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Assessing the asymmetrical effects of exchange rate devaluation on agricultural output: Nigeria in focus

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Abstract
The relationship between exchange rate devaluation and the agricultural sector performance has attracted the attention of researchers, since exchange rate is pertinent to agricultural output valuation. On the basis of this, the study examined the effects of exchange rate devaluation on the agricultural output in the case of Nigeria. The study employed the auto-regressive distributed lag (ARDL) on the annual time series data covering the period 1980 to 2021 being the sampled period to test the hypothesis. In line to the theoretical expectation, the outcome suggests that the explanatory variables used in the model satisfied the a priori predictions. However, the inverse relationship of the exchange rate lagged by two years' period also conforms to the expectation, implying that increase in exchange rate reduces agricultural output in Nigeria. The findings therefore suggest the need for government to have sound macroeconomic policies that can guarantee stability in the exchange rate as this will allow the monetary policies more effective to improving the performance of the agricultural sector in Nigeria. In addition, the government should increase its budget for the agricultural sector productivity as the findings attested to the claim

Keywords: Agricultural output, auto-regressive distribution lag, devaluation, exchange rate, Nigeria

1. Introduction

Agricultural output denotes the value of agricultural products produced in a given country for the purpose of both consumption and industrial uses. No doubt that Nigeria is characterized with a wide arable land, water coverage and increase in labour supply which are the key factors needed for agricultural growth. These are also important in the areas of revenue generation when much of the products are exported to other countries. It also enables employment possibility, by and large contributing to the growth of gross domestic product

No doubt agriculture up to have been the largest sector in the Nigerian economy, however, the sector has lost much billions of dollars annually due to short-fall arising from foreign exchange earnings from the agricultural export goods such as cocoa, groundnut cotton, palm oil etc (Karty, 2020). In recent time, the Nigeria government has put in place some concerted policies that are required for the consistent growth of agricultural output in the sector. Agricultural output has been recorded to the tune of about annual increase of 9.54 per cent on the average between 2014 to 2019. Considering the sectoral growth, there exists also average annual growth rate of output in terms of forestry, crops produce, livestock and also fishing these were found to be 5,8, 3.7,4.1 and 3,9 per cent (CBN Statistical Bulletins, 2017 and 2019). If this development is sustained over a long period, the agricultural sector would no doubt achieve full employment growth, increase in foreign earnings through a rise in export of agricultural goods. This is considered as non-oil growth.

Exchange rate plays vital role in the economy by way of valuing agricultural product (Schub, 2017), as cited by Anderson (2021), that variation in exchange rate will affect the agricultural output sector. For the fact that Nigeria relied on imports goods such as capital goods as factor costs for agricultural utilization, one can say that devaluation of exchange rate might adversely affect the sector. For this reason, it becomes necessary to empirically examine the asymmetrical effects to ascertain whether or not exchange rate devaluation can enhance agricultural output in Nigeria.

The direction of influence of exchange rate and agricultural productivity in terms of output is not quite clear, thus, no consensus has been reached in the literature in this direction. The findings relating to the relationship on the subject matter are also mixed. Exchange rate devaluation has contractionary effect on the agricultural output (Yaqub, 2018), (Kandil, 2020) and (Adesoye, 2021). Contrary to this school of thought, Lyons (2019), Adewuyi (2016) and Akinlo (2021) opined an expansionary impact relationship of exchange rate devaluation on the agricultural sector output.

The study employs the non-linear Autoregressive Distributed Lag (ARDL) approach which was developed by Shin, Yu and Greenwood-Nimmo (2014) for the reason being that it allows us not only to appropriately model the asymmetric effect of exchange rate on the agricultural output, but also enables the deeper examination of the response of agricultural output to exchange rate shocks. This non-linear ARDL is suitable on the account of its simplicity and capable of modelling asymmetric effect both on the long-run and also in the short-run during the dynamic adjustment (Shim, 2020). On the basis of this, the study focused on the long-run as well as the short-run asymmetric relationship between the agricultural output and the exchange rate devaluation in Nigeria. This becomes important in order to determine the appropriate exchange rate regime that can reliably sustain the development prevailing in the agricultural sector in the Nigerian economy and consequently recommend areas of improvement in the agricultural performance. The rest of this study is structured as follows: section two is the literature review, section three focuses on the methodology, while section four addresses the results and discussion of findings, the section five deals with conclusion and recommendations.

2. Literature Review

2.1 Theoretical Literature

As pointed out in the theoretical literature, a proper clear-cut exists between the exchange rate and agricultural output. The classical economists had it that exchange rate devaluation can enhance the balance of trade by a way of making export relatively cheaper when compare to import as a result of the change in relative prices, by this action, the problem of balance of payments is minimized, hence there exists a rise in both employment and output as indicated in the Marshall and Abba P. Lerner's theory.

In addition to the above, the monetarists had it that shocks arising from exchange rate may not necessarily affect the variables related to agricultural output in the long-run provided that the assumption of purchasing power parity holds (Domac, 2011). In line of this reasoning, one of the structuralists (Sir John Hicks) opined that exchange rate devaluation can affect output through the process of interactions between demand and supply. No doubt therefore, that when demand and supply are combined, it gives an indication of unanticipated movements in the exchange rate, net export, government expenditure and money supply. By this, it can be inferred that the supply side roots establish the fact that output varies with respect to anticipated variation in the exchange rate. Considering the demand side, there exists an increase in the

aggregate demand when there is a rise in money supply, government expenditure as well as output level. Therefore, the study relies on the general model of the IS-LM framework proposed by Sir John Hicks in 1937 and found pedagogically most useful in this case. By this, exchange rate is very likely to affect output through the process of interactions between the aggregate demand and aggregate supply (Mirzaie & Kandil, 2019). Therefore, exchange rate devaluation will enhance the level of export thereby making imports relatively more expensive.

2.2 Empirical Literature

There exists some empirical literature that deal with the relationship of exchange rate devaluation and agricultural output in the developed and developing countries. Some of these studies examined some of the macroeconomic factors that can warrant the influence changes in the agricultural outputs both in the developing and developed countries. On the basis of this, the study considered the work of Agenor (2021) who examine the effect of exchange rate depreciation on the economic growth in Nigeria from the period of 1985 to 2018 using the Ordinary Least Squares (OLS) technique. The results found out contractionary effect of exchange rate depreciation on the economic growth in Nigeria.

Obayelu and Salau (2019) investigated the relationship between exchange and non-oil export goods in Nigeria using the annual time series data covering the period 1980 to 2015. In the analysis, the study used error correction mechanism in the estimation of the parameters of the coefficient of the model. The results found out 87 per cent variation of the aggregate agricultural output in the long-run while 61 per cent variation in the short-run. By this, there is a higher agricultural output response in the long-run relative to the short-run period under investigation. Also, in the findings, there is statistical significance of the domestic agricultural out chosen as one of the exogenous variables at the 5 per cent level both in the long-run and the short-run periods.

Kandil and Bahmani (2020) considered the importance of the used of annual time series data on nominal and real effectiveness of exchange rate in Iran for the period spanning from 1970 to 2015 by using the auto-regressive distributed lag (ARDL) technique and also the co-integration to ascertain the existence of equilibrium long-run relationship. The rationale behind this, is to determine to what extent the exchange rate fluctuation affects the general output level in the country. The results established no evidence(s) of the existence of equilibrium long-run relationship between the exchange rate and output growth in the Iran economy

Akpokodje (2021), having examine whether or not the existence of the equilibrium long-run relationship between the exchange rate depreciation and the non-oil exports, the findings established that the reforms in the exchange rate do not satisfactorily guarantee economy diversification. However, the study recommends more comprehensive economic policy reform to achieve the desires.

Abiola (2021), in an attempt to address the problem surrounding the exchange rate and the prices of agricultural output, commercial openness was found to be directly related to agricultural output supply, however, nominal exchange rate was found to inversely related to agricultural output performance.

Yaqub (2021) examined the effect of exchange rate variations on the demand for livestock in some selected sectors in Nigeria. The study considered the period between 1990 to 2021 and the results found out that exchange rate variation enhances the optimum performance of the livestock productivity being one of the components of the agricultural sector.

Zhao (2020), investigated the impact of exchange rate volatility on trade flows of

the small-scale open economy of New Zealand, using vector error mechanism and co-integration to ascertain the existence of equilibrium long-run relationship in the model. The results proved that real exchange rate volatility is inversely related to the dependent variable. Therefore, the study concluded that the utilization of forward exchange markets to fully hedged exchange rate risk may have made exchange rate volatility less of a factor in explaining real export changes in the short-run, but found to be important factor in the long run equilibrium.

Taking a closer look at the empirical reviews, some study found out evidence(s) of contractionary effects of exchange rate devaluation on the aggregate output, while some do not find the evidence to claim the contractionary effect.

3. Methodology

3.1 Sources of Data

The data used for this study is annual time series obtained from the Central Bank of Nigeria (CBN) statistical bulletin of various issues 2017 and 2021. Sectoral agricultural output (AGP), government expenditure (GXT), exchange rate (EXR), net export (NXP) and money supply (M_2) are the variables employed in the cause of this study. The time series data covers the period beginning from 1980 to 2021. The agricultural output variables are: aggregate agricultural output ((AGP), livestock output (LVS), fishery output (FSP) and forestry output (FRY). The variables are in real terms except government spending and money supply and these are measured by M_2 and total government spending.

3.2 Theoretical Framework

The IS-LM framework established by Sir John Hicks in 1937 identified in the theoretical literature is considered relevant in order to appropriately specify the model as noted that exchange rate affects output through the general interactions between the aggregate supply and demand (Mirzaie & Kandil, 2019), hence the study adapts model (1) specified by Kandil and Bahmani (2020).

$\mathrm{AGP_t} = \varphi_0 + \emptyset_1 \mathrm{EXR_t} + \emptyset_3 M2_t + \emptyset_4 GXT_t + \delta_t$ …….. (1)

The above model (1) is however re-specified by incorporating net export (NXP) in order to bridge the gap as having discovered that exchange rate devaluation affects the level of export of any economy, therefore model (2) is specified below:

$\mathrm{AGP_t} = \varphi_0 + \emptyset_1 \mathrm{EXR_t} + \emptyset_2 \mathrm{NXP_t} + \emptyset_3 M2_t + \emptyset_4 GXT_t + \delta_t$ …….. (2)

$\emptyset_2 \rightarrow \emptyset_3 > 0$ and $\emptyset_1 < 0$

Where: AGP denotes Agricultural output, EXR represents exchange rate, NXP stands for net export, M_2 equals money supply, GXT is the government expenditure, δ_t represents the stochastic term, while $\emptyset_1 \rightarrow \emptyset_4$ are the parameters to be estimated and $\emptyset_0$ accounts for the intercept.

In addition, the study therefore applied the ARDL technique popularized by Pesaran and Peseran (1997), Peseran and Shin (1999), Peseran and Smith (1998) because of its numerous advantages. The main advantage of the technique lies in the fact that it is suitable irrespective of the fact whether the variables are integrated at different order i.e. I(0) or I(1) Peseran and Peseran (1997). The second advantage arising from the technique is that, the model accounts for the sufficient numbers of lags to appropriately capture the data generating process in the general to specific dynamic error correction model (ECM) which can be obtained from a simple linear transformation (Banerjer 1993). Error Correction Model integrates the short-run dynamics with the long-run equilibrium without losing any long-run information.

Being that as it may, equation (2) above accounts for the long-run agricultural model. In line with Mirzaie & Kandil, 2019, equation (2) can be established in an ARDL framework (see Pesaran and Shin 1999).

$$\Delta AGP_t = \vartheta_0 + \omega_1 AGP_{t-1} + \omega_2 EXR^{+}{}_{t-1} + \omega_3 NXP_{t-1}\ \omega_4 M_{2_{t-1}} + \omega_5 GXT_{t-1} + \omega_6 EXR^{-}{}_{t-1} + \sum_{i=0}^{s} \omega_i\, \Delta AGP_{t-1} + \sum_{i=0}^{s} \sigma_i\, \Delta AGP_{t-1} + \sum_{i=0}^{y} \propto_i \Delta NXP_{t-1} + \sum_{i=0}^{p} \nexists_i\, \Delta M_{2_{t-1}} + \sum_{i=0}^{s} \mu_i\, \Delta GXT_{t-1} + \sum_{i=1}^{v} (s_{i+}\, \Delta EXR^{+}{}_{t\text{-}1} + \sum_{i=1}^{p^+} (s_{i+}\, \Delta EXR^{-}{}_{t\text{-}1}) + \varepsilon_t \quad \ldots\ldots (2)$$

Where all the variables are previously defined, s, y, p and v are the lagged order and

$\emptyset_1 = -\frac{\omega_2}{\varphi_0}$,

$\emptyset_2 = -\frac{\omega_3}{\varphi_0}$, $\emptyset_3 = -\frac{\omega_4}{\varphi_0}$, $\emptyset_4 = -\frac{\omega_5}{\varphi_0}$

$\sum_{i=1}^{s} p^+$ accounts for the short-run effect of exchange rate on the agricultural output. The asymmetric effect of the short-run of exchange rate variation on the agricultural output variable may have also be captured by adding the asymmetric long-run relations

The study employs Augmented Dickey-Fuller Statistic and Phillip-Peron to ascertain stationarity of the time series data. Having established the existence of co-integration which determine the equilibrium long-run relationship between the dependent and the exogenous variables, inferences were drawn. The study also established the dynamic multiplier effect of 1% variation in $EXR^{+}{}_{t\text{-}1}$ and $EXR^{-}{}_{t\text{-}1}$ as:

$M_e{}^{+} = \sum_{i=0}^{e} \frac{\partial AGP_{t+i}}{\partial EXR^{+}{}_{t-1}}$, $M_e{}^{-} = \sum_{i=0}^{e} \frac{\partial AGP_{t+i}}{\partial EXR^{-}{}_{t-1}}$,

where e = 0, 1, 2 3 …n

Take note that e → ∞ as ∞ denotes n; $M_e{}^{+}$ → $\emptyset_3$ and $M^{-}{}_e \rightarrow \emptyset_4$

4. Results and Discussion

4.1 Unit Root Analysis

Table 1: Unit Root Test Results

Variables	At Levels		At First Diff.	
	ADF	Philip-Peron (PP)	ADF	Philip-Peron (PP)
AGP	-0.9622	-0.5214	-3.6632	-5.8144
EXR	-1.1330	-1.5661	-6.2311	-6.5233
NXP	-0.9221	-3.0869	-5.1131	Nil
M_2	-3.2441	-2.8642	Nil	-5.4006
GXT	-1.1843	-2.7712	-4.6412	-5.7114

The Test critical value at the 5% level: ADF = -2.9322 & Philip-Peron = -2.9271
Source: Author's Regression Output

The study employed the use of Augmented Dickey-Fuller (ADF) and Philip-Peron (PP) test statistic to ascertain stationarity. The findings are at levels and first difference as presented in table 1 above. The above results are characterized in ADF and Philip-Peron values in absolute terms. The implication is that the time series data indicate stationarity at level and at first difference which by implication would not guarantee long-run relationship except the time series data are differenced. Box and Jenkins (1978) had it that the non-stationary time series can be made stationary by taking the first difference of the variables. Given the results of the unit root test as reported in table 1, the ADF and (PP) test statistic of each of the variable shows that the variables are stationary at first difference except NXP and M_2 that obtained their stationarity at level thereby possessing unit root free. Bearing in mind that the asymptotic distribution of the Philip-Peron unit root test is the same with ADF test statistic, we can however accept either of the technique being suitable for our econometric analysis.

4.2 Lag Length Selection

Find below in table 2 the results of the lag length selection criteria. Annual time series data are employed for this study and the

maximum lag is 3 as indicated by the Final prediction error (FPE) indicating the minimum value.

Table 2 Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-2770.352	NA	2.65e+22	122.7521	122.8242	122.3303
1	-2464.254	451.8211	3.45e+25	103.1432	113.8055	105.1721
2	-2521.423	127.7501	6.72e+27	102.2611	112.4412	108.2230
3	-2241.991	95.1250*	2.17e+26*	101.5510*	111.4421*	104.3710*

*Indicates lag order selected by the criterion
Source: Author's Computation from the estimated output

4.3 Table 3: Bounds Test for Co-integration

F-statistic	Critical F-statistic Lower bound	K= 4 Upper bound	K= 4 Level of Significance
3.84	2.25	3.54	5%
	1.67	3.15	10%

K= Number of repressor i.e. 4

The table 3 above represents the computed F-statistic from the bound test result which is given as 3.84. The value appears greater than the upper bound critical value of 3.54 and 3,15 at the 5 and 10 per cent level. This means that the null hypothesis of no long-run relationship between the exchange rate devaluation and agricultural output is however rejected.

Table 5: Short–run Error Correction Representative for Selected ARDL Results with AGP as Dependent Variable

Variables	Coefficient	Std. Error	t-ststistic	Prob. value
C	85.1621	36.6621	2.3228	0.0512
D[AGP(-1)]	-0.6322	0.2054	-3.0778	0.0142
D[EXR(-2)]	-6.4503	3.5512	1.8163	0.1170
D[NXP(-1)]	0.0213	0.0041	5.1951	0.0162
$M_2(-3)$	2.5711	2.0052	1.2822	0.0233
D[GXT(-1)]	11.0821	4.4142	2.5105	0.0331
ECM(-1)	-0.9819	0.0607	16.1762	0.0281
R^2 = 0.84				
R^{-2} = 0.83				
F-statistic = 51.7732				
Durbin Watson = 1.92				

Source: Extracted from Regression Output

Table 6: Long-run Estimate with AGP as Dependent Variable

Variables	Coefficient	Std. Error	t-statistic	Prob. Value
EXR	10.1516	5.3376	1.9019	0.0822
NXP	1.8754	1.6114	1.1638	0.0210
M_2	1.8364	1.1261	1.6307	0.4502
GXT	-0.0005	0.0002	2.5000	0.0213
C	108.8926	10.7494	10.1301	0.0001

Source: Extracted from Regression Output

The results obtained from the estimated equation for the long-run and short-run indicates that the tested hypothesis of symmetrical relationship confirm the rejection of null hypothesis of long-run in the estimated models. The results also indicate that the long-run effect of exchange rate devaluation on the agricultural output are not the same with the short-run. Considering the short-run, the null hypothesis of asymmetrical adjustment was however rejected for the agricultural output. Given the results, there found asymmetrical relationship between the exchange rate and agricultural output in the short-run. The findings reveal that exchange rate devaluation has expansionary effect on agricultural output in Nigeria.

By this finding, we can see that the explanatory variables in the short-run estimate conform to the a-apriori theoretical expectation with a significant impact on the agricultural output. thereby accepting the theoretical views at their lagged periods.

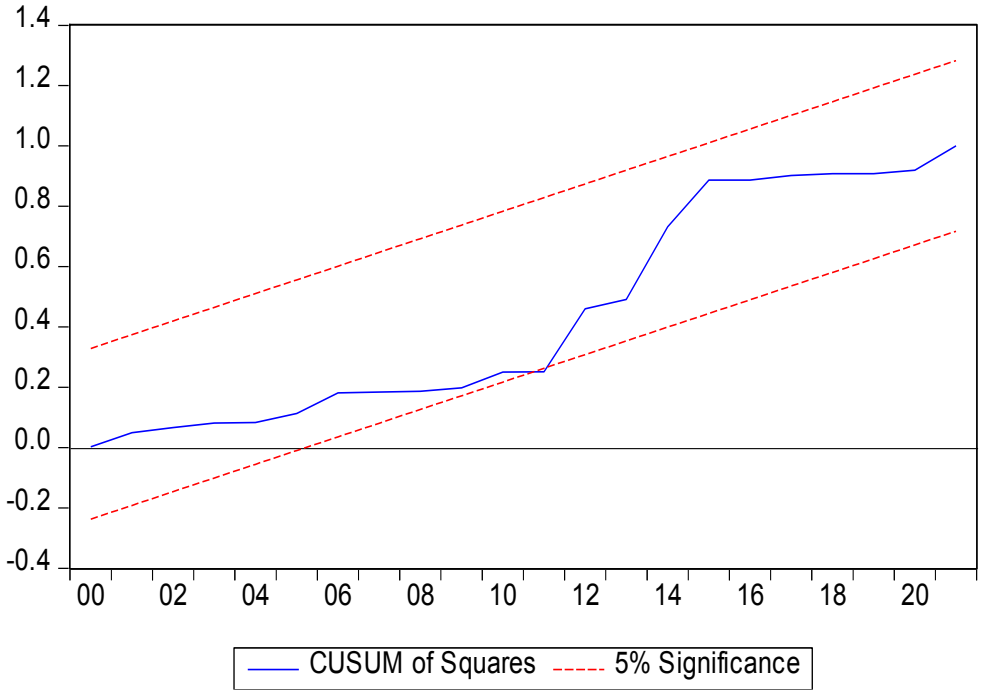
More importantly, the coefficient of exchange rate lagged two is correctly signed, implying that devaluation of exchange rate stimulates agricultural productivity in the economy. This is in line with the results of Kandil and Bahmani (2020) who examined the importance of the use of annual time series data on the nominal and real effectiveness of exchange rate in Iran where the study found out the existence of equilibrium long-run relationship between the exchange rate and output growth in Iran.

The coefficient of net export at lagged one is correctly signed. and conform to the theoretical view point that increase in net export enhances the agricultural performance. The findings also established statistical significance at the five per cent level. This result obtained is also similar with the long-run finding as an outcome performance of agricultural output.

As for the coefficient of money supply (M_2) in both long-run and short-run results, validate each other and this conforms to the theoretical hypothesized signed. The findings further show that a rise in money supply increases agricultural productivity. This finding also agrees with that of Yaqub (2021) who examined the effect of exchange rate variations on the demand for livestock in some selected sectors in Nigeria; where he obtained that exchange rate variation enhances the optimum performance of livestock productivity being one of the components of the agricultural sector.

The short-run dynamics of the model has the coefficient parameter estimate as -0.9819 and also statistically significant at the five per cent level which means the result is rightly signed as expected. This further denotes the speed of adjustment which stood at 98 per cent, by this, it defines disequilibrium in the short-run which the set of variables in the model are trying to correct in the long-run. Therefore, the long-run equilibrium is achievable.

Figure 1: Stability Test of the



Estimated Parameters

Stability test is performed using the cumulative sum of square (CUSUM Q) of residual of the ARDL Model as shown in figure 1 above. The essence of the parameter instability is established if the cumulative sum of the residual goes outside the area between the critical (dotted bounded) lines. It is estimated at the 5 per cent level of significance and it has been stable overtime.

5. Conclusion and Recommendations

This study attempts to explore the link between exchange rate devaluation and agricultural output in Nigeria. The study examined the relationship between the variables by analysing their long-run properties as well as the short-run dynamics. The econometric results from the error correction model revealed that net export, government expenditure and money supply have far reaching impact on the agricultural output in Nigeria.

The negative sign of the exchange rate marks the compliance of the economic theoretical expectation implying that exchange rate devaluation yields reduction in agricultural output.

From the foregoing, it is clear that the recent call for better economic policy that can appropriately warrant exchange rate stability is require as this can further bring about an improvement in the agricultural productivity performance and it will also enable a higher export product which by and large can warrants increase in the level of foreign exchange earnings.

The government should also increase the level of its expenditure on the agricultural sector because, by this action as discovered in the finding of this study will no doubt increase the agricultural output.

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