

# Exchange Rate Dynamics and Sectoral Output in Nigeria: A Symmetric and Asymmetric Approach

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## ABSTRACT

This study examined the symmetric and asymmetric effects of exchange rate dynamics on the performance of the agricultural, industrial and services sector of Nigeria using the ARDL and NARDL frameworks as well annual time-series data sourced from the Central Bank of Nigeria (CBN) Statistical Bulletin over the period of 1981-2016. The results of the short-run linear ARDL model reveal that exchange rate dynamics stimulates the performance of the agricultural and services sector of Nigeria while those of the nonlinear ARDL depict that exchange rate dynamics (depreciation and appreciation) is positively related to agricultural and services sector output but inversely related to industrial output. The result also showed that exchange rate dynamics has no asymmetric impact on sectoral performance which implies that positive and negative exchange rate movement have the same impacts on sectoral output both in the short-run and long-run. Therefore, this study recommended that the Nigerian government ensure adequate exchange rate management to encourage domestic investors and attract foreign investors to the various sectors of the Nigerian economy.

**Keywords:** ARDL, NARDL, Exchange rate, Sectoral output, Nigeria.

**JEL Classification:** C32; E58; F31.

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### **Highlights of this paper**

- This study evaluated the symmetric and asymmetric effects exchange rate dynamics on the performance of the agricultural, industrial and service sectors of Nigeria.
- The findings revealed that exchange rate dynamics stimulates the performance of the agricultural and services sector but dampens the performance of the industrial sector.
- Exchange rate dynamics has no asymmetric impact on sectoral performance

## **1. INTRODUCTION**

The introduction of Structural Adjustment Programme (SAP) by the International Monetary Fund (IMF) and World Bank in 1986 was instigated by the need to combat Nigeria's economic crisis which includes fiscal imbalance, fall in oil price, and persistent fluctuation of the exchange rate, among others. Nigeria dumped operating a fixed exchange rate regime, which she had adopted since her independence in 1960, in favour of a floating/flexible exchange rate regime where the forces of demand and supply are allowed to determine the value of the domestic currency (Adeoye & Atanda, 2011). However, since Nigeria floated her currency against other major currencies of the world by adopting a market determined exchange rate system via the second tier foreign exchange market, the naira exchange rate has exhibited signs of continuous depreciation and instability (CBN Statistical Bulletin, 2016; Hashim & Zarma, 1996).

This instability and continued depreciation of the naira in the foreign exchange market resulted in unfavourable balance of payments, rising public debts, depletion of foreign reserve, decline in the standard of living of the populace, and increased cost of production which was passed to the consumers in form of higher prices. It also undermined the international competitiveness of domestic products and made planning and projections difficult at both micro and macro levels of the economy. A good number of small and medium scale enterprises have been strangled out of business as a result of the volatility in exchange rate and so many other problems resulting from fluctuations in exchange rates (Adelowokan, Balogun, & Adesoye, 2015). This persistent depreciation of exchange rate since 1986 raises a lot of questions on the impact of exchange rate policies on sectoral output and the Nigerian economy as a whole.

Furthermore, the import-dependent nature of the Nigerian economy makes her be at the mercy of the developed countries, especially her trading partners, thereby making her highly susceptible to external shocks. Because the price of Nigeria's primary export product (crude-oil) is quoted in US dollar rather than in the domestic economy, there would be high demand for the US dollar at the expense of the Nigerian naira thereby leading to the appreciation of dollar at the expense of Naira. Consequently, a shock on the US economy will have devastating effect on the dollar/naira exchange rate. This is evidenced by the sharp fall in oil price in the international market from about \$120 per barrel to below \$40 per barrel between mid-2014 and late 2015. Recently, the Nigerian Naira depreciated greatly that the exchange rate stood at over ₦500 to 1USD (Akande, 2017).

In addition, the dependence of Nigeria on the rest of the world for not just finished goods but also raw materials and intermediate products shows that Nigeria imports all classes of products in different forms. These products (raw, intermediate and finished) are useful in the primary sector (agriculture), secondary sector (industry) and tertiary sector (services) of the Nigerian economy. Consequently, the effects of exchange rate movement infiltrates into the various sectors of the economy since all the sectors make use of imported products (consumer and capital goods) which are paid for in foreign exchange whose rate are highly volatile. Policy makers have often been presented with the problem of designing appropriate policies needed to cushion the effects of exchange rate movements and stimulate productivity in the various sectors of the Nigerian economy. Hence, the research questions this study seeks to provide answers to are: Is the relationship between exchange rate and sectoral output

linear (symmetric) or nonlinear (asymmetric)? Do exchange rate and sectoral output converge in the long-run? What are the symmetric and asymmetric effects of exchange rate movement on the performance of the agricultural, industrial and services sector of Nigeria? Which sector is most affected by exchange rate movement?

The results of this study will serve as an eye-opener to policy makers on the effects of exchange rate dynamics on sectoral output in Nigeria and how to cushion these effects to stimulate output in the various sectors of the economy. This study contributes to extant literature both empirically and methodologically. Empirically, it joins the debate on the effect of exchange rate dynamics on sectoral output and expands the frontier of knowledge on this subject matter in the extant literature especially in Nigeria. Methodologically, this study adopts the Autoregressive Distributed Lag (ARDL) and Nonlinear Autoregressive Distributed Lag (NARDL) framework to investigate the symmetric and asymmetric relationship between exchange rate movement and sectoral output in Nigeria. To the best of my knowledge, no study has employed these techniques simultaneously in Nigeria and no study has examined the impact of exchange rate movement on all the sectors of the Nigerian economy at a time.

The rest of this paper is structured as follows: section 2 focuses on stylized facts while review of the extant literature on exchange rate-output nexus is the main thrust of section 3. Section 4 contains data issues, methodology as well as empirical analysis while section 5 concludes the study with policy recommendations.

## **2. STYLIZED FACTS**

Exchange rate is an important macroeconomic variable as its appreciation/revaluation or depreciation/devaluation affects the performance of other macroeconomic variables in any open economy. Its value can be used to assess the overall performance of an economy hence, its consideration in key decision-making. Every government seeks to avoid exchange rate fluctuation because of its ability to cause negative distortion. Hence, the knowledge of exchange rate dynamics enables economic agents make informed decisions on hedging against risks resulting from exchange rate movement.

Nigeria has a long history of the exchange rate regimes adopted in the country overtime with the identification of five distinct regimes except for the period, 1972-1974, when there was confusion in the formulation of Nigeria's exchange rate policy. She operated a fixed exchange rate regime from 1960 to 1970, an adjustable peg exchange rate regime from 1974 to 1978, a managed float exchange rate regime from 1978 to 1985, a flexible exchange rate regime from 1986 to 1998 and a managed floating exchange rate regime from 1999 till date. Sadly, exchange rate volatility started in Nigeria in 1986 following the adoption of the Structural Adjustment Programme (SAP) and the deregulation of the foreign exchange market due to supply constraint (Hashim & Zarma, 1996). In addition, Pinto (1987) and Oyejide and Ogun (1995) argued that the fourth regime (1986-1998) is famous for its unprecedented level of exchange rate volatility.

Bridging the gap between the demand and supply of exchange rate in the foreign exchange market has been a major bottleneck for Nigeria which has resulted in the persistent depreciation of the naira. The institutions saddled with the responsibility of exchange rate management in Nigeria are the Foreign Exchange Market (FEM), the Federal Ministry of Finance and the Central Bank of Nigeria (CBN). The failure of these institutions to meet excess demand for foreign exchange compelled the government to ration the available foreign exchange which resulted in speculative hoarding and advancement of the parallel market.

The 2016 edition of the CBN statistical bulletin disaggregated the sector of the Nigerian economy into Agriculture, Industry, Construction, Trade and Services. However, this study will merge construction with industry and trade with Service, thereby summing up to three broad sectors with their corresponding sub-sectors – Agriculture (Crop Production, Livestock, Forestry and Fishing), Industry (Crude Petroleum & Natural Gas, Solid

Minerals, Manufacturing and Construction) and Services (Trade, Transport, Information and Communication, Utilities, Education, Human health and Social services, among others). The agricultural, industrial and services sectors denote the primary, secondary and tertiary sector respectively.

Figure 1 shows the trend of exchange rate and the sectoral output of Nigeria from 1981 to 2016. A cursory look at Figure 1 reveals that from 1981 to 1985, the naira exchanged favourably with the US dollars exchanging for less than one for one during this period before the introduction of SAP after which the exchange rate has continued to experience persistent depreciation. Following the fluctuation in exchange rate, the CBN regularly intervenes in the foreign exchange market and formulated several policies to ensure the stability of the naira even though this effort has not yielded the desired result as the rate stood at about ₦253/1USD in 2016.

Figure 1 also shows that agriculture, which was the mainstay of the Nigerian economy before the advent of oil in commercial quantities in the early 1970, has the lowest share in aggregate output for all the period under review except in 2016 when it toppled the share of industry in total output. In addition, it is apparent that the industrial sector takes the lion share in total GDP from 1981 to 1999. The high share of industry in total output is because the oil and gas sector, which has been Nigeria’s main export product and a major source of foreign exchange to the government, is a subsector of the industrial sector. The industrial sector has since 2003 surrendered its dominance to the services sector whose output has been growing consistently. Economic development theories postulate that when the service sector takes the lion share in total output, such economy is developed however, this assertion is not true for Nigeria as her growth is not sustainable, non-inclusive and inflationary.

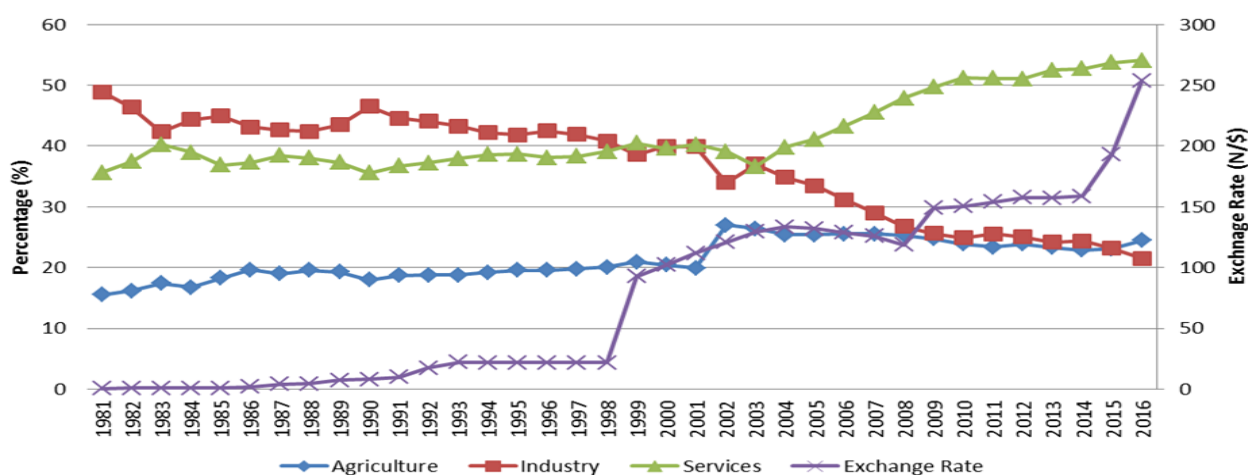


Figure-1. Sectoral share in total real GDP in Nigeria (1981-2016).

### 3. LITERATURE REVIEW

A plethora of country-specific and cross-country studies examining the macroeconomic impact of exchange rate movement on output exists in the extant literature albeit with mixed results. The proponents of positive impacts of exchange rate movement on output premised their arguments on the fact that there are several channels through which exchange rate movement affects output – it could affect output through price effect and employment effect (Abdul-Mumuni, 2016; Ajayi, Akinbobola, & Okposin, 2016; David, Umeh, & Ameh, 2010; Ebaidalla, 2013; Ehinomen & Oladipo, 2012; Enekwe, Ordu, & Nwoha, 2013; Ilechukwu & Nwokoye, 2015; Jongbo, 2014; Lawal, 2016; Mahmood, Ehsanullah, & Habib, 2011; Mensah, Awunyo-Vitor, & Asare-Menako, 2013; Sani, Hassan, & Azam, 2016).

On the other hand, some studies found that exchange rate volatility has negative effects on output and the aftermath is often devastating (Adelowokan et al., 2015; Basirat, Nasirpour, & Jorjorzadeh, 2014; Danladi & Uba,

2016; Dlamini, 2014; Javed & Farooq, 2009; Munthali, Simwaka, & Mwale, 2010; Sanginabadi & Heidari, 2012; Schnabl, 2007) while other studies found no relationship whatsoever between exchange rate variance and output (Akpan & Atan, 2011; Amassoma & Odeniyi, 2016). In addition, Uddin, Rahman, and Quaosar (2014) found a bidirectional causality running from exchange rate to GDP and vice versa in Bangladesh.

In terms of methodology, some authors employed the Generalised Least Square method (Basirat et al., 2014; Schnabl, 2007) two-stage least square and three-stage least square (Aman, Ullah, & Khan, 2017) Vector Error Correction Model (Adelowokan et al., 2015; Amassoma & Odeniyi, 2016; Munthali et al., 2010; Obayelu & Salau, 2010; Sani et al., 2016) Generalised Methods of Moment (Ajayi et al., 2016) Ordinary Least Square (Ehinomen & Oladipo, 2012; Ilechukwu & Nwokoye, 2015; Jongbo, 2014) Autoregressive Distributed Lag (Abdul-Mumuni, 2016; Javed & Farooq, 2009; Lawal, 2016; Sanginabadi & Heidari, 2012) Generalised Autoregressive Conditional Heteroscedasticity (Alagidede & Ibrahim, 2017; Dlamini, 2014; Ebaidalla, 2013; Sanginabadi & Heidari, 2012); Granger causality test (Adelowokan et al., 2015; Dlamini, 2014; Uddin et al., 2014) and the Structural VAR (Dlamini, 2014).

From the foregoing, it is apparent that there exist different studies in the extant literature examining the effects of exchange rate movement on output (sectoral or aggregate) in different countries of the world (Alagidede & Ibrahim, 2017; Ebaidalla, 2013; Munthali et al., 2010; Sanginabadi & Heidari, 2012; Uddin et al., 2014) however, only a few studies on this subject matter are available for Nigeria (Adelowokan et al., 2015; Ajayi et al., 2016; Amassoma & Odeniyi, 2016; Danladi & Uba, 2016). Disaggregating the Nigerian economy into agricultural, industrial and service sector, it was found that majority of the studies on the impact of exchange rate movement on sectoral output are done for the manufacturing sector (David et al., 2010; Ehinomen & Oladipo, 2012; Enekwe et al., 2013; Ilechukwu & Nwokoye, 2015; Jongbo, 2014; Lawal, 2016) while studies on the agricultural and services sector (Adekunle & Ndukwe, 2018; Obayelu & Salau, 2010) are particularly rare. This study will fill this gap by examining the impact of exchange rate dynamics on sectoral output in Nigeria.

Furthermore, the methodological review showed that some studies adopted the techniques of Ordinary Least Square (OLS) and Generalised Method of Moments (GMM) technique as well as Vector Error Correction Model (VECM), Vector Autoregression model (VAR), among others. The innovation of this study owing to the gaps in the literature, is that it employs the Autoregressive Distributed Lag (ARDL) and Nonlinear Autoregressive Distributed Lag (NARDL) framework in estimating the specified equations of this study because it can accommodate series that are integrated of the same order (that is,  $I(1)$  series) or series that are integrated of different orders (that is, both  $I(0)$  and  $I(1)$  series).

## **4. METHODOLOGY AND EMPIRICAL ANALYSIS**

### *4.1. Theoretical Framework and Model Specification*

Given that Nigeria is a small open economy, this study adopts the Mundell-Fleming model to examine the theoretical linkage between exchange rate and sectoral output. The Mundell-Fleming model describes the short-run relationship between an economy's nominal exchange rate, interest rate, and output as against the closed-economy IS-LM model, which focuses only on the relationship between the interest rate and output. It describes a situation where all market clear that is, a situation where there is equilibrium in the money market, product market and the balance of payments. The Mundell-Fleming model posits that exchange rate affects output through its effect on the current balance while interest rate affects output through investment. In relating exchange rate with output, a depreciation leads to an improvement in trade balance because export and domestic production would rise while an appreciation does otherwise, hence, exchange rate and output are positively related. On the other hand,

whereas an increase in interest rate lowers investment, its fall stimulates investment thus, interest rate and output are inversely related (Pilbeam, 2006).

In investigating the symmetric and asymmetric effects of exchange rate dynamics on sectoral output, this study employs the ARDL and NARDL framework developed by Pesaran, Shin, and Smith (2001) and Shin, Yu, and Greenwood-Nimmo (2014) respectively. The NARDL is an extension of the ARDL framework. The choice of these estimation techniques is predicated on the following reasons. First, the ARDL and NARDL framework accommodate variables that are stationary at level  $I(0)$ , first difference  $I(1)$  and/or both. Second, they offer a technique (Bounds test) that test for long-run relationship among macroeconomic variables incorporated in the model. Third, while the ARDL framework measures symmetric (linear) effect of the explanatory variable(s) on the dependent variable and NARDL measures the asymmetric (nonlinear) effects, they measure both the fixed and dynamic effect(s) the regressor(s) has/have on the regressand. Lastly, NARDL offers positive and negative partial sum decompositions of the independent variable(s) to capture the dynamic effect(s) of both positive and negative changes in an independent variable on the dependent variable.

Prior to the estimation of a time-series model, it is imperative to run some preliminary analysis such as stationarity and cointegration test to assess the time-series properties of the variables so as to guard against spurious results. In view of this, this study employs the Augmented Dickey-Fuller (ADF) and Philip Perron (PP) unit root test to check for stationarity and the ARDL Bounds test approach to check for cointegration. After ascertaining the stationarity and cointegration state of the variables, the short run and/or long run ARDL and NARDL models will be run. Subsequently, post-estimation tests will be carried out on the estimated models to check the appropriateness of the model results for policy prescription. It is expected that the estimated models do not violate the assumptions of the Classical Linear Regression Model (CLRM) which includes: no serial correlation, no heteroscedasticity, normal distribution and correct specification. The Wald test would also be carried out to test for short-run and/or long-run asymmetry.

Based on the theoretical framework, the explanatory variables of this study are: interest rate which is a key determinant of equilibrium in both IS-LM curves and exchange rate which is key to determining equilibrium in the BP curve. Since the Nigerian economy is disaggregated into three sectors -agriculture, industry and services, three models will be specified and estimated to analyse the relationship between exchange rate and sectoral output. The data used for analysis in this are annual time-series are sourced from Central Bank of Nigeria (CBN) Statistical Bulletin, 2016 edition, for the period of 1981-2016. All variables, except interest rate which is already in percentage, are expressed in their natural logarithm to aid the interpretation of the coefficients as elasticity form which helps avoid the complications that may arise from unit of measurement. With the first three models being the linear model [1 to 3] and the last three [4 to 6], the nonlinear model, the econometric models can be written as follow:

$$LAGRY_t = \alpha_0 + \alpha_1 MPR_t + \alpha_2 LEXR_t + \varepsilon_{1t} \tag{1}$$

$$LINDY_t = \beta_0 + \beta_1 MPR_t + \beta_2 LEXR_t + \varepsilon_{2t} \tag{2}$$

$$LSERY_t = \delta_0 + \delta_1 MPR_t + \delta_2 LEXR_t + \varepsilon_{3t} \tag{3}$$

$$LAGRY_t = \Omega_0 + \Omega_1 MPR_t + \Omega_2 EXR_t^+ + \Omega_3 EXR_t^- + \varepsilon_{4t} \tag{4}$$

$$LINDY_t = \infty_0 + \infty_1 MPR_t + \infty_2 EXR_t^+ + \infty_3 EXR_t^- + \varepsilon_{5t} \tag{5}$$

$$LSERY_t = \mathcal{L}_0 + \mathcal{L}_1 MPR_t + \mathcal{L}_2 EXR_t^+ + \mathcal{L}_3 EXR_t^- + \varepsilon_{6t} \tag{6}$$

#### 4.1.1. A priori Expectation

$$\alpha_0, \alpha_2 > 0; \alpha_1 < 0; \quad \Omega_0, \Omega_2, > 0; \Omega_1, \Omega_3 < 0$$

$$\beta_0, \beta_2 > 0; \beta_1 < 0 \quad \infty_0, \infty_2 > 0; \infty_1, \infty_3 < 0$$

$$\delta_0, \delta_2 > 0; \delta_1 < 0 \quad \mathcal{L}_0, \mathcal{L}_2 > 0; \mathcal{L}_1, \mathcal{L}_3 > 0$$

The ARDL representation of Equations 7, 8 and 9 and their corresponding error correction term (ECT) areas follow:

$$\Delta LAGRY_t = \phi_0 + \beta_1 \Delta LAGRY_{t-1} + \beta_2 \Delta MPR_{t-1} + \beta_3 \Delta EXR_{t-1} + \sum_{i=1}^n \alpha_{1i} \Delta LAGRY_{t-i} + \sum_{i=0}^n \alpha_{2i} \Delta MPR_{t-i} + \sum_{i=0}^n \alpha_{3i} \Delta EXR_{t-i} + \varepsilon_{1t} \tag{7}$$

$$\Delta LINDY_t = \omega_0 + \phi_1 \Delta LAGRY_{t-1} + \phi_2 \Delta MPR_{t-1} + \phi_3 \Delta EXR_{t-1} + \sum_{i=1}^n \gamma_{1i} \Delta LINDY_{t-i} + \sum_{i=0}^n \gamma_{2i} \Delta MPR_{t-i} + \sum_{i=0}^n \gamma_{3i} \Delta EXR_{t-i} + \varepsilon_{2t} \tag{8}$$

$$\Delta LSERY_t = \nu_0 + \sigma_1 \Delta LAGRY_{t-1} + \sigma_2 \Delta MPR_{t-1} + \sigma_3 \Delta EXR_{t-1} + \sum_{i=1}^n \zeta_{1i} \Delta LSERY_{t-i} + \sum_{i=0}^n \zeta_{2i} \Delta MPR_{t-i} + \sum_{i=0}^n \zeta_{3i} \Delta EXR_{t-i} + \varepsilon_{3t} \tag{9}$$

The NARDL representation of Equations 10, 11 and 12 are as follow:

$$\Delta LAGRY_t = \theta_0 + \psi_1 \Delta LAGRY_{t-1} + \psi_2 \Delta MPR_{t-1} + \psi_3^+ \Delta EXR_{t-1}^+ + \psi_4^- \Delta EXR_{t-1}^- + \sum_{i=1}^n \alpha_{1i} \Delta LAGRY_{t-i} + \sum_{i=0}^n \beta_{2i} \Delta MPR_{t-i} + \sum_{i=0}^n \beta_{3i}^+ \Delta EXR_{t-i}^+ + \sum_{i=0}^n \beta_{4i}^- \Delta EXR_{t-i}^- + \varepsilon_{4t} \tag{10}$$

$$\Delta LINDY_t = \theta_0 + \lambda_1 \Delta LINDY_{t-1} + \lambda_2 \Delta MPR_{t-1} + \lambda_3^+ \Delta EXR_{t-1}^+ + \lambda_4^- \Delta EXR_{t-1}^- + \sum_{i=1}^n \alpha_{1i} \Delta LINDY_{t-i} + \sum_{i=0}^n \alpha_{2i} \Delta MPR_{t-i} + \sum_{i=0}^n \alpha_{3i}^+ \Delta EXR_{t-i}^+ + \sum_{i=0}^n \alpha_{4i}^- \Delta EXR_{t-i}^- + \varepsilon_{5t} \tag{11}$$

$$\Delta LSERY_t = \xi_0 + \tau_1 \Delta LSERY_{t-1} + \tau_2 \Delta MPR_{t-1} + \tau_3^+ \Delta EXR_{t-1}^+ + \tau_4^- \Delta EXR_{t-1}^- + \sum_{i=1}^n \kappa_{1i} \Delta LSERY_{t-i} + \sum_{i=0}^n \kappa_{2i} \Delta MPR_{t-i} + \sum_{i=0}^n \kappa_{3i}^+ \Delta EXR_{t-i}^+ + \sum_{i=0}^n \kappa_{4i}^- \Delta EXR_{t-i}^- + \varepsilon_{6t} \tag{12}$$

Moreover, the error correction term representations of the above specified models are as follow Equations 13-18:

$$\varepsilon_{1t-1} = LAGRY_{t-1} - \alpha_1 MPR_{t-1} - \alpha_2 EXR_{t-1} \tag{13}$$

$$\varepsilon_{2t-1} = LINDY_{t-1} - \partial_1 MPR_{t-1} - \partial_2 EXR_{t-1} \tag{14}$$

$$\varepsilon_{3t-1} = LSERY_{t-1} - \infty_1 MPR_{t-1} - \infty_2 EXR_{t-1} \tag{15}$$

$$\varepsilon_{4t-1} = LAGRY_{t-1} - \gamma_1 MPR_{t-1} - \gamma_2^+ EXR_{t-1}^+ - \gamma_3^- EXR_{t-1}^- \tag{16}$$

$$\varepsilon_{5t-1} = LINDY_{t-1} - \int_1 MPR_{t-1} - \int_2^+ EXR_{t-1}^+ - \int_3^- EXR_{t-1}^- \tag{17}$$

$$\varepsilon_{6t-1} = LSERY_{t-1} - \mathcal{G}_1 MPR_{t-1} - \mathcal{G}_2^+ EXR_{t-1}^+ - \mathcal{G}_3^- EXR_{t-1}^- \tag{18}$$

Where:

LAGRY = Log of Agriculture GDP (Agricultural Sector Output).

LINDY = Log of Industry GDP (Industrial Sector Output).

LSERY = Log of Services GDP (Services Sector Output).

MPR = Monetary Policy Rate (Interest Rate).

LEXR = Log of Exchange Rate.

EXR<sup>+</sup> = Positive Changes in Exchange Rate (Exchange Rate Depreciation).

EXR<sup>-</sup> = Negative Changes in Exchange Rate (Exchange Rate Appreciation).

Δ = First Difference Operator.

ε<sub>1t</sub> = Disturbance Term for Linear Agricultural Output Equation.

ε<sub>2t</sub> = Disturbance Term for Linear Industry Output Equation.

ε<sub>3t</sub> = Disturbance Term for Linear Services Output Equation.

$\epsilon_{4t}$  = Disturbance Term for Nonlinear Agricultural Output Equation.

$\epsilon_{5t}$  = Disturbance Term for Nonlinear Industry Output Equation.

$\epsilon_{6t}$  = Disturbance Term for Nonlinear Services Output Equation.

#### 4.2. Preliminary Analysis

##### 4.2.1. Descriptive Statistics

Table 1 shows the descriptive statistics of the variables employed in this study. A cursory look shows that that all the variables except negative exchange rate changes (EXR<sup>-</sup>) are normally distributed as shown by the probability value of the Jarque-Bera supported by Skewness and Kurtosis for the series. In addition, the standard deviation shows moderate variability. The average value of negative changes in exchange rate, positive changes in exchange rate, log of exchange rate, log of agricultural output, log of industrial output, log of services output and monetary policy rate stand at 0.76, 2.54, 3.29, 8.66, 9.19, 9.34 and 12.99 percent respectively.

Table-1. Summary of descriptive statistics of the variables.

	EXR <sup>-</sup>	EXR <sup>+</sup>	LEXR	LAGRY	LINDY	LSERY	MPR
Mean	0.76	2.54	3.29	8.66	9.19	9.34	12.99
Median	0.00	2.97	3.81	8.43	9.12	9.09	13.00
Maximum	5.06	5.54	5.54	9.72	9.70	10.52	26.00
Minimum	0.00	-0.40	-0.49	7.74	8.68	8.59	6.00
Std. Dev.	1.75	2.15	1.95	0.67	0.30	0.66	4.20
Skewness	1.87	-0.07	-0.74	0.25	0.08	0.58	0.71
Kurtosis	4.60	1.43	2.20	1.55	1.86	1.87	4.12
Jarque-Bera	24.86	3.75	4.20	3.54	2.00	3.96	4.87
Probability	0.0000	0.1535	0.1224	0.1706	0.3672	0.1382	0.0875
Observations	36	36	36	36	36	36	36

##### 4.2.2. Correlation Matrix Result

Table 2 presents the correlation matrix result of the variables employed in this study. Correlation test is indispensable as it helps to determine the degree and direction of association between two variables as well as help in detecting multicollinearity among independent variables. Asteriou and Hall (2007) alluded that multicollinearity results when the correlation coefficient is more than the threshold of 0.9 or 90 per cent. Accordingly, incorporating the log of agricultural output, log of industrial output and log of services output and log of exchange rate in the same model as explanatory variables pose multicollinearity problems, a situation which this study took cognisance of when specifying its models. In addition, the correlation matrix result shows that except for monetary policy rate that is inversely correlated with negative exchange rate, log of agricultural output, log of industrial output and log of services output, all other variables are positively correlated with each other. It is noteworthy that negative changes in exchange rate has a relatively weak positive correlation with log of agricultural output, log of industrial output and log of services output as depicted by the correlation coefficient of 0.37, 0.34 and 0.33 respectively. On the other hand, positive changes in exchange rate has a moderate positive correlation with log of agricultural output, log of industrial output and log of services output as revealed by the correlation coefficient of 0.50, 0.52 and 0.48 respectively.

##### 4.2.3. Unit Root Test

It is customary in time-series analysis to carry out unit root test in order to check if a variable is stationary or time-variant that is, its order of integration so as to avoid a spurious regression. A variable is said to be stationary when it has constant mean, variance and covariance. Accordingly, this study adopts the Augmented Dickey-Fuller



(ADF) as well as the Phillip Perron (PP) unit root test approach. For a variable to be stationary, its ADF and PP test statistic must exceed the test critical values in absolute term at all significance level or its associated probability value must be less than 10 percent or 0.1.

Table-2. Correlation matrix result.

	EXR <sup>+</sup>	EXR <sup>-</sup>	MPR	LEXR	LAGRY	LINDY	LSERY
EXR <sup>+</sup>	1.00						
EXR <sup>-</sup>	-0.53	1.00					
MPR	0.33	-0.20	1.00				
LEXR	0.63	0.32	0.19	1.00			
LAGRY	0.50	0.37	-0.14	0.89	1.00		
LINDY	0.52	0.34	-0.05	0.89	0.97	1.00	
LSERY	0.48	0.33	-0.19	0.83	0.98	0.96	1.00

The unit root test for this study is presented in Table 3 and the ADF and PP unit root test results both show that monetary policy rate (MPR), log of industrial output (LINDY) as well as positive (EXR<sup>+</sup>) and negative (EXR<sup>-</sup>) change in exchange rate are stationary at level while log of agricultural output (LAGRY), log of service output (LSERY) and log of exchange rate (LEXR). Having established that none of the variables is integrated at order two, I(2), the use of the ARDL and NARDL framework is justified. The next line of action is to proceed to testing for cointegration using the ARDL Bounds test approach.

Table-3. Unit root test results.

	Augmented Dickey Fuller (ADF)			Phillip Perron (PP)		
	Level	First Difference	I(d)	Level	First Difference	I(d)
EXR <sup>+</sup>	-3.54***b	-	I(0)	-3.54***b	-	I(0)
EXR <sup>-</sup>	-3.68***b	-	I(0)	-3.69***b	-	I(0)
LAGRY	-2.09b	-5.72*a	I(1)	-2.11b	-5.72*a	I(1)
LEXR	-1.93a	-5.36*b	I(1)	-2.08a	-5.63*b	I(1)
LINDY	-3.93***b	-	I(0)	-3.93***b	-	I(0)
LSERY	-2.17b	4.02***b	I(1)	-1.82b	-3.37***b	I(1)
MPR	-3.19***a	-	I(0)	-3.14***a	-	I(0)

Note:\*, \*\* and \*\*\* implies statistical significance at 1%, 5% and 10% level respectively; 'a' denotes model with constant and 'b' is for model with trend and constant and I(0) and I(1) indicate stationarity at level and first difference respectively.

#### 4.2.4. Bounds Test Cointegration Result

Consequent upon the unit root test results, long-run relationship is checked using the Bounds test approach to cointegration. The justification for adopting this approach is that the variables of this study are stationary at levels and at first difference [I(0) and I(1)], a major requirement of the ARDL and NARDL framework. The null hypothesis of no long-run relationship among the variables will be tested. The decision rule for the Bounds test is that the null hypothesis should be accepted if the F-statistic is less than the lower bound, rejected when it falls above the upper bound and inconclusive if it falls in between the upper and lower bound.

Table 4 displays the results of Bounds test. It shows that the F-statistic of both Model 1 (1.23) and Model 4 (0.91) fall below the lower bound critical value at all level of significance thereby refuting the existence of linear and nonlinear cointegration among the variables in the respective models. In addition, the F-statistic of Model 2 (4.25) and Model 5 (3.35) fall between the lower and upper bound critical value at 5 per cent significance level suggesting that the cointegration test is inconclusive and would later be proven by the error correction coefficient of the estimated ARDL short-run model. Hence, for Model 2 and 5, the existence of the long-run relationship among the variable is uncertain. On the other hand, the F-statistic of Model 3 (7.76) and Model 6 (7.05) fall above the upper bound critical value at all significance level implying that there is a long-run relationship among the variables of

Model 3 and 6. In sum, it is evident that the same level of cointegration exists among the variables in the linear and nonlinear models for each sector of the Nigerian economy. Specifically, the results depict evidence in favour of both linear and nonlinear cointegration in all the sectors of the Nigerian economy.

The results of the Bounds test determine the type of model that would be estimated. The decision rule states that short-run and long-run ARDL and NARDL models should be estimated for models that show cointegration as well as those whose result is inconclusive while only the short-run error correction model should be estimated and reported for models that show no evidence of cointegration. Sequel to this, short-run and long-run ARDL and NARDL models will be estimated for Model 2, 3, 5 and 6 while only short-run ARDL model will be estimated for Model 1 and 4.

Table-4. Bounds test cointegration result.

Linear ARDL Models					
Significance Level	Critical Value		Model 1	Model 2	Model 3
	Lower (I0) Bound	Upper (I1) Bound	Computed F-Statistic	Computed F-Statistic	Computed F-Statistic
1%	5.15	6.36			
5%	3.79	4.85	1.23	4.25	7.76
10%	3.17	4.14			
Nonlinear ARDL Models					
Significance Level	Critical Value		Model 4	Model 5	Model 6
	Lower (I0) Bound	Upper (I1) Bound	Computed F-Statistic	Computed F-Statistic	Computed F-Statistic
1%	4.29	5.61			
5%	3.23	4.35	0.91	3.35	7.05
10%	2.72	3.77			

- Model 1: Linear Relation Between Exchange Rate and Agricultural Output.
- Model 2: Linear Relation Between Exchange Rate and Industrial Output.
- Model 3: Linear Relation Between Exchange Rate and Services Sector Output.
- Model 4: Nonlinear Relation Between Exchange Rate and Agricultural Output.
- Model 5: Nonlinear Relation Between Exchange Rate and Industrial Output.
- Model 6: Nonlinear Relation Between Exchange Rate and Services Sector Output.

4.3. Presentation and Analysis of Empirical Results

4.3.1. Analysis of the Short-run Symmetric and Asymmetric Effects of Exchange Rate on Sectoral Output

Table 5 presents the result of the symmetric and asymmetric effects of exchange rate variation on sectoral output in Nigeria. The coefficients of the error correction term (ECT) measures the speed at which the dependable variable adjusts from a short-run variance to its long-run equilibrium. It has to fulfil three basic conditions which are: it must be negative, statistically significant at 10 percent level and less than one in absolute term. A cursory look at Table 5 shows that the ECT coefficients meet a priori expectation at -0.28, -0.04 for the linear models and -0.20 and -0.04 for the nonlinear industrial and services sector output respectively. This implies that the speed of adjustment of industrial sector from its short-run disequilibrium to its long-run convergence is slow as about 28 per cent (for the linear model) and 20 per cent (for the nonlinear model) of the shock to its determinants in the previous period is accounted for in the current period. Similarly, the speed of adjustment of the Services sector from its short-run disequilibrium to its long-run convergence is extremely slow as only about 4 per cent of the shock to its explanatory variables in the previous period is corrected in the current period. However, the ECT coefficient of the agricultural sector output model is not significant at any conventional significance level indicating that there is no

long-run relationship among the variables in the model thus, giving credence to the result of the cointegration test earlier conducted.

In the linear ARDL model results, it is apparent that exchange rate has a significant positive relationship with agriculture and services output while it has a negative impact on industrial output albeit insignificant. Specifically, a depreciation in the exchange rate stimulates output in the agricultural and services sector by 0.04 percent and 0.03 per cent respectively. This result agrees with the findings of [Obayelu and Salau \(2010\)](#), [Jongbo \(2014\)](#) and [Ilechukwu and Nwokoye \(2015\)](#), [Adekunle and Ndukwe \(2018\)](#) as well as with economic theory which posits that a depreciation in exchange rate makes exports cheaper and imports dearer thus triggering price and volume effect which leads to an increase in domestic production in order to meet up with the increasing demand for local products by the rest of the world. The result of the negative and insignificant relationship between exchange rate and industrial output is in consonance with the findings of [David et al. \(2010\)](#) and [Nwokoro \(2017\)](#) and could be linked to the neglect of the manufacturing sector when crude-oil was discovered in commercial quantities in the early 1970s which has drastically reduced its contribution to aggregate output and investment in the sector. It could also be explained by the J-curve effect which posits that the effect of exchange rate movement takes time before it affects economic performance owing to time lag in producer and consumer responses as well as imperfect competition.

On the other hand, the nonlinear ARDL results show that negative and positive changes in exchange rate signifying exchange rate appreciation and depreciation respectively have significant influence on agricultural output. Interestingly, exchange rate appreciation and depreciation have the same impact on agricultural output. Specifically, an appreciation or depreciation in exchange rate by one per cent will respectively increase or reduce agricultural output by 0.04 percent. Similarly, exchange rate appreciation and depreciation have a significant positive relationship with service sector output such that a positive or negative change in exchange rate will lead to 0.02 per cent and 0.03 percent increase in services sector output respectively. This indicates that the productivity of the services sector will increase irrespective of the direction of movement in exchange rate although an appreciation has more impact on its output than a depreciation. However, there is an inverse relationship between industrial output and exchange rate depreciation and appreciation. Specifically, industrial output plummets by about 0.04 per cent and 0.03 per cent respectively if exchange rate depreciates or appreciates by one per cent. This implies that the impact of a depreciation in exchange rate on industrial output is more than that of an appreciation.

Moreover, in line with theoretical postulation, [Table 5](#) shows that monetary policy rate is inversely related to agricultural, industrial and services output for both the symmetric and asymmetric models except in the linear industrial model (Model 2) that reveals a positive relationship between monetary policy rate and industrial output. However, the relationship is only significant in the service sector indicating that monetary policy rate is a major driver of output in the Nigerian services sector. Specifically, an increase in monetary rate by one percent decreases service sector output by 0.004 percent implying that services sector output is less responsive to a change in monetary policy rate. Economic theory posits that an increase in interest rate is a disincentive to investors as they lower investment thereby reducing productivity in the various sectors of the economy. This result supports the finding of [Mensah et al. \(2013\)](#), [Ehinomen and Oladipo \(2012\)](#) and [Nwokoro \(2017\)](#).

It is noteworthy that the linear and nonlinear models for each sector have the same explanatory power and a viable goodness of fit such that about 98, 96 and 99 percent of the variation in the agricultural, industrial and service sector output are explained by exchange rate and interest rate. Furthermore, the respective probabilities of the F-statistic of each linear and nonlinear sectoral model show that the explanatory variables in each model jointly influence the dependent variable. Remarkably, the robustness of this analysis is apparent as the results of the linear

ARDL models are closely related or the same in some case with the nonlinear ARDL models thus, validating the appropriateness of these models for policy formulation and/or prescriptions.

Of utmost importance is the test for asymmetry whenever a NARDL framework is adopted. Hence, this study tests for short-run and long-run asymmetry using the Wald test. The null hypothesis states that there is no asymmetry while the alternative hypothesis states otherwise. The decision rule is that if the probability value of the Wald test is less than 0.1 or 10 percent, the null hypothesis will be rejected and accepted if otherwise. A cursory look at the result of the Wald test as presented in Table 5 shows that probability values of the Wald test are greater than 0.1 or 10 percent in all the models suggesting that the null hypothesis should not be rejected both in the short-run and long-run. Intuitively, this indicates that exchange rate dynamics (depreciation and appreciation) have no asymmetric impact on the performance of the agricultural, industrial and services sector of Nigeria and that positive and negative exchange rate movement have the same impacts on sectoral output both in the short-run and long-run. The Wald test result is similar to the findings of Adekunle and Ndukwe (2018) most especially in the case of agricultural output.

Also, post-estimation tests were carried out to examine if the respective estimated models do not violate the assumptions of the Classical Linear Regression Model (CLRM) so as to determine if the estimated models are reliable and appropriate for policy prescriptions. Specifically, this study checked for serial correlation, heteroscedasticity, normality and correct specification form of the estimated models. The results as depicted in the latter part of Table 5.5 show that all the errors of the estimated models except Model 1 and 4 are normally distributed; serial correlation and heteroscedasticity are absent in all the models and all the models except Model 3 passed the correct specification test indicating that they are correctly specified.

Table-5. Results Short-run ARDL and NARDL Models.

Variables	ARDL Models			NARDL Models		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
D(EXR <sup>+</sup> )	-	-	-	0.037***	-0.035**	0.023*
D(EXR <sup>-</sup> )	-	-	-	0.036***	-0.032**	0.029*
D(LEXR)	0.037***	-0.048	0.026*			
D(MPR)	-0.004	0.003	-0.004**	-0.004	-0.001	-0.003***
ECT(-1)	-0.09	-0.28*	0.04***	-0.09	-0.20**	-0.04***
Adj. R <sup>2</sup>	0.98	0.96	0.99	0.98	0.96	0.99
F-Statistic	858.58 (0.0000)	171.96 (0.0000)	3740 (0.0000)	624.34 (0.0000)	182.20 (0.0000)	2929.60 (0.0000)
Jarque-Bera	299.57 (0.0000)	1.72 (0.4230)	0.36 (0.8362)	290.73 (0.0000)	0.70 (0.7045)	3.90 (0.1422)
Normality Test						
Breusch-Godfrey	1.52 (0.4688)	1.89 (0.3890)	0.69 (0.7096)	1.67 (0.4344)	1.34 (0.5107)	0.12 (0.9437)
Serial Correlation LM Test						
Heteroscedasticity Test (ARCH)	0.03 (0.8596)	0.48 (0.4897)	0.57 (0.4500)	0.03 (0.8613)	0.32 (0.5692)	0.16 (0.6807)
Ramsey RESET	1.38	2.24	4.48	1.29	2.22	2.34
Linearity Test	(0.2494)	(0.1264)	(0.0429)	(0.2653)	(0.1473)	(0.1365)
Wald Test for Short-Run Asymmetry	-	-	-	0.06 (0.8150)	0.37 (0.5470)	2.37 (0.1341)
Wald Test for Long-Run Asymmetry	-	-	-	0.05 (0.8175)	0.33 (0.5675)	1.25 (0.2726)

Note: \*, \*\*, \*\*\* represent the probability values of the coefficients at 1%, 5% and 10% level of significance respectively; the values in parentheses are the probability values of the post-estimation tests.

4.3.2. Analysis of the Long-run Symmetric and Asymmetric Effects of Exchange Rate on Sectoral Output

Table 6 presents the results of the long-run symmetric and asymmetric effects of exchange rate and sectoral output in Nigeria. As reported by the Bounds test, there is no long-run relationship among the variables in Model 1 and Model 4. However, as reported by the Bounds test (for Model 3 and 6) and ECT coefficients (for Model 2, 3, 5 and 6), the variables of these models converge in the long run. For the linear ARDL model, the long run results show that exchange rate has a positive impact on industrial and service sector output in Nigeria such that industrial and service sector output will increase by 0.16 per cent and 0.64 per cent respectively if exchange rate depreciates by one per cent. This implies that the services sector is more affected by exchange rate movement than the industrial sector thus, giving credence to the earlier assertion that the low contribution of the industrial sector to total national output due to its neglect in the past 3 decades. Similarly, the results reveal an inverse relationship between monetary policy rate and industrial and services sector output. Specifically, an increase in monetary policy rate by one percent will, on the average, lower industrial and service sector output by 0.01 per cent and 0.1 per cent respectively. This result is in line with theoretical expectation.

On the other hand, the results of the asymmetric (nonlinear) effect of exchange rate dynamics on sectoral output show that positive and negative changes in exchange rate (exchange rate depreciation and appreciation respectively) have a significant positive relationship with industrial and services sector output in Nigeria. Specifically, if exchange rate depreciates or appreciates by one percent, industrial output will increase by approximately 0.18 percent and 0.16 percent respectively while services sector output will increase by 0.62 percent and 0.77 percent respectively. This shows that exchange rate appreciation exerts more impact on services sector output than its depreciation while the converse is true for the industrial sector. This further implies that irrespective of the direction of movement of exchange rate, industrial and services sector output will increase. As is the case in the linear models, monetary policy rate exerts significant negative impacts on industrial and services sector output in Nigeria such that industrial and services sector output decreases by approximately 0.01 percent and 0.09 percent respectively when monetary policy rate increases by one percent.

Summarily, a critical look at the long-run linear and nonlinear models reveals that the magnitudes of the impact of exchange rate changes as well as monetary policy rate on industrial and service sector output are almost the same or very close. In addition, the direction of relationship between exchange rate and industrial and service sector output (positive) as well as monetary policy rate and industrial and service sector output (negative) are the same for the linear and nonlinear model thereby indicating the robustness of the findings of this study. The values of their constant term too are worth mentioning in that they are positive in line with a priori expectations and almost the same in both the symmetric and asymmetric model.

Table-6. Results of Long-run ARDL and NARDL Models.

Variables	ARDL Models			NARDL Models		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
EXR <sup>+</sup>	-	-	-	-	0.177*	0.616*
EXR <sup>-</sup>	-	-	-	-	0.157*	0.770**
LEXR	-	0.158*	0.635*	-	-	-
MPR	-	-0.006	-0.102**	-	-0.005	-0.089***
Constant	-	8.851*	9.822*	-	8.755*	9.709*

Note: \*, \*\*, \*\*\* represent the probability values of the coefficients at 1%, 5% and 10% level of significance respectively.

5. CONCLUSION AND POLICY IMPLICATIONS

This study examined the symmetric and asymmetric effects of exchange rate dynamics on sectoral output by disaggregating the Nigerian economy into agricultural, industrial and service sector using annual time-series data

sourced from the Central Bank of Nigeria (CBN) Statistical Bulletin over the period of 1981 – 2016. Accordingly, six models (3 linear ARDL models and 3 Nonlinear ARDL models) were specified and estimated. The results of the Augmented Dickey Fuller and Philip Perron unit root tests showed that the variables are integrated of different orders, I(0) and I(1) thus meeting the requirement for carrying out a Bound test cointegration test. The Bounds test results showed the non-existence of cointegration in Model 1 and 4, inconclusive results for Model 2 and 5 and the existence of cointegration in Model 3 and 6.

Furthermore, the results of the short-run linear ARDL model reveal that exchange rate dynamics stimulates the performance of the agricultural and services sector of Nigeria while those of the nonlinear ARDL depict that exchange rate depreciation and appreciation is positively related to agricultural and services sector output but inversely related to industrial output. In addition, the monetary policy rate is inversely related to agricultural, industrial and services sector output, however, the degree of responsiveness of agricultural, industrial and services sector output to a change in monetary policy rate in both the linear and nonlinear models is very low.

Similar to the short-run results, the long run results show that exchange rate movement (depreciation and appreciation) have positive impacts on agricultural, industrial and services sector output while monetary policy rate is inversely related to these sectors' performance. The results of the Wald test suggested that exchange rate dynamics (depreciation and appreciation) have no asymmetric impact on the performance of the agricultural, industrial and services sector of Nigeria and that positive and negative exchange rate movement have the same impacts on sectoral output.

In the light of these empirical findings, it is imperative to highlight some policy implications. First, the Nigerian government and monetary authorities should formulate appropriate exchange rate policies and develop sound exchange rate management mechanism to effectively manage exchange rate so as to cushion the effects of its shock on the Nigerian economy. Second, Nigeria should give priority to the enhancement and promotion of a stable exchange rate and interest rate policy that will encourage domestic investors and attract foreign investors to invest in the various sectors of the Nigerian economy. Lastly, since exchange rate dynamics affect each sector differently, it is needful that a sector be given priority at a time by implementing the exchange rate and interest rate policy that would stimulate the growth of the sector.

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