

A Vector Autoregression Analysis of the Efficacy of External Reserves Management on Exchange Rate Stability: Evidence from Nigeria

Abstract

This paper investigates the dynamic relationship between exchange rate variations and international reserves in Nigeria. The study aimed at ascertaining whether a lead-lag relationship exists between both phenomena using monthly time series data on the bureau de change exchange rate and international reserves extracted from the central bank of Nigeria's statistical publications covering 108 observations between January 2010 and December 2018. The econometric techniques utilized included Granger causality based on the vector error correction and the AR inverse root test for stability and reliability. The empirical result indicates the absence of causality between exchange rate volatility and international reserves fluctuation for Nigeria. On the basis of our empirical result, the study vehemently concluded that monetary authorities do not have to depend on external reserves management as an efficient strategy to stabilizing the value of the Nigerian currency. Thus, external reserves accumulation could be a face lifting parameter for credit ratings and attraction of needed capital to stimulate the much desired economic growth in Nigeria.

Keywords: *Exchange Rate Stability, External Reserves Management, Granger causality, Vector Autoregression.*

1. Introduction

The accumulation of International Reserves and its prudent management is a core aspect of international finance and a macroeconomic indicator for inter-country economic analysis. Essentially, international reserves policies and strategies to drive reserve accumulation were earlier given adequate policy and research attentions in Asia during and after the 1991 balance of payment crisis that rocked the continent (Tiwari & Kyophilavong, 2017). However, in recent years, other countries have adopted external reserves accumulation and management strategies especially the oil exporting nations with highly volatile economies attributed to the exogenous

29 crude oil price determination (Abdullateef & Waheed, 2010; Abdulazeez & Omade, 2013), in a
30 view to attaining price and exchange rate stability.

31 Internal and external economic stability through international reserves management are
32 coordinated by the Apex bank through intervention in foreign exchange market, thus, preventing
33 appreciation of domestic current, promoting competitiveness in the global market, stimulating
34 economic growth and enhancing entrepreneurial development. In an effort to achieve the
35 foregoing in Nigeria, the Central Bank monitors capital outflows and encourage capital inflows
36 for external reserve accumulation (Folorunsho, Ajisafe, & Olofin, 2019).

37 Statistical evidence reveals a significant volatility in Nigeria's external reserve; it jumped from
38 US\$ 4.98 billion in May 1999 to US\$ 59.37 billion in March, 2007, occasioned by economic
39 reforms, rising crude oil price, and reduced debt repayment burden (Abdullateef & Waheed,
40 2010). The continual intervention to stabilize the Nigeria's exchange rate through external
41 reserve strategies during the 2008/09 economic crisis costs the economy about 33 percent of her
42 international reserve with a decline to US\$ 44.53 billion in 2010, depleted further to US\$ 39.10
43 billion in 2011, marginally recovered in 2012, 2013 and 2014 with respective external reserves
44 value of US\$ 45.71 billion, US\$ 54.73 billion and US\$ 44.66 billion as a result of the hike in
45 crude oil price. Conversely, in the build up to the 2016 economic recession external reserves was
46 traded off for exchange rate stability through the foreign exchange market. Thus, in 2015, 2016
47 and 2017, its values contracted tremendously to ₦35.77 billion, ₦ 31.24 billion and ₦ 38.67
48 respectively (CBN, 2018). In the face of the depletion to stabilize exchange rate, how did
49 exchange rate respond?

50 Though the guided floating exchange rate system introduced by the CBN due to exchange
51 market liberalization yielded stability in exchange rate, however, the slump in international crude
52 oil prices that culminated in dwindling foreign exchange earnings led to the widening of the
53 margin between the interbank market and the rDAS windows. This created sharp practices
54 amongst economic agents with rising pressure and grave consequences on the real sector of the
55 economy.

56 Ironically, exchange rate became more volatile, depreciating unpredictably and totally lost
57 stability. For instance, considering the exchange rate market dynamics using the bureau de

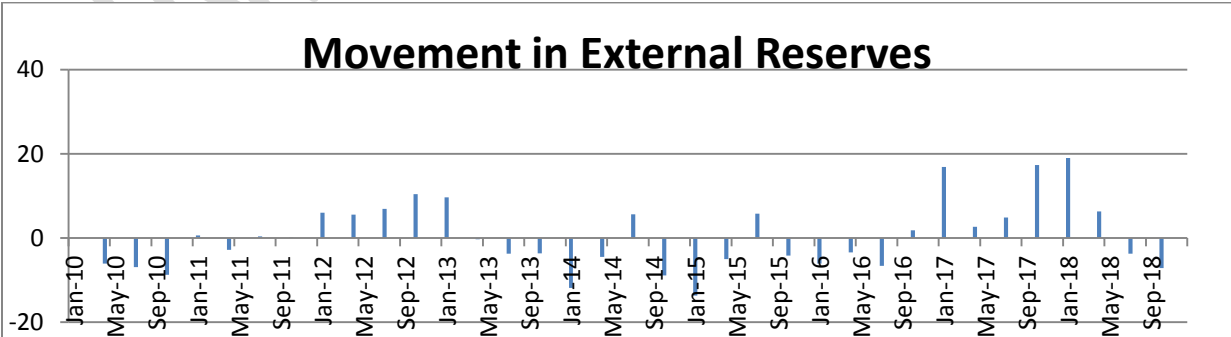
58 change (BDC) rates, the average exchange rate in 2014 was ₦171.44: \$1, but depreciated to
 59 ₦258.3 by December, 2015, worsen further to ₦320, ₦364, ₦431, ₦455 in April, June,
 60 September, and December in 2016 and by February, 2017 exchange rate boomeranged to ₦494
 61 (CBN, 2018). The situation depicted a dilemma yearning for empirical searchlight.

62 Thus, this study extends previous studies (Ajibola, et al., 2015; Nwachukwu et al., 2016) on a
 63 threshold cointegration analysis of exchange rate and external reserves, but departs significantly
 64 in the following four ways; one; the scope of this article covers the most recent volatility era –the
 65 post 2016 recession, two; monthly time series data against daily series with high frequency and
 66 volatility properties, three; this study used the changes/variations in exchange rate as against
 67 exchange rate, this helps to capture the true dynamics in foreign exchange market, four; standard
 68 VAR causality rather than threshold analysis. These points of depart from existing studies create
 69 a niche for this study in economics literature.

70 The remaining paper is organized as follows. Part two details our stylized facts on external
 71 reserve, exchange rate variation and all shares index in Nigeria. Empirical reviews are carried out
 72 in Part three, while Part four describes the methodology and data employed in the study. Part 5
 73 contains analysis of data and discussion of results. Part six summarizes the paper with conclusion
 74 and policy implications.

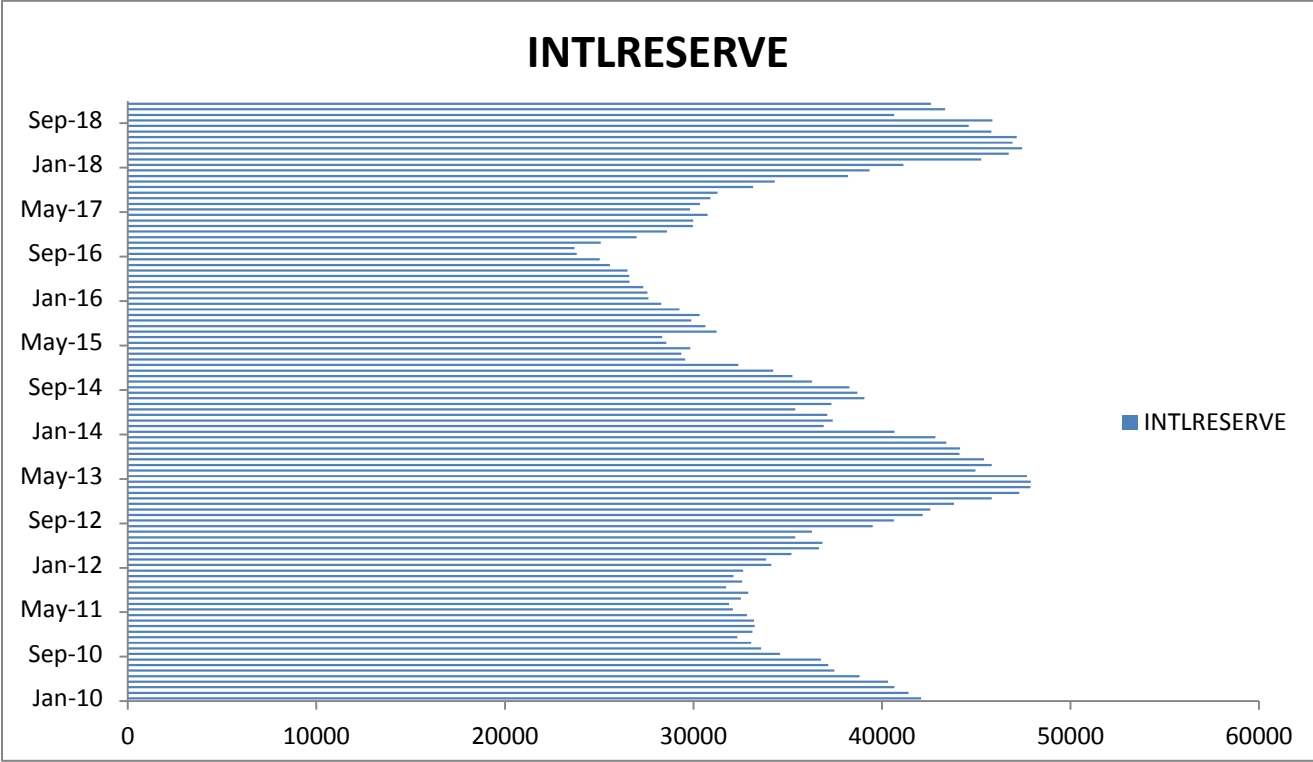
75 **2. Stylized Facts**

76 In this section, the study presents the trends in Nigeria’s foreign reserves, exchange rate
 77 fluctuations and provides basic analysis of facts on the responses of exchange rates to
 78 interventions through external reserve depletion from January 2010 to December 2018.



79
 80 **Figure 1. External Reserve Depletion and Accumulation Rates between 2010 and 2018.**

81 In an attempt to salvage the value of Naira against other international currencies, the CBN
 82 depleted the Nigeria’s external reserves by 6.08 percent between Q1 and Q2; 2010, that is, down
 83 from \$12.41 billion to \$11.66billion between January and June, 2010. Further depletions were
 84 not uncommon, thus, from Figure 1 above, external reserve declined by 8.77 percent between the
 85 third and fourth quarters of 2010. In 2013, the marginal depletion was recorded in similar periods
 86 as 2010 with 0.31 percent and 3.66 percent respectively in 2013. A thorough look at chart reveals
 87 external reserves accumulation and recovery due to favourable crude oil price and relative peace
 88 that enhanced domestic output in oil exploration. However, as oil price sneezes, the shrinking in
 89 external reserves worsened as shown by an 11.83 percent, 6.64 percent, 3.70 percent and 7.10
 90 percent between Q4-Q1, 2013, Q1-Q2, 2016, Q2-Q3, 2016, Q2-Q2, 2018 and Q3-Q4, 2018
 91 respectively (CBN, 2018).



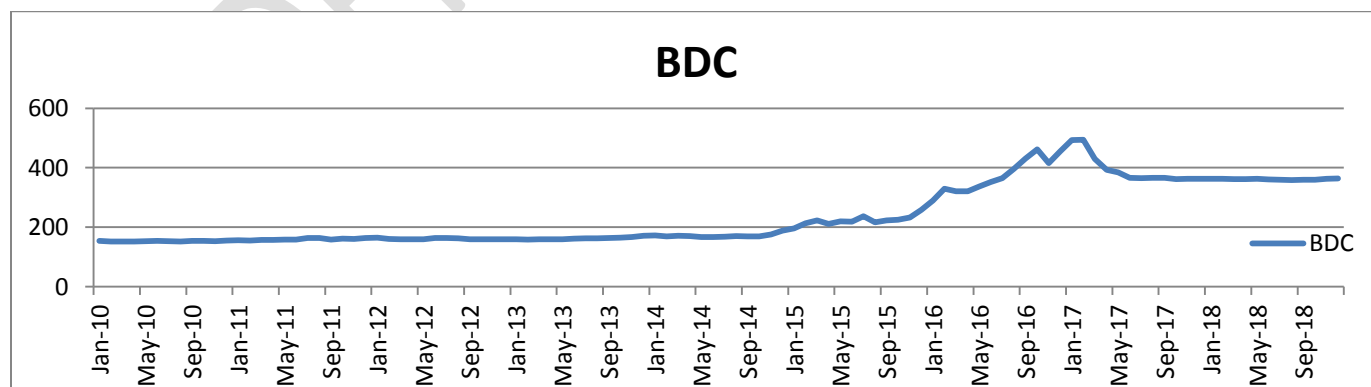
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93 **Figure 2: Nigeria’s International Reserves (Jan. 2010 to Dec., 2018)**

94 The CBN Act of 1958, as amendment in 1999 and 2007 CBN empowers CBN to safeguard the
 95 value of the national currency through the management of external reserves. In a bid to carry out
 96 these responsibilities saddled on the CBN by law, various exchange rate management policies
 97 have been adopted with mixed results in the past.

98 In this vein, the Inter-bank Foreign Exchange Market (IFEM) was introduced in January 1989 in
 99 in an attempt to cushion the excess demand pressure that greeted the introduction of an
 100 Autonomous Foreign Exchange Market (AFEM) in 1988. Under IFEM, authorized dealers were
 101 saddled with funding responsibility under the watch and intervention of the CBN when the need
 102 arises. This was aimed at developing the depth of the Nigerian Foreign Exchange Market (FEM)
 103 through augmentation of the market supply base. However, the objective was largely unrealised
 104 to the extent of CBN non-active participation as the major supplier of foreign exchange as cited
 105 in (Ajibola, et al., 2015). The IFEM period was characterised by market pressure due to
 106 excessive demand, bubbling parallel market resulting from the widening of the arbitrage
 107 premium between the official and parallel rates.

108 To develop a functional foreign exchange market that will establish a realistic and stable value
 109 for the Naira, the Dutch Auction System and a fully deregulated system were emerged in 1990
 110 and 1992, respectively. The inability of these policies to resolve the crises in the FEM
 111 necessitated a drastic policy reversal. The policy shift was undertaken in 1994 when the naira
 112 exchange rate was pegged to about N21.9/US\$. The key target was exchange rate stability. In
 113 sum, during the interbank foreign exchange market (IFEM) introduced in January 1989,
 114 exchange rate stood at ₦12.9377/US\$, in 1994 the fixed exchange rate system pegged it at
 115 ₦21.8861/US\$, the Autonomous Foreign Exchange Market (AFEM) in 1995 retained the rate at
 116 1994, the reintroduction of IFEM in October 1999 saw exchange rate devalued to ₦108.0000/
 117 US\$.



118

119

Figure 3: Trends in BDC Exchange Rate of the Naira from January, 2010 to December, 2018

120 However, in 2002, the Retail Dutch Auction System (rDAS) of foreign exchange management
121 was introduced with exchange rate deteriorating to ₦130.8500/US\$. Four years later, the
122 Wholesale Dutch Auction System (wDAS) was introduced and exchange rate stood at
123 ₦141.7600US\$, and the Retail Dutch Auction System (rDAS) of foreign exchange management
124 resurfaces on October 2, 2013 at exchange rate of ₦157.4166 US\$. The persistent decline in the
125 external reserves as well as increased foreign exchange demand can be largely attributed to
126 uncertainty over the impact of the falling crude oil prices on the Nigeria's external reserves and
127 the exchange rate of the naira.

128 **3. Literature Review**

129 The collapse of the Bretton Wood Agreement in 1970s which emphasized on a fixed exchange
130 rate system and the subsequent global financial crises arouse awareness on the need to manage
131 and stabilize the value of national currencies discretionarily. One of the known ways is the use of
132 external reserve management policies. Thus, the International Monetary Fund-IMF (1993)
133 conceptualized international reserves as “official public sector foreign assets that are readily
134 available to and controlled by the monetary authorities for direct financing of payment
135 imbalances, and directly regulating the magnitude of such imbalances, through intervention in
136 the exchange markets to affect the currency exchange rate and/or for other purposes”.

137 A further perusal of international finance and economics literatures show that external reserves
138 and exchange rate could be related in either of four distinct ways (Tiwari & Kyophilavong,
139 2017).

140 The first argument is that exchange rate volatility causes reserve, occasioned by the adopting of
141 flexible exchange rate system which does not need high international reserve accumulation and
142 economic crisis which causes perpetual domestic currency depreciation. Thus, exchange rate
143 volatility underscores exchange rate management policies, and in turn affects external reserve
144 accumulation (See Prabheesh, Malathy & Madhumathi, 2009; Ramachandran & Srinivasan,
145 2007; Srinivasan et al., 2009). This position is corroborated by the work of Choi & Baek (2004)
146 that report smaller reserve holdings for economies with hard pegs than those under flexible
147 exchange rate system. In an earlier study by Romero (2005) for China and India, the ordinary
148 least squares (OLS) regression results revealed that exchange rate significantly determines
149 external reserves in India but does not in China. In Nigeria studies by (Ahmad & Pentecost,

150 2009; Olayungba & Akinbobola; 2011) validated the argument that exchange rate causes
151 external reserves. The study employed the structural break modeling technique and found that
152 Nigeria's international reserves adjust faster to variations in nominal exchange rate. Also, the
153 study by Tariq et al. (2014) for Pakistan which employed the mercantilist methods to ascertain
154 the relationship between the real exchange rate and foreign exchange reserves between 1973 and
155 2008, document that the reserves holdings in Pakistan are as a result of the export-led growth
156 strategies through real exchange rate depreciation supports this position. Furthermore, Tiwari &
157 Kyophilavong (2017) examine the relationship between real effective exchange rate (REER) and
158 international reserve in India using bivariate and conditional bivariate Granger causality test in
159 frequency domain framework. The study found that the International Reserves in India are
160 significantly influenced by exchange rate and as such Indian Reserve Bank should reckon with
161 exchange rate as an appropriate tool in managing external reserve.

162 The second argument subsists on the position that reserve accumulation causes exchange rate.
163 Tiwari & Kyophilavong (2017) document that the Asian crisis between 1997 and 1998, the
164 Russian and Brazilian disaster of 1999 pointed to the fact that inadequate external reserves
165 stimulates financial crisis. Since creating an effective intervention is a function of external
166 reserve accumulation, international reserves therefore causes exchange rate. In Nigeria,
167 Abdullateef & Waheed (2010) employed dual techniques of OLS and Vector Error Correction
168 (VEC) methods to examine the impact of change in external reserve positions of Nigeria on
169 major macroeconomic variables including exchange rate. The result of the study indicated that,
170 changes in external reserves in Nigeria have significant effect on exchange rates. This gets
171 credence from Chinaemerem (2012) that utilized Vector Autoregression (VAR) approach that
172 reported a significant relationship between external reserves and exchange rates in Nigeria. In
173 addition, Ajibola et al., (2015) investigate the long run relationship between exchange rate and
174 external reserves in Nigeria using quarterly time series data spanning first quarter 1990 to fourth
175 quarter 2012. Model results revealed that cointegration between the variables occurs only when
176 the equilibrium error exceeds an estimated threshold parameter of 0.52. Having partitioned the
177 TVECM into two regimes based on the obtained threshold, the study found that the error
178 correction coefficients of the exchange rate in the two regimes are not significant, implying that
179 exchange rates do not respond to equilibrium error during the estimation period. On the other
180 hand, external reserves adjust to correct past divergence, albeit only when the equilibrium error

181 exceeds the threshold parameter. Overall, external reserves adjust to maintain long run
182 equilibrium while exchange rates do not, which seems to align with the monetary authority's
183 action of deploying external reserves to maintain exchange rate stability in the country. In line
184 with this assertion, another study by Nwachukwu et al. (2016) for Nigeria on the long-run
185 relationship between the Bureau De Change exchange rate and external reserves using the
186 Threshold Vector Error Correction Model (TVECM) framework on high frequency daily data
187 from Jan 1, 2014 to Jul 31, 2015, found that the adjustment mechanism flows from external
188 reserves to BDC exchange rate.

189 From the third perspective, the argument is that neither external reserves nor exchange rate
190 causes each other. This implies the absence of any meaningful cause-effect nexus between the
191 two variables, this position is found in the works of (Gokhale & Raju, 2013; Nwude, 2012).
192 Gokhale & Raju (2013) investigate the existence of a forward-backward and long run
193 cointegrating relationship between exchange rate and external reserves for India using
194 annualized time series data that cover the period between 1980 and 2010. The study the results of
195 their analysis led to the conclusion that there is neither short nor long run relationship between
196 the exchange rate and reserves. However, their position invalidates earlier study by Romero
197 (2005) for the same economy, but lends credence to the empirical report by Nwude (2012) for
198 Nigeria.

199 The fourth perspective is the existence of a bi-directional causal relationship between exchange
200 rate and external reserves. This possibility has not been established in economic literature to the
201 best of our knowledge. Thus, the quest for further empirical inquiry into the relationship between
202 both variables remains an issue in the front burner amongst policymakers and researchers. This
203 study hopes to contribute to the on-going exercise by considering the volatility in both variables,
204 which again lacks empirical consideration amongst previous studies as deduced from the
205 reviewed literatures.

206 **4. Methodology**

207 **Estimation Technique**

208 This study distinguishes itself from previous empirical analyses on external reserve and
209 exchange rate in Nigeria by adopting a dynamic methodology of the standard vector

210 autoregression (VAR) technique. Though previous studies (Abdullateef & Waheed, 2010;
211 Nwachukwu et al., 2016; Ajibola et al., 2015) used ordinary least square (OLS), threshold vector
212 error correction model (TVECM), threshold cointegration technique respectively, in analyzing
213 the relationship between exchange rate and external reserve, this paper departs considerably by
214 adopting similar approach as Chinaemerem (2012) that employed the standard vector
215 autoregressive causality test.

216 **Data**

217 The paper employed monthly time series data on variations exchange rate, that is,
218 depreciation/appreciation and external reserve volatility sourced from the Central Bank of
219 Nigeria statistical bulletin spanning 108 months from January 2010 to December 2018 for the
220 empirical analyses.

221 **Model Specification**

222 The general VAR model is expressed as follows:

$$223 \quad z_{1t} = \alpha_1 + \alpha_{11}z_{1t-1} + \alpha_{12}z_{2t-1} + \beta_{11}z_{1t-2} + \beta_{12}z_{2t-2} + \epsilon_{1t} \quad (a)$$

$$224 \quad z_{2t} = \alpha_1 + \alpha_{21}z_{1t-1} + \alpha_{22}z_{2t-1} + \beta_{21}z_{1t-2} + \beta_{12}z_{2t-2} + \epsilon_{2t} \quad (b)$$

225 The compact form of the above VAR equations is expressed in the equation below.

$$226 \quad z_t = \Omega + \alpha_1 z_{t-1} + \beta_2 z_{t-2} + \mu_t \quad (c)$$

227 Where

228 Ω depicts an $n \times 1$ Column vector

229 α_j 's are the $n \times n$ square metrics

230 μ_t is an $n \times 1$ column vector of serially uncorrelated vector of innovations variable which is
231 independently, identically and normally distributed with zero mean and constant variance
232 $\{\mu_t \sim iidn(0, \sigma^2)\}$.

233 If z_t is a column vector ($n \times 1$) matrix which encompasses all the logged variables in the model,
234 the VAR model establishes a link between the current z_t , its lags (z_{t-i}) and the white noise variable
235 (μ_t).

236 Furthermore, the Granger causality test is employed to estimate equations 4 and 5 to establish the
 237 empirical linkages between $\Delta EXRT$ and $\Delta INTRZ$.

$$238 \log \Delta EXRT_t = \alpha_0 + \sum_{t-1}^n \alpha_1 \log \Delta EXRT_{t-1} + \sum_{t-1}^n \beta_2 \log \Delta INTRZ_{t-1} + \mu_t \quad (d)$$

$$239 \log \Delta INTRZ_t = \alpha_0 + \sum_{t-1}^n \alpha_1 \log \Delta INTRZ_{t-1} + \sum_{t-1}^n \alpha_2 \log \Delta EXRT_{t-1} + \varepsilon_t \quad (e)$$

240 Equations (d) and (e) produce the following hypotheses:

$$241 H_0 = \sum_{t-1}^n \beta_i = 0, \text{ and } \sum_{t-1}^n \alpha_i = 0 \quad (f)$$

242 The H_0 states that there is no causality between $\Delta EXRT$ and $\Delta INTRZ$

$$243 H_1 = \sum_{t-1}^n \beta_i \neq 0, \text{ and } \sum_{t-1}^n \alpha_i \neq 0 \quad (g)$$

244 While H_1 states otherwise, that is, causality exists between $\Delta EXRT$ and $\Delta INTRZ$. From
 245 equations (d) to (e), if the estimates β_2 and α_2 are statistically significant, it indicates the
 246 existence of bi-directional relationship between $\Delta EXRT$ and $\Delta INTRZ$. But if β_2 is statistically
 247 significant and α_2 is not, a unidirectional causal relationship exists running from $\Delta EXRT$ to
 248 $\Delta INTRZ$, and if α_2 is statistically significant and β_2 is not, a unidirectional relationship exists
 249 that runs from $\Delta INTRZ$ to $\Delta EXRT$.

250 5. Empirical Analyses and Discussion of Results

251 Descriptive and Summary Statistics

Table 1

Summary Statistics

	$\Delta EXRT$	$\Delta INTRZ$
Mean	1.961776	4.852056
Median	0.300000	-200.2100
Maximum	40.05000	4123.720
Minimum	-65.22000	-5208.400
Std. Dev.	13.71028	1438.063
Skewness	-0.746362	-0.081225
Kurtosis	10.38063	4.563940

Jarque-Bera	252.7961	11.02234
Probability	0.000000	0.004041
Sum	209.9100	519.1700
Sum Sq. Dev.	19925.00	2.19E+08
Observations	107	107

Source: Computed by Author using eviews 10

252
253 In Table 1 above, the summary and descriptive statistics reveal interesting results. First, the
254 standard deviation of both series lies above their average values; this implies that exchange rate
255 and international reserves fluctuate considerably within the period under observation. The
256 skewness test indicates that both variables are negatively skewed. This shows that the
257 observations are tilted to the left or fatter to the left than the right. Kurtosis test reveals whether
258 the series are flat or peak. The values of kurtosis of 10.38 and 4.56 for exchange rate and
259 international reserves respectively show that the series are normally distributed because they are
260 greater than 3. This Jarque-Bera statistics further affirms the normality of the series with
261 statistical value of 252.79 and 11.02 and corresponding p-values of 0.0000 and 0.0040. Thus, the
262 overall preliminary statistics implies that the data employed for analyses are in good nature, as
263 such, the author proceeded to the unit root test.

264 **Test for Stationarity (Unit Root Test)**

265 In Table 2 the results unit root tests from the Dickey Fuller (DF), Augmented Dickey Fuller
266 (ADF) and the Phillips-Perron (PP) techniques are presented. The null hypothesis states the
267 absence of unit root in data series at 1%, 5% and 10% significance levels, while the alternative
268 hypothesis states otherwise. To validate either of the hypotheses, the study utilized the
269 Mackinnon critical values as summarized in Table 3.

270 The DF result is inconclusive as the series are stationary at without trends but fails the
271 stationarity test with trend; thus, the null hypothesis is accepted at 5% significance level.
272 However, the ADF results in first-difference series confirm that the series are stationary at 1%

273 significant level. The Phillips-Perron stationarity results validate the ADF test results at 1% level
 274 of significance. Therefore, the pre-test estimation reveals that the series would produce reliable
 275 results at first difference.

Table 2

Unit root tests: Exchange rate dep/app ($\Delta exrt$) and change in external reserve ($\Delta intrz$) from Jan. 2010 to Dec. 2018

Series	DF test at levels		ADF test in first difference				PP test in first difference			
	No trend	With trend	No trend	Lag	With trend	Lag	No trend	Lag	With trend	Lag
$\Delta EXRT$	-2.49**	-2.69	-5.13***	12	-5.10***	12	-18.2***	12	-18.10***	12
$\Delta INTRZ$	-3.03***	-3.38**	-5.97***	12	-6.01***	12	-27.6***	12	-27.5***	12

276 Source: Author's computation using eviews 10. Note: *, **, *** respectively indicates the
 277 rejection of the null hypothesis of unit root at 10%, 5% and 1%.

278

Table 3

Mackinnon critical values for rejection of hypothesis of unit root

Critical Value	DF test at levels		ADF test in first difference		PP test in first difference	
	No trend	With trend	No trend	With trend	No trend	With trend
1% level	-2.58	-3.59	-3.50	-4.05	-3.49	-4.05
5% level	-1.94	-3.04	-2.89	-3.46	-2.99	-3.45
10% level	-1.61	-2.75	-2.58	-3.15	-2.58	-3.15

279 **Source: Mackinnon (1996).**

280

281 **Cointegration Test**

282 The co-integration test is used to examine the existence of long run association between volatility
 283 in exchange rate and changes in international reserves. The concept of co integration introduced
 284 by Engle and Granger (1991) is as follows. The variables $\Delta EXRT$ and $\Delta INTRZ$ are said to be co
 285 integrated if there is a long run association or co-movement between these variables. "More

286 generally a vector of I(1) random variables is said to be co integrated if there exists a vector if-
 287 such that $\beta_i - Y_t$ is trend stationary” (Gokhale & Raju, 2013). Hence, the study considers a linear
 288 combination of vectors which exhibit long run co-movement. The Trace and Maximum Eigen
 289 Value tests indicate that $\Delta EXRT$ and $\Delta INTRZ$ are co-integrated. The affirmation of co-
 290 integrating relationship at 0.05 significant levels, suggests the presence of long run equilibrium
 291 between $\Delta EXRT$, and $\Delta INTRZ$ variables in this study.

Table 4
Co-integration Results

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.155280	27.12273	15.49471	0.0006
At most 1 *	0.092589	9.910272	3.841466	0.0016
Trace test indicates 2 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.155280	17.21246	14.26460	0.0166
At most 1 *	0.092589	9.910272	3.841466	0.0016
Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Source: Author's computation using eviews 10

292 Hence, the paper proceeds to the estimation of the adjustment parameters using the VECM
 293 method since co-integrated trends are observed as shown in Table 4 above.

294

295

296 **Optimal lag selection criteria**

297 In Table 5, the optimal lag selection criteria employed in estimation of the adjustment estimates
 298 of the VECM are presented. The criteria include the sequential modified LR test, final prediction
 299 error test, Akaike information criterion, Schwarz information criterion and the Hann-Quinn
 300 information criterion. Interestingly, the results from the FPE, AIC, and HQ criteria affirmed a
 301 one period lag as optimal lag for the VECM model estimation.

Table 5
VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1216.108	NA	4.70e+08	25.64438	25.69815*	25.66610
1	-1209.119	13.53738	4.42e+08*	25.58144*	25.74274	25.64662*
2	-1206.313	5.315290	4.53e+08	25.60660	25.87543	25.71522
3	-1202.567	6.941286	4.55e+08	25.61193	25.98829	25.76401
4	-1198.008	8.253101	4.50e+08	25.60017	26.08407	25.79570
5	-1197.043	1.707054	4.81e+08	25.66406	26.25549	25.90304
6	-1194.441	4.491832	4.96e+08	25.69349	26.39245	25.97592
7	-1189.518	8.291093	4.87e+08	25.67407	26.48055	25.99995
8	-1187.010	4.118695	5.04e+08	25.70547	26.61949	26.07480
9	-1180.954	9.68883*	4.84e+08	25.66220	26.68375	26.07498
10	-1178.956	3.113292	5.07e+08	25.70434	26.83342	26.16057
11	-1178.738	0.330220	5.51e+08	25.78396	27.02058	26.28365
12	-1176.760	2.914438	5.79e+08	25.82654	27.17068	26.36967

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

302 **Source: Author's computation using eviews 10**

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Table 6
VEC Granger Causality/Block Exogeneity Wald Tests

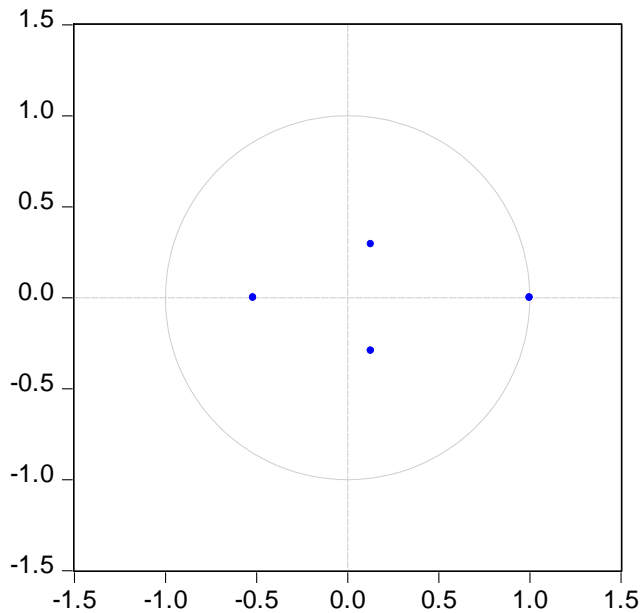
Dependent variable: D(Δ EXRT)			
Excluded	Chi-sq	df	Prob.
D(Δ INTRZ)	3.122104	2	0.2099
All	3.122104	2	0.2099
Dependent variable: D(Δ INTRZ)			
Excluded	Chi-sq	df	Prob.
D(Δ EXRT)	0.473874	2	0.7890
All	0.473874	2	0.7890

Source: Author's computation using eviews 10

307 The causality test is employed to further test if the observed long run association from the trace
 308 test and maximum eigen value co-integration test between exchange rate changes and
 309 international reserves volatility have elements of causality. Surprisingly, the VEC granger
 310 causality results presented in Table 6 indicate that despite the long run association between
 311 exchange rate volatility and fluctuations in international reserve, neither exchange rate nor
 312 external reserves causes each other. This is revealed by the chi-square value of (3.12) with p-
 313 value (0.2099) and (0.47) with p-value (0.7890) respectively. This implies that exchange
 314 volatility does not translate to external reserve volatility and vice versa.

315 The findings of this study lend credence to previous and disagree with some others. For instance,
 316 for Nigeria, Nwude (2012) reported absence of causality between exchange rate and external
 317 reserves and Gokhale & Raju (2013) found similar result for Indian economy. Thus, the result of
 318 this paper buttresses the positions of Nwude (2012) and Gokhale & Raju (2013) that exchange
 319 rate does not lead international reserves and international reserves does not lead exchange rate.
 320 However, the study's empirical result departs from earlier empirical findings that external
 321 reserves causes exchange rate (Nwachukwu, Ngozi et al., 2016; Tiwari & Kyophilavong, 2017)
 322 and (Ahmad & Pentecost, 2009; Olayunga & Akinbobola, 2011) that reported the existence of a
 323 uni-directional causality flow from exchange rate to external reserves.

Inverse Roots of AR Characteristic Polynomial



324

325 **Source: Author's computation using eviews 10**

326 **Figure 4: Inverse Root Test**

327 The inverse AR root characteristic test for the VEC granger causality result reveals that the
328 empirical results are reliable and stable as the roots of the polynomial fall within the unit circle.
329 Thus, indicating reliable and stable policy outcome on the based on recommendations drawn
330 from the findings.

331

6. Conclusion

332 Essentially, international reserves accumulation and its fluctuation do not necessarily have a
333 lead-lag relationship with exchange rate volatility in case of Nigerian economy. Although the
334 accumulation of external reserves are high in recent times due to rising crude oil price in the face
335 of worsening exchange rate which is a deviation from the reports of previous researchers, it does
336 not have a direct bearing on the exchange rate as suggested by some authors and there could be
337 many other parameters that propel the excessive volatility in the exchange rate between the
338 dollar and Nigerian Naira. The international reserve accumulation in the Nigerian context could
339 have been largely in anticipation of overcoming financial crisis than a tool for regulating the
340 exchange rate. It could also be looked upon as a face lift to the Nigerian economy through
341 enhanced credit ratings which in turn would attract foreign direct investment and portfolio
342 investments to Nigeria thereby supplying capital to stimulate economic growth.

343 Based on our empirical findings, the study strongly concludes that monetary authorities should
344 not rely on the management of Nigerian exchange rate through intervention using external
345 reserves. This is because external reserves management does not lead or follow fluctuations in
346 exchange rate.

347 It will be interesting for future studies to investigate other interventional policies that could be
348 appropriate for the management of the exchange rate of the Nigerian Naira aside external reserve
349 management.

350

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