

# Foreign Exchange Market Intervention and Exchange Rate Stability: An Empirical Anayisis for Nigeria

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## **Authors' contributions**

*This work was a collaborative effort of all the authors. Author EAK is the lead author, who conceived the idea for the study, supplied the background, the summary and the recommendation. Author OAM ran the regression, performed the statistical analysis and handled the logistics. Author IAB contributed the literature review, sourced for data and logistic support. All authors read and approved the final manuscript.*

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## **ABSTRACT**

The essential roles played by exchange rate on general macroeconomic stability has attracted the Central Bank of Nigeria (CBN) to intervene in the foreign exchange market, in order to smoothen exchange rate volatility, among other goals. The study to examine the impact of foreign exchange market intervention on stability of exchange rate in Nigeria with a monthly time series data from 2000M1 to 2020M12. The research employs the use of Autoregressive Distributive Lag approach (ARDL) of analysis. The result indicates that the currency interventions policy of the CBN in Nigeria is effective and exerts significant impact on the exchange rate stability of Naira in both in the short and long-run within the period under investigation. We, therefor, recommend that the monetary authority should continue to employ the usage of stock of foreign reserves in supporting the exchange rate by increasing funding of the operations in foreign exchange market.

*Keywords: Foreign exchange intervention; exchange rate; CBN; ADF; PP; ARDL.*

## 1. INTRODUCTION

One of the major mandates of the Central Bank of Nigeria is to ensure monetary and price stability. Various macroeconomic policies are set out to impact positively on general macroeconomic stability [1-4]. The policies are deployed to accomplish various economic purposes which include: inclusive and sustainable economic growth, stable prices and exchange rate, optimal employment rate and favourable position for balance of payments (Moreno, 2005). Achieving the objectives is a sine-qua-non for economic prosperity of any nation, though an objective may conflict with another. The duo of monetary and exchange rate policies is employed in conjunction with fiscal policies to achieve the critical macroeconomic objectives [5].

The Central Bank of Nigeria (CBN) has been engaging in intervention activities in the foreign exchange market (FEM) in the last two decades, largely to stabilize and support the naira value of Nigerian currency, though the supportive initiatives remain provisionally and brief [6,7]. Typical illustration of this is the fact that the country has been among the most active economies in the foreign exchange market (FEM) in the period between 1993 and 1995 [6,8]. In December 2014 only, the Bank expended around \$2.30 billion in the defense of her currency from depreciating in value [9]. Similarly, in her bid to stabilize and strengthen the Naira value, the Bank engaged in other intervention operations in Q1 2015, which cost the Central Bank of Nigeria \$4.70 billion according to [10]. Basu, K., Varoudakis, A. [11] contended that the monetary authorities intervene in the foreign exchange market, particularly in economies using floating exchange rate to: (i) avoid misalignment of exchange rate; (ii) circumvent disorderly foreign exchange market; (iii) external reserves management; and (iv) "lean against the wind." In Nigeria, like several Emerging Market and Developing Economies (EMDEs), conserving a reasonable local currency value is highly essential, given the nature and structure of the economy as well as the wish to achieve a balance for domestic consumption and production, generate and enhance the sources of foreign exchange inflows and create enabling environment for foreign capitals from multi-national concerns [12-18]. In

addition, it is believed that it would address the protracted waves facing Nigerian economy, which consist of capital flights, huge consumable commodities importation, brain drain and lack of linkages among processes of production [6].

At present, the CBN operate a flexible floating exchange rate regime with multiple windows including the interbank (official), Investors and Exporters (I&E) window, Bureau de Change (BDC), Small and Medium Enterprises (SME) and Secondary Market Intervention Sales (SMIS). Under the multiple windows arrangement, some transaction takes place in a freely market determine rate, while rates are pegged for different critical sectors of the economy [19,20].

However, research works abound on the impact of central bank's intervention activities in the foreign exchange market, majority of them paid attention to the developed economies (America, Europe and Asia). The studies on the subject are scanty in Africa and Nigeria especially. For example, in Nigeria, there are few works [7,8,21] known to the author. The existing studies for Nigeria exclude the variable for exchange rate, which is the variable of interest for foreign exchange intervention. Since the inception of the Import & Export (I&E) window in 2017, the level of intervention by the CBN has increase significantly, yearly intervention excluding I & E sales amounted to \$15,193.45 million, \$17,404.51 million, \$22,013.84 million and \$5,535.51 million for 2017, 2018, 2019 and 2020 respectively (CBN) [22-27]. Therefore, there is need to expand the period of the existing studies in order to capture current economic realities. This is practically the motivation for this study.

The aim of this research work is to evaluate the long-run relationship between the CBN foreign exchange interventions and the stability of naira exchange rate. To achieve this objective, the study employs time series data from 2000M1 to 2020M12 with both the Augmented Dickey Fuller (ADF) and Phillips Perron (PP) test to ascertain the stationarity status of the variables. In addition, to establish the long-run relationship between the parameters, we adopt Autoregressive Distributive Lag (ARDL) approach.

The study is arranged as follows: The first chapter is introduction while Chapter 2 reviews the relevant empirical literature. Chapter 3 deals with Methodology while Chapter 4 entails Data presentation, data analysis and interpretation of Result. Finally, Chapter 5 presents the summary, conclusion, and recommendations.

## 1.1 Review of Empirical Literature

The impact of Monetary Authority's intervention in Foreign Exchange Market to address certain market failure has been a subject of controversial discussion in various researches [28]. The status is attributable to inconclusiveness of findings of earlier researches [29,30] (Dominguez, 2003).

Bonser-Neal, C., Roley, V.V., Sellon, G.H.Jr. [31] adopted Model of Event-Study and discovered that intervention operation of Federal Reserve in the foreign exchange market is effective and significant in stabilizing the US Dollar value. This result contradicts Dominguez [32], using GARCH (1, 1) Model and discover that the covert intervention by the Federal Reserve in foreign exchange market accentuate the volatility in the value of US Dollar whereas the publicized intervention results in disorderliness and uncertainty in the foreign exchange Market.

Simwaka and Mkwandawire [33] with the aid of GARCH (1, 1) researched into impact of the Intervention of the Monetary Authority and discovered that the formal interventions in the foreign exchange market by the Reserve Bank of Malawi (RBM) impact on Kwacha, though very insignificant, nevertheless, still important in decreasing the unwelcome fluctuation in the currency value. They resolved that there is depreciation rather than appreciation in the value of Kwacha net sales of dollars by RBM.

Frenkel et al., [34] establish that intervention operations in the foreign exchange market by the Bank of Japan (BoJ) is unproductive and insignificant in stabilization of Japanese Yen value. Nevertheless, their discovery contradicts Hillebrand and Schnabl [35], Kurihara (2011), Reitz and Taylor (2012) and Seerattan [36]. Adebisi, [7] employed autoregressive distributed lag (ARDL) approach in evaluating the intensity of foreign exchange intervention on monetary aggregates. He concluded that that there was no strong relationship between intervention variables and exchange rates. This was not unconnected with insufficient funding of

intervention operations due largely to lower external reserves accumulation, non-harmonization of policy on intervention with relevant macroeconomic policies and recurrent interference in the process of policy execution by politicians.

The economic relationship among inter-bank exchange rate, covert intra-daily data, and the dollar amount transacted (bought and sold) was investigated by Lahura and Marco [37] with the aid of structural vector autoregressive (VAR) Model, and they discover that intervention in foreign exchange market in Peru is effective and substantial in inducing the exchange rate in the desired path. It is however, discovered that sales interventions are more efficient, compared with purchase interventions.

Investigation of the impact of Foreign exchange market intervention on the stability of Naira was conducted by Omojolaibi and Gbadebo [8]. They applied ARDL model on four yearly time series data between the year 1970 to 2006. The variables of interest consist of the cumulative foreign private inflow, money supply, the real gross domestic product, the structural break and the cumulative net foreign assets. The outcome established the presence of long run equilibrium relationship between the monetary authority's foreign exchange market intervention and the variables for supply of money. Consequently, the Central Bank of Nigeria's intervention activity is viewed as non-sterilized [38-41]. It should be noted that this work excluded the exchange rate variable, which is the key focus of the intervention in foreign exchange in Nigeria. The ARDL adopted has been found to possess very low degree of freedom with respect to equation estimation on regressors containing numbers that are large. This suggests that the ARDL may not display more than one relationship of equilibrium in a given model [42].

It is also noted that most of the previous works mentioned made use of GARCH (1, 1) model in their researches. A GARCH (1, 1) model requires several years of daily data for the model to be statistically significant. However, as a result of insufficient data on interventions in the economies examined, as well as the lack of actual data on intervention in most nations, their results from the GARCH (1, 1) model may not be absolutely dependable. Other disadvantage of GARCH (1, 1) is that its outcomes are premised on extent of

movements among the variables under study and without consideration for causality route [43-46].

Lorna K. & Frank W. Agbola [47] evaluate the impact of central bank's foreign exchange intervention on the degree of fluctuation of the Uganda Shillings/US dollar (UGX/USD) exchange rate, in an inflation targeting environment, using GARCH framework. Their empirical results show that the intervention has mixed impact on the fluctuation in the foreign exchange rate, as the inflation targeting framework is able to curtail short-term exchange rate shocks. It is discovered in the study that an increase in operating target and interbank rate are capable of increasing exchange rate volatility, while inflation targeting is a potent instrument for curtailing exchange rate fluctuations.

Hamisu A. and James T. H. [21] employ Error Correction Model (ECM) to evaluate the impact of currency intervention on the volatility of exchange rate of naira against the US dollar (N/US dollar). They find out that the intervention has no significant short-run impact on the exchange rate and that the intervention is not sterilized.

Agenor P., Jackson P. I. and Da Silva L. P [48] examine the effect of sterilized intervention in foreign exchange market for an open economy with the aid of DSGE model assuming imperfect capital mobility and financial frictions. The monetary authority adopts a managed float regime with sterilization bonds issuance, which are regarded as imperfect substitutes for investment loans in portfolios of banks. They parameterized the model, which is employed to evaluate macroeconomic impact and response of the policy to, inflows of capital related to temporary shocks to global interest rates. They discover that interventions that are sterilized could be accommodative via portfolio effect of bank and could exacerbate volatility and risk of financial stability. They conclude that the complete sterilization is optimum only if the portfolio effect of bank is lacking. However, the optimum level of intervention is better impactful

when the monetary authority can simultaneously select the sterilization level, that is, the instruments are compliments and the objectives function depend on the sterilization cost. The consideration for the cost are adequately high, noting that sterilization and intervention could be substitutes; independent of whether financial stability and exchange rate consideration are essential.

Ali U. A., Suraya I., Siba D., Ahmad A. A., Ibrahim S. F., Aminu H. J. & Umar A. M. [49] examine the long run relationship between the CBN intervention and exchange rate from 1980 – 2018, with the aid of non-linear unit root, co-integration and causality testing approach. Their findings reveal that there is a long run relationship between the intervention and Naira/USD exchange rate.

Though, earlier studies maintained that the more regular, timely and appropriate interventions in the market tend to be more productive than interventions that are bulky and mostly one-off. [36]; interventions relating to sales are discovered to be more efficient than purchases-based interventions in the market [37]; government meddling and supports for intervention measures influence the efficiency of policies on interventions [7,35]. Greater percentage of the studies that affirm the efficacy of interventions in foreign exchange in decreasing disorderly market and exchange rate volatility employ VAR Markov-Switching Models and structured VAR (SVAR) [36].

## 2. RESEARCH METHODOLOGY

### 2.1 Data and Variables

To analyze the long-run relationship between forex intervention as proxy by International Reserves and the stability of naira exchange rate (BDC), the study employs monthly time series from 2000M1-2020M12, data sourced from the statistics database of Central Bank of Nigeria (CBN). The summary of the variables and their sources are presented below.

**Table 1. The summary of the variables and their sources**

Variable	Description	Source
EXR	Interbank Exchange Rate	CBN
Oil Price	International Oil Price	CBN
Reserves	External Reserves	CBN
NFA	Net Foreign Asset	CBN

## 2.2 The Model

The analysis considers a model with impact of forex intervention on the stability of exchange rate with International Reserves as proxy for intervention and other control variables including NFA and oil price, which have direct impact on the exchange rate stability in Nigeria. The Nigerian International Reserves remain an important macroeconomic variable as it has always helped the Central Bank of Nigeria to sustain forex interventions and reduce pressure on the local currency against major international currencies. Therefore, the work enlist Reserves to proxy interventions in accordance with the work of Nwachukwu, Ngozi E. et al. [50].

Accordingly, the model takes the following format in accordance with the works of Adebisi [7] and Hamisu Ali et al [51] and with all the parameters expressed in log and linear equation as captured below:

$$\ln(EXR_t) = \delta_0 + \ln(\delta_1 Res_t) + \ln(\delta_2 NFA_t) + \ln(\delta_3 Oil Price_t) + e \tag{1}$$

Where EXR. Rate is the log of exchange rate which represents the dependent variable whose behavior and reaction is to be measured; Res is the log of International Reserves; NFA is the log of Net foreign Asset in US\$ million, and Oil Price is the log of International Oil Price. Stochastic error term is represented by e.

The coefficients are:  $\delta_1, \delta_2, \delta_3$ , denote the elasticities of all the independent variables in the long-run. The parameters in equation (1) capture the response of Exchange Rate to changes in its determinants, which are other parameters in the model. Based on theory, Exchange rate, Oil Price, Reserves and Net Foreign Asset are expected to be negatively related.

## 2.3 Econometric Method

This study adopts the Auto Regressive Distributive Lag (ARDL) Bound testing model developed by Pesaran and Shin [52] which is an improvement on the existing literature on the subject matter. The model is preferred because it is not only appropriate for modelling a time series small samples analysis like this but also have inbuilt mechanism to overcome spurious outcomes over the use of an ordinary least squared (OLS) model. However, according to [53], other methods to cointegration have inbuilt restrictive assumptions. ARDL also has advantage of application regardless of the order of integration of the variables (I (0) or I (1)),

though must not be I(2) especially in determining the long-run relationships. The use of ARDL approach does not only overcome the shortcomings of unit-root in regression, but also capable of solving the often-present problem of serial correlation in time series data Laurenceson and Chai [54] and [55]. Moreover, in cases where some parameters are endogenous, the use of ARDL also provides unbiased estimates of the long-run model.

Following [52], the error correction version of the ARDL model is stated as follows:

$$\Delta y_t = \omega + \sum_{i=1}^{n-1} \Lambda_i \Delta y_{t-i} + \sum_{i=0}^{n-1} \Pi_i \Delta x_{t-i} + \Omega_1 y_{t-n} + \Omega_2 x_{t-n} + \varepsilon_t \tag{2}$$

Equation (2) captures the error correction in the ARDL model in which,  $\omega$  is the constant vector parameter,  $\Lambda$  and  $\Pi$  are the short run parameters;  $y_t$  captures the endogenous vector variable,  $x_t$  is a vector of the other explanatory variables as outlined above and  $\Omega_1$  and  $\Omega_2$  are the parameters of the long-run relationship.  $\varepsilon_t$  is error term, assumed to be serially uncorrelated and homoscedastic.

As noted whilst introducing the ARDL model, all the variables have to be stationary, either in level or at first difference, to check this property before proceeding to the full ARDL model. This paper engages the widely used Augmented Dickey Fuller (ADF) test to examine the unit root property of the coefficients. This is to ensure that none of the variables is I(2), otherwise the use of the ARDL would be invalid.

## 2.4 ARDL and Bounds testing Procedure

The [52] cointegration technique involves a 2-stage procedure in the estimation of the long-run relationship. In the first stage, the existence of cointegration amongst the variables (bounds testing) is tested using the standard Wald or Fisher F-test. The null hypothesis is that the coefficients of the lagged regressors in the error correction version of the ARDL model (equation 2) are zero i.e.  $H_0: \Omega_1 = \Omega_2 = 0$ . This null is tested against the alternative hypothesis of  $H_1: \Omega_1 \neq \Omega_2 \neq 0$ . The second stage of estimation can only proceed to once has been cointegration established among the variables. At this stage, the short-run and long-run parameters are estimated using the following two equations: Long-run equation:

$$\hat{\Omega}_1 y_t + \hat{\Omega}_2 x_t = 0; y_t = -\frac{\hat{\Omega}_2}{\hat{\Omega}_1} x_t. \tag{3}$$

Obtained from a version of equation (2) where appropriate lags would have been selected for both the dependent and independent variables using any of the information criterion after confirming the existence of long-run relationship in Stage one.

The short-run dynamic error correction equation for coefficients obtained from the equation below:

$$\Delta y_t = c + \sum_{j=1}^k \chi_j \Delta y_{t-j} + \sum_{j=0}^q \gamma_{1j} \Delta x_{t-k} + \varpi ecm_{t-1} + v_t \quad (4)$$

Where  $ecm_{t-1} = y_{t-1} - \frac{\hat{\alpha}_2}{\hat{\alpha}_1} x_{t-1}$  obtained from (3) above;  $y_t$  and  $x_t$  are as previously defined;  $\gamma_{1j}$  are the short-run parameters;  $\phi$  measures the speed of adjustment to a new equilibrium whenever there is a shock. It also provides another means of validating the existence of cointegration or long-run relationship among the variables. It is expected to be negative and significant and less than one in absolute value for the model to be stable.

## 2.5 Stability Checks

Brown, et al. [56] affirms that a stability verification check should be carried out on the model. In this case, the cumulative sum (CUSUM) and cumulative sum of square (CUSUMSQ) are called out on recursive regression residual. However, the plots must fall within 5% critical bounds of significance to accept the stability of the model. Based on the first set of  $n$  observations, which is updated recursively and plotted against the breakpoints, the test is based on the cumulative sum of recursive residual, and CUSUMSQ follows the same procedure.

## 2.6 Diagnostic Test

The study is expected to carry out diagnostic tests on the model where the presence of serial correlation and heteroscedasticity test would be evaluated. In serial correlation test, the null hypothesis is that there is presence of serial correlation, while the null hypothesis in heteroscedasticity test is that the model is heteroscedastic. If the null hypothesis are rejected in both tests, it indicates a well specified model, does not suffer from serial correlation

problem and that the model is also adjudged to be homoscedastic.

## 3. RESULTS AND DISCUSSION

As the table above suggests, NFA has the maximum number on the average relative to remaining parameters in the model. The entire series equally show substantial deviation from their mean value as shown by the standard deviation command and all the series are positively skewed. The result largely suggest uneven normal distribution as revealed by the probability value and Jaque-Bera figures that are far from zero.

### 3.1 Unit root test

Data on time series that contain unit root mostly results into a confusing and spurious relationship among variables. Therefore, it is essential to take into consideration, the dynamism characteristic of parameters and the data, by measuring them before evaluation. Diebold and Kilian [57] noted that determining the variables' stationarity is decent for forecasting before progressing to modeling and that the prospect of ensuring that the integration order of both independent and dependent parameters converge to the equal level. For the process of ascertaining the unit root status of the parameters, the study adopts the Augmented Dickey Fuller (ADF) test and Phillips- Perron (PP) test as proposed by Dickey and fuller (1981) and Phillips and Perron (1988), respectively.

The unit root property of the parameters of the model is examined in this section with the aid of ADF and PP test at both levels and first difference. While result show that the null hypothesis for both the PP and ADF test for all the variables could not be rejected at levels, the computed first difference figures demonstrate that the coefficients are stationary significantly at all levels (1%, 5% & 10%) and integrated at order 1(1). It is important to note that none of the variables is integrated at order 1(2), which could have automatically rendered this method unsuitable for the purpose of this analysis. This, therefore, pave the way for the conduct of Autoregressive Distributive Lag (ADL) to ascertain a long run relationship and capture both the short and long-run mechanism as captured.

**Table 2. Descriptive statistics or summary statistics**

	EXR	NFA	OIL PRICE	RESERVES
Mean	179.9581	5887184.	64.72683	31333.38
Median	151.3850	6567347.	60.90500	34189.06
Maximum	381.0000	13430683	138.7400	62081.86
Minimum	98.97000	710751.7	14.28000	5789.200
Std. Dev.	76.81879	3088998.	30.61462	14551.78
Skewness	1.215021	-0.189902	0.447443	-0.325901
Kurtosis	3.059605	2.263311	2.153315	2.184549
Jarque-Bera	62.04093	7.213111	15.93582	11.44296
Probability	0.000000	0.027145	0.000346	0.003275
Sum	45349.43	1.48E+09	16311.16	7896011.
Sum Sq. Dev.	1481183.	2.40E+15	235251.0	5.32E+10
Observations	252	252	252	252

**Table 3. Phillips-perron (PP) and augmented dickey fuller tests**

Variables	Phillips-Parron		Remarks Order of Integration	ADF		Remarks Order of Integration
	Level	1 <sup>st</sup> Difference		Level	1 <sup>st</sup> Difference	
<i>InEXR</i>	-0.824023	-11.29269***	1(1)	-1.172932	-11.29269***	1(1)
<i>InReserves</i>	-1.567424	-12.33997***	1(1)	-1.600523	-7.377214***	I(1)
<i>InOilPrice</i>	-1.874049	-10.69249****	1(1)	-2.363126	-11.20291***	I(1)
<i>InNFA</i>	-2.202619	-17.95943***	1(1)	-2.294938	-17.95293***	I(1)

Source: Author's Computation 2021

**Table 4. ARDL short-run estimate**

Short-run estimation	Coefficient	Std. Error	t-statistic	Prob.
<i>InEXR</i>	-0.035671	0.175118	-0.203699	0.8444
<i>InOil price</i>	-0.004689	0.001656	-2.831447	0.0076
<i>InNFA</i>	-0.125256	0.060336	-2.075970	0.0765
<i>InReserves</i>	-0.117951	0.044767	-2.634751	0.0337
<i>ECT CointEq(-1)*</i>	-0.692596	0.095965	-7.217148	0.0000
C	24812.43	5737.911	4.324296	0.0035

Source: Author's Computation; R- Squared =0.999; Adjusted R-Squared = 0.999; F-Statistic = 2870.643; Probability (F-Stat) = 0.0000

### 3.2 Durbin-Waston Statistic: 2.08

The F-Statistic figure of 2870.643 which is way above the rule of thumb put at 2 demonstrates the overall significance of the model. The R-Squared of 0.99 indicates that the variations in the model between the dependent and the explanatory parameters is explained to the tune of about 99%, meaning that the model is fit and well specified. It also shows that it does not suffer from serial correlation problem with DW Statistic figure of 2 approximately. In the short-run, all the recorded coefficients are statistically different from zero and complied with expected signs except the EXR that is though negative but not significant. It shows that reserves, oil price and NFA do have significant impact on Exchange rate in the short-run. The outcome indicates that currency interventions policy in Nigeria have

significant impact on the exchange rate stability of Naira in the short-run.

The degree of error correction term (ECT) is not only negative but also statistically significant with an absolute value that lies between zero and one in compliance with error correction principle. It is a confirmation of the existence of a long-run convergence between the EXR and Nigeria's International Reserves, which implies that if any external shock is introduced into the model, it would still converge with time. However, the coefficient of error correction term (ECT) is estimated to be -0.692596 (approximately 69%), meaning that the speed of error adjustment of the growth of GDP from the initial shock would be corrected and converge to the tune of about 69% in the long run per month.

### 3.3 Bounds Test

As stated earlier, the ARDL model approach is implemented in two stages in estimating the long-run relationship. In the first stage, the existence of long-run relationship is tested using the bounds test. The bounds test F-statistic must be greater than the upper bound critical values at 5% or 10% as represented.

The F-statistic critical values as observed above is higher when compared with the (Pasarant et al ,2001) critical value at the lower and upper bounds (1%, 5%, and 10% respectively). Based on the results, we found a very strong evidence for cointegration between the forex intervention and proxy by the international Reserves and the stability of exchange rate in Nigeria. The implication is that the ideal of forex interventions

by the Central Bank of Nigeria has made tremendous contribution to the stability of exchange rate and by extension the Nigerian economy in the period under investigation.

The long-term coefficients are significant statistically at all levels and comply with expected signs. Specifically, results show that if the Internationals Reserves (proxy for intervention) rises by 1%, the Naira exchange rate will appreciate by about 15%. In addition, a 1% increase in Oil Price will improve the naira exchange rate by about 60% and the Nigerian naira exchange rate will rise by 0.05% if the Net Foreign Asset goes up by 1% in the long-run. The study suggests that the currency interventions policy in Nigeria have significant impact on the exchange rate of Naira in the long-run.

**Table 5. Bound Test for the existence of a long- run relationship**

Models	K	F-Statistic	Lower Bound Critical Value 5%	Upper Bound Critical Value 5 %
$\ln EXR = f(\ln Reserves, \ln Oil\ price, \ln NFA)$	5	9.714222	2.39****	3.38****

Note \*, \*\*, \*\*\* and \*\*\*\* represent 10, 5, 2.5 and 1% level of significance respectively

**Table 6. ARDL long-run estimate**

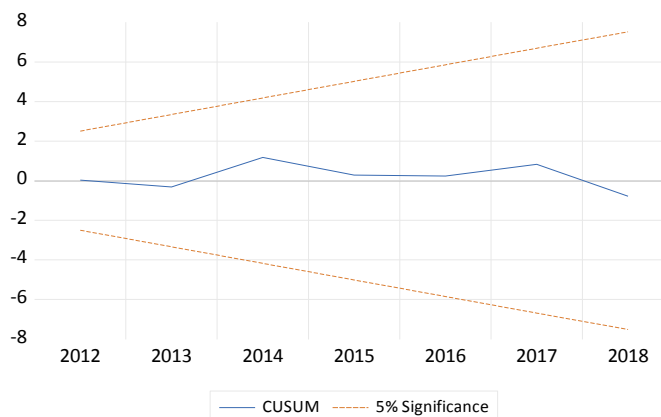
Long-run estimation	Coefficient	Std. Error	t-statistic	Prob.
<i>lnNFA</i>	-0.005234	0.001325	-3.951136	0.0055
<i>lnOil price</i>	-0.607100	0.093612	-6.485283	0.0003
<i>lnReserves</i>	-0.152592	0.022028	-6.927200	0.0002
<i>C</i>	14358.18	382.2564	37.56166	0.0000

Source: Author's Computation

**Table 7. Stability and diagnostic test**

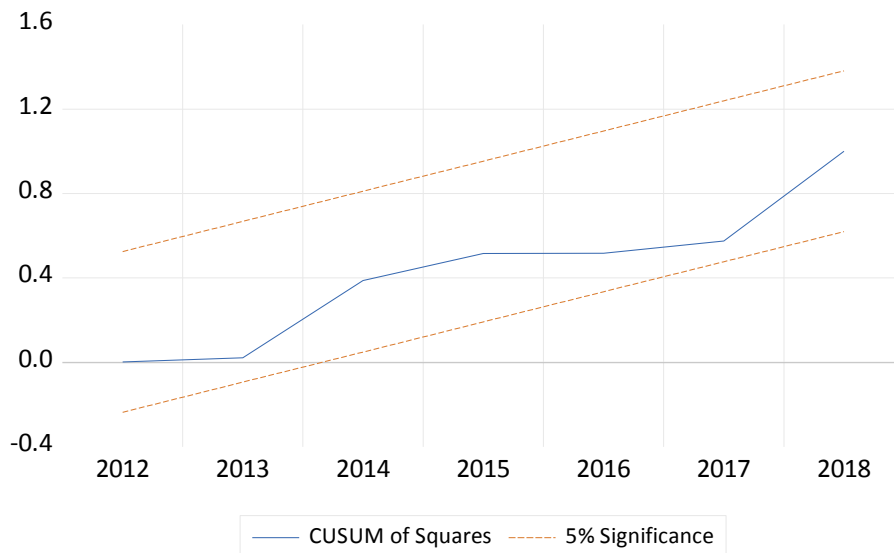
Stability Test	Stable	Unstable	Diagnostic Test	F-statistic	Prob. Value
<i>CUSUM</i>	Stable		Serial Correlation	1.187914	0.1281
<i>CUSUM SQUARE</i>	Stable		Heteroscedasticity	0.326393	0.9828

Source: Author's Computation



**Fig. 1. Cusum**





**Fig. 2. Cusum square**

In principle, the stability of a model is established when the plots of the CUSUM and CUSUMSQ statistics fall within the 5% critical bounds. In this case, the CUSUM stability test and CUSUM SQUARE complies with the theory and its principle and fall within the 5% critical bounds. However, the diagnostics tests were also carried out on the models where the presence of serial correlation is rejected, indicating a well-specified model, and the model is also adjudged homoscedastic based on heteroscedasticity test. The results of the diagnostic tests and CUSUM stability test are confirmation that the relationship between the forex intervention proxy by International Reserves and EXR model is a good fit, robust, stable and sufficient for policymaking.

#### 4. CONCLUSION AND POLICY RECOMMENDATIONS

The objective of the study is to analyze the impact of forex intervention on the stability of exchange rate with International Reserves as proxy for intervention and other control variables including (NFA & Oil Price) from year 2000M1 to 2020M12. We employed the use of ADF and PP tests to ascertain the order of integration of the variables; the results indicate that all the variables are integrated at order 1(1). The results of both the stability and diagnostic tests indicate that the model is not only stable, fit and well specified but has no serial correlation problem and adjudged homoscedastic. The F-statistic critical values is higher when compared with the (Pasarant et al ,2001) critical value at the lower and upper bounds (1%, 5%, and 10%

respectively). We conclude that there is strong evidence of a long-run relationship between Forex intervention and exchange rate in Nigeria within the period under study. In addition, the coefficient of error correction term (ECT) is estimated to be -0.692596 (approximately 69%), meaning that the speed of error adjustment of forex intervention as proxy by International Reserves from the initial shock would be corrected and converge to the tune of about 69% in the long run per month. We, therefore, conclude that the long-term and short-term coefficients, which are significant statistically, suggests that the currency interventions policy in Nigeria is effective and have significant impact on the exchange rate of naira in both the short and the long-run. It is on this background that we recommend that the monetary authority should continue to employ the usage of stock of foreign reserves in supporting the exchange rate by increasing funding of the operations in foreign exchange market. With the current stock of external reserves, which stood at US\$ 34.78 billion as at May 12, 2020, it is, therefore, feasible as a temporary measure. In addition, to ensure a stable naira exchange rate, the appropriate authorities should eschew unhealthy speculation in the foreign exchange market as well as rent-seeking behavior with the adoption of positive attitudes.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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