and significant. For the crop output, one lagged-period changes in exchange rate increase is negative and significant while that of real exchange rate decrease is positive and significant. For livestock output, changes in real exchange rate increase lagged once is positive but not significant while the two period-lagged changes in exchange rate decrease is negative and significant. The one-period lagged changes in exchange rate decrease is positive and significant (fishery output) while changes in exchange rate decrease is negative and significant (forestry output).

The dynamic multipliers in Figure 2 explain the responses of agricultural output variables to both positive and negative shocks in real exchange rates. Aggregate agricultural output and crop output respond slowly and positively to both positive and negative shocks in real exchange rate at the initial phase. We also observe that aggregate agricultural output and crop output respond more to positive shocks than negative shocks initially; equilibrium state is not achieved during the period of the analysis. There is a quick adjustment back to equilibrium state for both fishery output and forestry output. The response of livestock to both shocks is in the same direction but slowly. Livestock output responds more to positive shocks than negative shocks.

Table 4: Long-run Estimates

Total Agricultural Output Model			Crop Output Model		
Independent variable			Independent variable		
	Coefficients	p-value		Coefficients	p-value
Constant	8.0135	0	Constant	7.853	0
GVEX	-0.8526	0	GVEX	-0.7818	0.0001
MS	0.6543	0	MS	0.618	0.0001
EXCH_P	0.4354	0.0001	EXCH_P	0.3875	0.0005
EXCH_N	-0.3268	0.0014	EXCH_N	-0.3151	0.0053

Source: Author's compilation

Table 4 Contd: Long-run Estimates

Livestock Output Model			Fishery Output Model		
Independent variable			Independent variable		
	Coefficients	p-value		Coefficients	p-value
Constant	5.9289	0	Constant	3.5651	0
GVEX	-0.7087	0	GVEX	-1.1686	0.0001
MS	0.5618	0	MS	0.8886	0.0001
EXCH_P	0.4647	0.0001	EXCH_P	0.6263	0.0005
EXCH_N	-0.113	0.0014	EXCH_N	-0.4287	0.0053

Source: Author's compilation

Table 4 Contd: Long-run Estimates

Forestry Output Model		
Independent variable		
	Coefficients	p-value
Constant	3.7969	0
GVEX	-0.1414	0.0586
MS	0.3405	0.0001
EXCH_P	-0.1265	0.0157
EXCH_N	0.106	0.0035

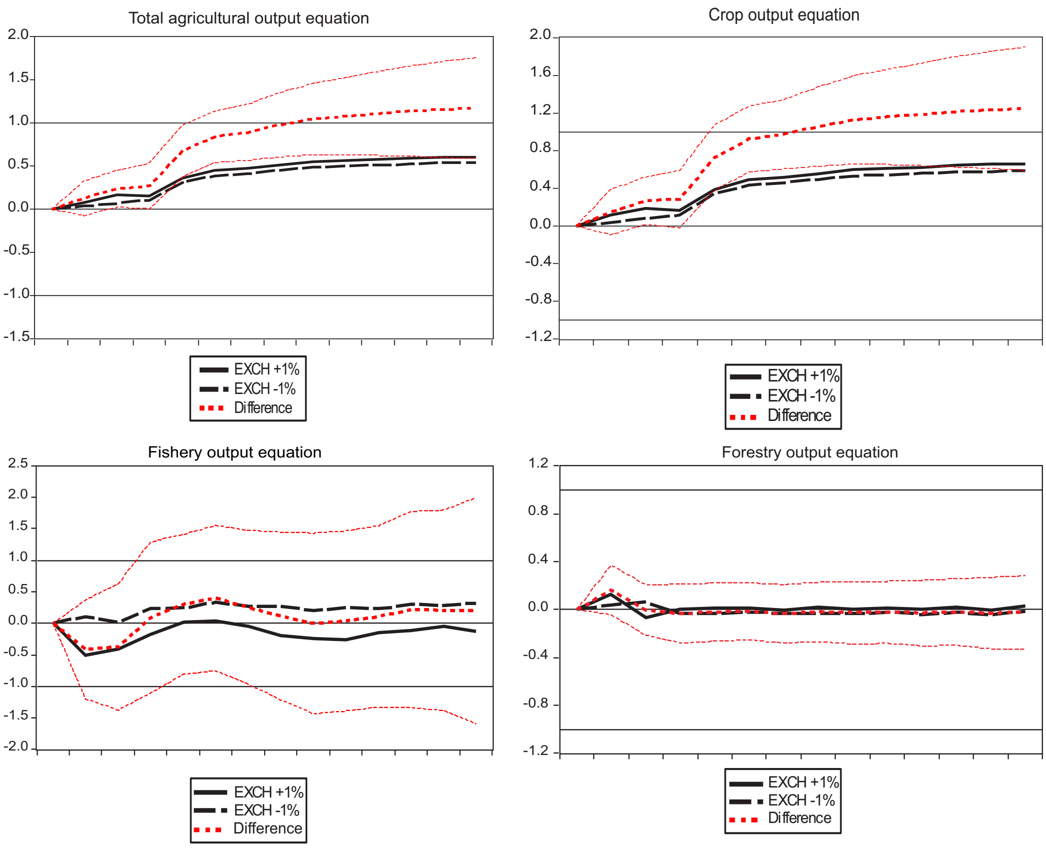
Source: Author's compilation

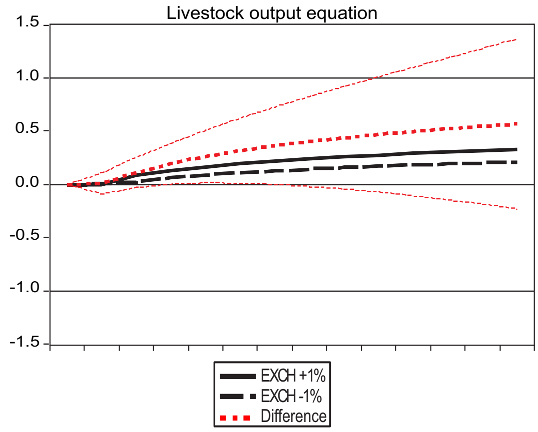
Table 5: Wald Test for Presence of Long-run and Short-run Asymmetry

Total agricultural output model		Crop output model	
Chi-square statistic	p-value	Chi-square statistic	p-value
25.2855 **(LR)**	0.0001	17.4404 **(LR)**	0.0005
11.35538 **(SR)**	0.0008	5.806465 **(SR)**	0.016
Livestock output model		Fishery output model	
Chi-square statistic	p-value	Chi-square statistic	p-value
3.7620 **(LR)**	0.0524	14.0631 **(LR)**	0.0002
		0.456769 **(SR)**	0.4991
Forestry Output Model			
Chi-square statistic	p-value		
11.0624 **(LR)**	0.0009		

Source: Author's computation

Figure 2: Dynamic Multipliers





V. Conclusion

Conscientious policy attention by the government must be directed to the agricultural sector to achieve its full potentials in order to place the Nigerian economy on the path of economic development. This must be facilitated through appropriate exchange rate policies to contain market power in the foreign exchange market. In this study, we examined the effects of positive changes (appreciation) and negative changes (depreciation) in the real exchange rate on aggregate and sectoral agricultural outputs. The nonlinear ARDL cointegration framework was used to empirically determine the relationship between these variables.

From the empirical analysis, there exists a nonlinear cointegration between real exchange rate and agricultural output. Evidence also supports both long-run and short-run asymmetries between agricultural output and real exchange rate. In the long-run, increases in real exchange rate (appreciation) leads to a corresponding increase in aggregate agricultural output, crop output, livestock output and fishery output, whereas decreases in real exchange rate (depreciation) is negatively related to aggregate agricultural output, crop output, livestock output and fishery output. Forestry output was found to be negatively related to increases in real exchange rate while a decline in real exchange rate led to an increase in forestry output.

In the short-run, changes in real exchange rate is negatively related to aggregate agricultural output, livestock output, crop output and fishery output, while changes in real exchange rate decrease shows positive and significant relationship with aggregate agricultural output, crop output and fishery output. The effect of changes in real exchange rate decrease on forestry output is negative and significant. Other findings include, a negative and significant long-run relationship between total government expenditure and aggregate agricultural output, crop output, livestock output, fishery output and forestry output while, the effects of money supply on aggregate agricultural output, crop output, fishery output and forestry output are positive and significant. The effects on aggregate agricultural output, crop output and fishery output of changes in total government expenditure and money supply are mixed in the short-run.

Finally we observe that real exchange rate increases (appreciation) have greater effects on aggregate and sectoral agricultural outputs than real exchange rate decreases (depreciation). We have contributed to knowledge by using nonlinear cointegration analysis known as Asymmetric Autoregressive distributed lag (NARDL) and also showed that aggregate and sectoral agricultural outputs are nonlinearly related to real exchange rate. In conclusion Exchange rate policies are germane to agricultural sector development in Nigeria and government need to determine which exchange rate policy is appropriate.

References

Abiola, A. (2017). Agricultural supply response to trade and exchange rate reforms in Nigeria. Munich, GRIN Verlag. Retrieved from https://www.grin.com/document/447234.

Adelowokan, O. A, Adesoye, A. B., & Balogun, O. D. (2015). Exchange rate volatility on investment and growth in Nigeria, an empirical analysis. *Global Journal of Management and Business Research*, *15*(10).

Adewuyi, A. O. (2005). Trade and exchange rate policies and economic performance in Nigeria: An empirical analysis. *The Nigerian Journal of Economic and Social Studies*, *47*(2), 249-280.

Adubi, A. A., & Okumadewa, F. (1999). Price, exchange rate volatility and Nigeria's agricultural trade flows: A dynamic analysis. *African Economic Research Consortium*, *87*.

Agenor, P. (1991). Output, devaluation and real exchange rate in developing countries. *Review of World Economics*, *127*(1), 18-41.

Bahmani-Oskooee, M. (1998). Are devaluations contractionary in LDCs?. *Journal of Economic Development*, *23* (1)131-144.

Bahmani-Oskooee M., & Kandil, M. (2007). Real and nominal effective Exchange rates in MENA countries: 1970-2004. Applied Economics, *Taylor & Francis Journals*, *39*(19), 2489-2501.

Bakare, A. S. (2011) The macroeconomic impact of foreign aid in Sub-Sahara Africa: The case of Nigeria. *Business and Management Review*, 1, 24-32.

Bautista, R. M. (1987). Production incentives in Philippine agriculture: Effects of trade and exchange rate policies. International Food Policy Research Institute Washington, DC: Research report, *59*.

Central Bank of Nigeria. (2016). Statistical Bulletin of Central Bank of Nigeria. Retrieved from http/www.cbn.org/out/publications.

Central Bank of Nigeria. (2017). Statistical Bulletin of Central Bank of Nigeria. Retrieved from http/www.cbn.org/out/publications.

Chamber, R. G., & Just, R.E. (1982). An investigation of the effect of monetary factors on agriculture. *Journal of Monetary Economics*, *9*(2), 235-247.

Domac, I. (1977). Are devaluation contractionary? Evidence from Turkey. *J. Econ. Dev*, *22*, 145-163.

Edwards, S. (1989). Real and monetary determinants of real exchange rate behavior: Theory and evidence from developing countries. *Journal of Development Economics*, *29*(3), 311-341.

Ehinomen, C., & Oladipo, T. I. (2012). Exchange rate management and the manufacturing sector performance in the Nigerian economy. *IOSR Journal of Humanities and Social Science*, *5*(5), 1-12.

Elvis, Picardo. (2020 February 2). *Understanding the indirect effects of Exchange rates*. Retrieved from https://www.investopedia.com/

articles/forex/053115/understand-indirect-effects-exchange-rates.asp.

Fajardo, D., McCarl, B. A., & Thompson, R. L. (1981). A multicommodity analysis of trade policy effects: The case of Nicaraguan agriculture. *American Journal of agricultural Economics*, *63*(1), 23-31.

Ibrahim, M. H. (2015). Oil and food prices in Malaysia: A nonlinear ARDL analysis. *Agricultural and Food Economics*, *3*(2).

International Financial Statistics, Country Tables, Exchange Rates, Official Rates (June, 2018).

International Food Policy Research Institute. (2012). Global Food Policy Report (Washington, DC).

Kandil, M. (2004). Exchange rate fluctuations and economic activity in developing countries: Theory and evidence. *Journal of Economic Development, 29*(1), 85-108.

Kandil, M., & Mirzaie, A. (2002). Exchange rate fluctuations and disaggregated economic activity in the US: Theory and evidence. *Journal of International Money and Finance*, 21, 1–31.

Katrakilidis, C., & Trachanas, E. (2012). What drives housing price dynamics in Greece: New evidence from asymmetric ARDL cointegration. Econ Model 29:1064–9.

Kristinek, J. J., & Anderson, D. P. (2002). Exchange rates and agriculture: A literature review. AFPC Working Paper 02-2.

Lyons, R. (2000). The microstructure approach to exchange rates Market, MIT Press.

Obayelu, A. E., & Salau, A. S. (2010). Agricultural response to prices and exchange rate in Nigeria: Application of co-integration and vector error correction model (VECM). *Journal of Agricultural Sciences*, (2), 73-81.

Odusola, A. F., & Akinlo, A. E. (2001). Output, inflation and exchange rate in developing countries: Application to Nigeria. *The Developing Economies*, *39*(2), 199-222.

Omojimite, B. U., & Akpokodje, G. (2010). A comparative analysis of the effect of exchange rate volatility on exports in the CFA and Non-CFA countries of Africa. *Journal of Social Sciences*, *24* (1), 23-31.

Opaluwa D., Umeh, C., & Ameh, A. (2010). The effect of exchange Rate fluctuation on Nigerian manufacturing sector. *African Journal of Business Management, 4*(14), 2994-2998.

Pesaran, M. H., & Shin, Y. (1999). An autoregressive distributed lag modelling approach to cointegration analysis. In: Storms (ed) and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium, Chapter Cambridge University Press, Cambridge.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics, 16* (3), 289–326.

Schuh, G. E. (1974). The exchange rate and U.S. agriculture. *American Journal of Agricultural Economics, 56*(1), 1–13.

Shin, Y., Yu, B., & Greenwood-Nimmo, M. (2011). Modelling asymmetric cointegration and dynamic multipliers in an ARDL framework. In William C. Horrace and Robin C. Sickles (Eds.), Festschrift in Honor of Peter Schmidt. New York (NY): Springer Science & Business Media. Schuh, G.E. "The exchange rate and U.S. agriculture." *American Journal of Agricultural Economics*, *56*, 1-13.

Taye, H. K. (1999). The impact of devaluation on macroeconomic performance: The case of Ethiopia. *Journal of Policy Modeling*, *21* (4), 481-496.

Waziri, S. I., Nor, N. M., Muktar, U., & Muktar, B. G. (2017). Export of agricultural raw materials, exchange rate and economic growth in Nigeria: An ARDL approach to cointegration. *Journal of Economics and Sustainable Development, 8*(22), 76-86.

World Bank. (2018). World Development Indicators. Retrieved from https://databank.worldbank.org/source/world-development-indicators.

Yaqub, J. O. (2010). Exchange rate changes and output performance in Nigeria: A sectoral analysis. *Journal of Social Sciences*, Pakistan, 370-387.

Yaqub, J. O.(2013). The impact of exchange rate changes on disaggregated agricultural output in Nigeria: A two- stage-least-squares approach. *International Journal of Economic Sciences and Applied Research*, ISSN 1791- 3373, Eastern Macedonia and Thrace Institute of Technology, Kavala, 6(1), 75-89.