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Effect of Exchange Rate Volatility on Foreign Reserves in Nigeria

[1]Ikwuagwu, Eberechi Bernadine, [2]Eze, Ignatius, [3]Chioma D. Oleka

[1]Department of Banking and Finance College of Management Sciences Michael Okpara University of Agriculture Umudike, Umuahia, Abia State Nigeria
[2]Obollo-Eke,Udenu L.G.A. Enugu State.
[3]Department of Banking and Finance, Faculty of Management Sciences, Enugu State University of Science and Technology Nigeria
Email: eberechibikwuagwu@gmail.com

ABSTRACT

The study focused on effect of exchange rate volatility on foreign reserves in Nigeria. For this purpose, data were sourced from Central Bank of Nigeria Statistical Bulletin. Exchange rate was measured by real exchange rate values while foreign reserves was measured by total value of dollar-denominated assets held by the CBN in reserves. The study used Generalized Autoregressive Conditional Heteroscedasticity (GARCH) to test for possible volatility of exchange rate. Also, the ARDL approach was used to estimate the effect of real exchange rate volatility on Nigeria's foreign reserves. Based on the findings, it was found that real exchange rate was volatile. The long-run ARDL estimation revealed that real exchange rate volatility had no significant effect on foreign reserves of Nigeria. On the other hand, real exchange had a negative and significant effect on foreign reserves in the short-run which occurred amidst negative and significant interest rate. Based on these findings, it was recommended that Central Bank focuses primarily on interest rate control to ensure price and exchange rate stability.

Keywords: Foreign reserves, exchange rate, real exchange rate and volatility

INRODUCTION

Foreign reserve accumulation is often considered a form of self-protection against financial upheavals; they enable central banks to intervene in the foreign exchange market and help to cushion the economy from external shocks [1]. International Monetary Fund (IMF) view foreign reserves as a means of crisis prevention and proposed new measures to evaluate their adequacy (IMF, 2000). Hence, it is proposed that emerging markets rely on sufficient foreign exchange reserves as a form of self-protection and to count less on assistance by the IMF. Countries have sought to reach a height of self-insurance against future crises, either because of a possible increase in the cost of crises or because of the perceived conditionality costs of using IMF credit [2]. A country is required to maintain international reserve for various purposes, such as import financing, maintain exchange rate stability, or to maintain a certain level of reserve for precautionary events [3]; [4].

In today's world, there is no country that will expose its currency to foreign exchange market without putting adequate measures of intervention in place. In this light, monetary authorities saddled with the responsibility of foreign exchange management make deliberate effort to influence their countries' exchange rates by buying and selling currencies in order to manage their country exchange rate. This is because the currency rates affect any given economy through trade balance (capital and current transaction account) and these automatically determine the value and quantity of exchange reserves holdings of a country. From this perspective, almost all currencies are managed since central banks or governments intervene to influence the value of their currencies. As such, management of external reserve is seen as one of the core functions of Central Bank of any nation. It connotes maintenance of adequate volume of reserve in order to protect the value and exchange rate of the domestic currency. For instance, sufficient

holdings of external reserves which are usually denominated in foreign currencies such as Dollar, Pounds, Yen, Euro, gold, precious stones, foreign treasury bills, SDR rights etc. are very significant to a country. It tends to help the country to withstand shock which might set in unknowingly or as a cushion effects when an economy is faced with pressing financial problems, intervention when the exchange rate is volatile or to boost a country credit worthiness when access to international market is difficult or impossible [5].

Adequacy of foreign exchange reserves is key efficient and effective macroeconomic management. Foreign reserves are accumulated by a country and used to cushion balance of payments shocks, to maintain exchange rate parity, avoid the macroeconomic costs of adjustment to temporary shocks and smooth adjustment of the macroeconomic impact on some permanent shocks [6]; [7]. According to [8], foreign reserves can also be used to smooth exchange rate volatility in illiquid foreign exchange markets. After independence, Nigeria operated fixed exchange rate and therefore, needed to keep high amount of reserves in order to maintain the exchange rate at a pegged level. But later, she witnessed some flexibility in the exchange rate market. Currently, Nigeria is operating the managed-float exchange rate system which means that the Central Bank of Nigeria (CBN) should intervene occasionally in the exchange rate market to prevent excessive short-term exchange rate volatility [8]. However, for the Central Bank to perform this role effectively, adequate amount of reserves should be kept at all times.

Generally, exchange rate is associated with some degree of volatility. Exchange rate volatility refers to uncertainties associated with fluctuations in exchange rate. This uncertainty has posed serious economic problems (such as capital flight due to loss of investors' confidence) in both developed and developing countries [9]; [10]; [11]. The issue of exchange rate volatility became a prominent feature in countries following the adoption of flexible exchange rate system due to the collapse of the Bretton Woods Agreement in 1973 [12]. The proponents of fixed exchange rate system believe that a flexible exchange rate system accelerates uncertainty associated with international trade [13]. However, exchange rates have been highly volatile in African countries since the adoption of the flexible exchange rate system. Nigeria adopted the Structural Adjustment Programme recommended by the Bretton Woods institutions (World Bank and International Monetary Fund) in 1986. This led to shift from the fixed exchange rate system to the flexible exchange rate system. A shift to flexible exchange rate regime has seen foreign reserves of Nigeria deplete in recent times as the CBN usually intervene in the foreign exchange market with the accumulated reserve funds [14].

Recently, Nigeria's foreign Reserves decelerated from $45 billion in July to $40.3 billion in October 18 2019 which suggests that foreign reserves depleted by $5 billion in less than four months. (CBN, 2019). This depletion in Nigeria's foreign reserves has been adduced to several monetary interventions in the economy following the drop in oil prices and volatile Naira-Dollar exchange rate. While the decline in the country's foreign reserves has coincided with recent fluctuations in global oil prices, the depletion in reserves has more to do with CBN intervention in the foreign exchange market. For instance, as foreign capital flowed out of the country, the CBN had to actively intervene to keep the Nigerian Naira in line. The CBN in its monthly economic report for August 2019 stated that the decrease was due, mainly, to increased foreign exchange market interventions and external debt service payments, as well as, direct payments. Since the introduction of the Investors and Exporters' window in Nigeria, the CBN has increasingly intervened in the forex market as an active buyer and seller of currencies (CBN, 2017). For instance, the half-year report recently released by the CBN's Financial Markets Department showed that for half-year 2019 (January – June), the apex bank made available a whopping sum of $8.28 billion to authorized dealers in the FX market.

Figure 1 demonstrates the relationship between the external reserves and real exchange rate of Nigeria. The figure shows that real exchange rate volatility and

growth of foreign reserves moved in the opposite direction. This implies that as real exchange rate volatility surged, foreign reserves depleted. This scenario could be seen between 1981 and 1983 due to economic recession witnessed in the early 1980's; 2008 and 2009, probably due to the global financial crisis. It was also evident between 2016 and 2017 due to the recent economic recession witnessed in Nigeria as well as drop in international crude-oil prices [15]. This indicates that periods of high exchange rate volatility and depleting foreign reserves were associated with periods of economic crisis

Figure 1: Trend of real exchange rate fluctuation and growth of foreign reserves

The literature indicates that results of studies that have examined the determinants of foreign reserves remains mixed as their method of analysis, time period studied and selection of variables varied. Empirical studies such as [16]; [17]; [18], established that exchange rate volatility had caused significant drawdown on Nigeria's external reserves at varying degrees. On the other hand, [19], showed the exchange rate volatility was an insignificant determinant of foreign reserves in Nigeria. The rest of the paper is organized in five sections. Section two is devoted to the review of related literature, while section three deals with research methods. Section four presents the results and discussions, while conclusion and recommendations are presented in the last section.

LITERATURE REVIEW

Conceptual review

Exchange rate is defined as the price of one unit of the foreign currency in terms of the domestic currency. Also, exchange rate as a price of one currency in terms of another [20]. This exchange rate, which is a price of the domestic currency in terms of other currencies, is usually determined in principle by the interplay of supply and demand in a free market environment. In practice, however, no currency is allowed to float freely by the monetary authorities. Between the fixed and floating systems exchange rate management and other regimes such as the managed and dual exchange rate regimes. While exchange rate volatility is defined as the risk associated with unexpected movements in the exchange rate. Economic fundamentals such as the inflation rate, interest rate and. the balance of payments, which have become more volatile in the 1980s and early 1990s, by themselves, are sources of exchange rate.

Foreign exchange reserves or external reserves are a country's external assets held in gold, Special Drawing Rights (SDRs), foreign currency deposits and bonds held by central banks and monetary authorities of a country. According to International Monetary Fund, foreign exchange reserves are those external assets that are readily available to and controlled by the monetary authorities for meeting balance of payments financing needs, for intervention in exchange rate markets to affect the currency exchange rate, and for other related purposes (IMF, 2003).The accumulation of reserves in Africa and emerging economies has accelerated over the last decade with the bulk of the increase occurring in oil-exporting countries. The accumulation of reserves has occurred at a time of generally stable or slightly appreciating exchange rates, particularly against the US dollar.

Theoretical review

The Purchasing Power Parity/Theory {PPP} was developed by Gustav Cassel in 1920 to determine the exchange rate between countries on inconvertible paper currencies. The theory states that equilibrium exchange rate between two inconvertible papers currencies is determined by the equality of relative change in price in the two countries. In other words, the rate of exchange between two countries is determined by their relative price levels. There are two versions of the Purchasing Power Parity (PPP) theory, namely the absolute and relative versions.

Another theory explaining exchange rate mechanism is the mint parity theory. This theory is associated with the working of the international gold standard. Under this system, the currency in use was made of gold or was convertible into gold at a fixed rate. The value of the currency unit was defined in term of certain weight gold, that is, so many grains of gold or the naira, dollar, pounds and so on. The apex bank of the country was always ready to buy and sell gold at the specified price. The rate at which the standard money of the country was convertible into gold was called the "mint price" of gold. If the official British price of gold was £6 per ounce and US price gold $36 per ounce. These will be the mint price of gold in their respective countries. The exchange rate between the dollar and pound would be fixed at $36/£6=$6 [21]. This rate was called the mint parity or mint price of gold. Thus under the gold standard, the normal or basic rate of exchange was equal to the ratio of their mint per values. However the actual rate of exchange could vary above or below the mint parity by the cost of transporting gold from one country to other. The mint parity theory has certain assumption as stated below:

1) The price of gold is fixed by a country in terms of its own currency.
2) It buys and sells gold in any amount at that price.
3) Its supply of money consists gold or paper currency which is backed by gold.
4) Its price level varies directly with money supply.
5) There is movement of gold between countries.
6) Capital is mobile within countries.
7) The adjustment mechanism is automate.

Empirical review

In a recent study, [22], examined the relationship between international reserve and its determinants in West African States for the period of 2005 to 2014. The study was based on buffer stock model and was estimated using Panel ARDL approach. In the short-run, all the variables except imports and nominal exchange rate had a positive impact on international reserve. In the long-run, imports, exports and nominal effective exchange does not have a statistical relationship with international reserves accumulation.

In a similar study, [23], analyzed determinants of foreign reserve in Nigeria for the period 1970-2013. Data were sourced from the Central Bank of Nigeria Statistical Bulletin while Ordinary Least Square technique was employed for the analysis. The result revealed that oil price and domestic credit were the major determinants of foreign reserve. Other variables such as domestic income, price level, interest rate and exchange rate were considered as determinants of foreign reserve in the long-run. Furthermore, the granger causality test revealed a unidirectional relationship between oil price and foreign reserve. Among others they recommended that Nigerian government should encourage other sources of foreign reserve apart from oil to minimize the effect of oil price volatility on the foreign reserve as well as the economy.

Also, [4], attempted to identify factors affecting foreign India's foreign reserves from 1996-97:Q1 to 2014-15:Q4. While the ratio of India's forex reserves to its GDP is considered as the dependent variable, the ratio of M3 to GDP of India, trade openness of India, and volatility of U.S. dollar-INR bilateral nominal exchange rate were considered as the explanatory variables. The study performed stationarity tests, Johansen's cointegration test, Johansen's Vector Error Correction Model (VECM) in VAR, impulse response function and variance decomposition analysis. They found that foreign reserves varied positively with money supply and trade openness, and negatively with exchange rate volatility.

Again, [7], identified determinants of foreign exchange reserves during 1983-2014. The unit root results showed that data, which are included in the model were non-stationary in raw form and they become stationary at second difference i.e., they are integrated order of I (2). The Cointegration analysis revealed there was a relationship among the variables in the long-run. However, long-run real exchange rate had positive but weak significant effect on long-run foreign reserves.

In another study, [9], modeled the long-run relationship between the Bureau De Change exchange rate and external reserves in Nigeria in a Threshold Vector Error Correction Model (TVECM) framework using daily data that spanned from Jan 1, 2014 to Jul 31, 2015. The supLM test result indicated that there was a non-linear long-run relationship between the series, providing empirical support in favor of a TVECM specification. Two regimes were implied by the model: the "usual" regime, which accounts for 93.1per cent of the observations and the "unusual" one, representing about 6.9 per cent of the observations of the sample. It was also found that the error correction coefficients for both the bureau de change exchange rate and external reserves equations were not statistically significant at the 5 per cent significance level. While in the second regime, error correction coefficient for the external reserves equation was found to be statistically significant at 10 per cent. This implied that the adjustment mechanism between the two variables flow from external reserves to BDC exchange rate.

In Nigeria, [12], focused on the interaction among selected monetary variables-crude oil price, exchange rate and external reserves over the period of 1970-2014, using long-run vector error correction model (VECM) and the short-run Granger Causality/Block Exogeneity Wald tests. VEC test indicated a self-adjusting mechanism for correcting any deviation of the variables from equilibrium. It insinuated that external reserves converged back to steady state in 5 years, Crude oil price in approximately 4 years, while foreign exchange rate returned to its steady state in 96 years. This was due to Nigeria's over-dependent on imported products, foreign medical tourism, and the effect of declining oil price, stock market speculation and

capital flight. In order to correct the disequilibrium of the external reserves, cointegrating long-run equation showed that a 1% increase in crude oil price led to 1.8% increase in external reserves.

Similarly, [12], evaluated the determinants of foreign reserves in Nigeria.The model of the study hypothesized that foreign reserve in Nigeria is afunction of some macroeconomic variables. The Johansen cointegration tests established evidence of a long-run relationship among the variables. The results of the estimated short-run coefficients based on parsimonious Error Correction Model (ECM) indicated that RGDP, oil exports were positive and significant determinants of foreign reserves. Expectedly, exchange rate was found to be significant but negative determinant of foreign reserves.

In Bangladesh, [11], undertook an econometric analysis of determinants of foreign exchange reserves. The study used Augmented Dickey-Fuller (ADF) unit root test to examine the stationarity, Engle Granger residual based cointegration approach to show the cointegrating relationship among variables, and diagnostic tests for better modeling. The empirical results confirmed a strong relationship among foreign exchange reserves, exchange rate, remittance, home interest rate, broad money, export, import, and per capita GDP. Drawing inferences from these findings, it can be suggested that exchange rate, a strong remittance related policies, quality items of exports, and sustainable GDP can keep a substantial and feasible roles to make up a healthy amount of foreign exchange reserves for the host country like Bangladesh.

Also, [21], modeled the relationship and causality link between foreign exchange reserves and exchange rate (nominal and real exchange rate) for economy of Pakistan using annually data series started from 1983 to 2009. The empirical methodology used cointegration analysis. The cointegration result pointed out that there was long-run relationship between foreign exchange reserves and exchange rate. This study also examined causality relationship and suggested that the direction of causality was from nominal effective exchange rate and real effective exchange rate towards foreign exchange reserves, it meant that in Pakistan both nominal effective exchange rate and real effective exchange rate affected foreign exchange reserves.

Again, [23], examined various determinants of Nigeria's foreign reserves. Using annual time series data from 1970 to 2009, the study regressed international reserve variable on macroeconomic variables: real income, interest rate differential (a measure of opportunity cost), exchange rate volatility, financial openness, openness to trade (a measure of current account vulnerability), benchmark stock of reserves, and the demand for foreign exchange. The empiricalevidence showed that growth in Nigeria's foreign reserves was influenced in the long-run by exchange rate volatility and the demand for foreign exchange, among other variables. Further, in the short-run, growth in Nigeria's foreign reserves was influenced by exchange rate volatility among other economic factors.

Model Specification and Method of Data Analysis

Leaning on empirical works earlier reviewed, the model of this study included foreign reserve as the dependent variable and real exchange rate (REER), real GDP growth rate (GRRT) and interest rate (INTR) as the explanatory variables. The study hypothesized that foreign reserve (FRSEV) in Nigeria is afunction of the aforementioned explanatory variables. This was algebraically expressed in equation one (1) below;

$$Log(FRSEV) = f(REER, GRRT \text{ and } INTR) + \varepsilon_t \quad \text{Eq. (1)}$$

Equation two (2) presents the estimable version of equation (1).

$$Log(FRSEV) = \beta_0 + \beta_1(REER) + \beta_2(GRRT) + \beta_3(INTR) + \varepsilon_t \quad \text{Eq. (2)}$$

Where,

β_0 = Constant term

$\beta_1 - \beta_3$ = Population parameter

ε_t = Estimated error term.

The study used autoregressive distributed lag (ARDL) bounds test approach for the study. The bounds testing was used to determine if the long-run relationship between the variables in the model. If the variables are cointegrated, the long-run ARDL model will be estimated and also the

speed of adjustment will be found. In ARDL analysis, long-run and short-run coefficients are estimated simultaneously, and model could be developed and utilized for cointegrationtest even if all the variables were not stationary after first differencing 1(1), or at level i.e. 1(0). ARDL model is developed when there is mixed integration at order one, 1(1) and at level, 1(0), but none is integrated at second differencing, 1(2) [12]. The ARDL bounds testing specification of equation (2) was expressed as error correction mechanism (ECM) to test for cointegration between the variables in view:

$\Delta \log (FRSEV)_t = \delta_o + \sum_{i=1}^{p} \delta_1 \Delta log(FRSEV)_{t-i} + \sum_{i=0}^{p} \delta_2 \Delta REER_{t-i} + \sum_{i=0}^{p} \delta_3 \Delta GRRT_{t-i} + \sum_{i=0}^{p} \delta_4 \Delta INTR_{t-i} + \beta_1 \log (FRSEV)_{t-1} + \beta_2 REER_{t-1} + \beta_3 GRRT_{t-1} + \beta_4 INTR_{t-1} + \mu_t$ ---------- Eqn. (3)

After cointegration is established, the estimation of the long-run relationship would follow, thus:

$\Delta \log (FRSEV)_t = \delta_0 + \beta_1 \log (FRSEV)_{t-1} + \beta_2 REER_{t-1} + \beta_3 GRRT_{t-1} + \beta_4 INTR_{t-1} + \mu_t$.- ----------Eqn. (4)

The short-run relationship is estimated using an error correction mechanism as shown below:

$\Delta \log (FRSEV)_t = \delta_o + \sum_{i=1}^{p} \delta_1 \Delta \log (FRSEV)_{t-i} + \sum_{i=0}^{p} \delta_2 \Delta REER_{t-i} + \sum_{i=0}^{p} \delta_3 \Delta GRRT_{t-i} + \sum_{i=0}^{p} \delta_4 \Delta INTR_{t-i} + \theta ecm_{t-i} + \mu_t$ ----------Eqn. (5)

Where,

δ_0 = Constant

δ_1 - δ_6 = short-run elasticities (coefficients of the first-differenced explanatory variables)

β_1 - β_6 = long-run elasticites (coefficients of the explanatory variables)

θ = Speed of adjustment

ecm_{t-i} = Error correction term lagged for one period

Δ = First difference operator

p = Lag length

Prior to ARDL estimation, the time series data was tested for stationarty. The test for stationarity of data was carried with Augmented Dickey Fuller (ADF) unit root test (Dickey & Fuller, 1979). This particular stage is very necessary, because most macroeconomic time series contains unit root and any regression involving non-stationary series almost always produce significant relation where in fact no relationship exist between the variables. The general model for Augmented Dickey-Fuller unit root test could be represented, thus:

$\Delta y_t = \beta_0 + \beta_1 t + \beta \lambda y_{t-1} + \sum_{j-1}^{p} \delta_j \Delta y_{t-j} + \mu_t$- ---------- Eqn. (3.6)

Where,

y_{t-1} = Lagged value of y_t at first difference

Δy_{t-j} = A change in lagged value

δ = Measure of lag length

Δy_t = First difference of y_t

μ_t = Error term

DATA ANALYSIS AND DISCUSSION OF FINDINGS

Unit root tests

Prior to the empirical analysis, the stationarity of data was ascertained with the augmented Dickey-Fuller (ADF) unit root test and Philip-Perron (PP) test. The results of these two tests were presented in Table 1 below:

Table 1: Unit root test results

Variables	Level; I(0)	First difference; I(1)	Level; I(0)	First difference; I(1)
FRSEV	-1.400464 {0.5716}	-7.212991 {0.0000}	-1.400464 {0.5716}	-7.303332 {0.0000}
REER	-1.934551 {0.3135}	-4.156971 {0.0025}	-1.710165 {0.4180}	-4.508317 {0.0009}
INTR	-3.212879 {0.0271}	--	-3.169741 {0.0300}	--
GRRT	-4.641001 {0.0006}	--	-4.661577 {0.0006}	--

Source: Author's computations (2019), using EViews 10.0
Note: Figures in { } are p-values

The result of the ADF and Philip Perron (PP) revealed that at levels; interest rate (INTR) and growth rate of domestic real GDP (GRRT) were stationary while all other variables were not stationary at level but attained stationarity at first difference. The order of integration at which stationarity was attained determined the estimation of technique suitable for each model. Based on above scenario, the study employed autoregressive distributed (ARDL) model towards achieving the aim of this study.

GARCH (1,1) modelling for exchange rate volatility test

To ascertain the level of volatility in real exchange rate (REER), the GARCH (1,1) was estimated and results given in Table 2 as follows:

Table 2: GARCH(1,1) results for exchange rate volatility

Variable	Coefficient	Std. Error	z-Statistic	Prob.
REER(-1)	0.936242	0.000538	1741.061	0.0000
C	5.444475	1.990982	2.734568	0.0062
	Variance Equation			
C	2.145090	17.66958	0.121400	0.9034
RESID(-1)^2	-0.127603	0.055494	-2.299408	0.0215
GARCH(-1)	1.096914	0.081632	13.43725	0.0000

Source: Author's computations (2019), using EViews 10.0

The Table 2 above shows the estimated GARCH (1, 1) model for exchange rate volatility. It can be seen from the table that most of the estimated parameters are significant. The variance equation confirmed the existence of non-persisted volatility in exchange rate, and the extracted volatility is depicted below in Figure 1.The series generated for the volatility was included in the short-run and long-run models below:

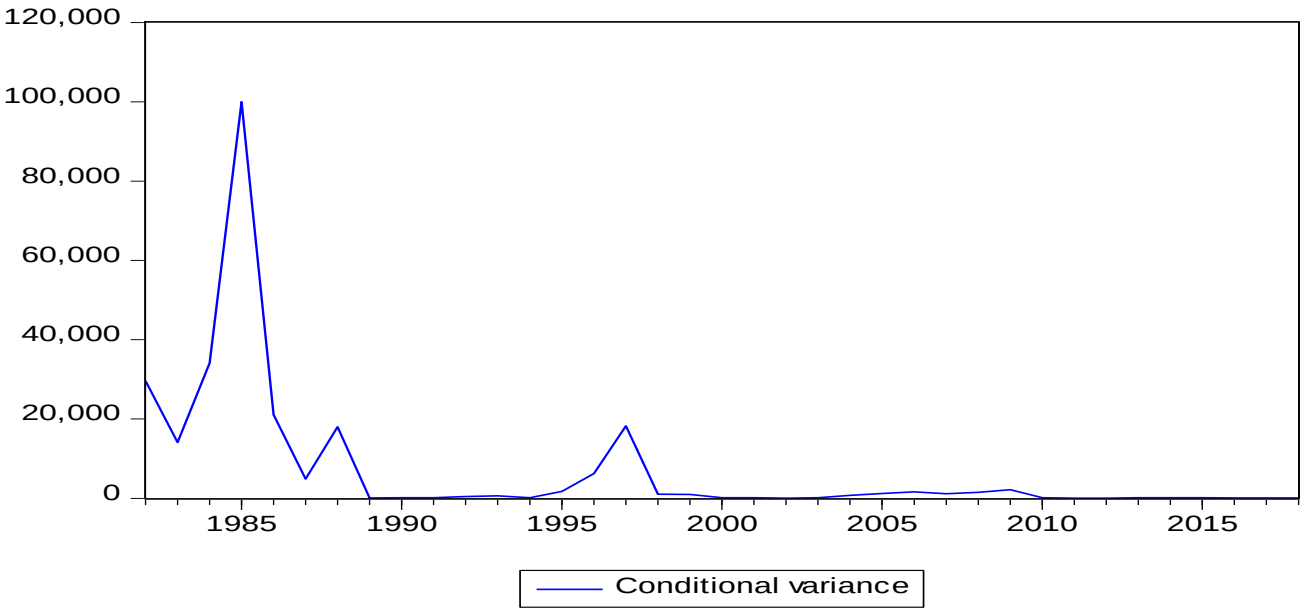

Figure 1: Volatility from exchange rate

Short-run and error correction model

The short-run dynamics associated with the ARDL model is as presented in Table 4.3 below:

Table 3: Estimated short-run parameters from ARDL (1,1,1, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.210641	0.979473	5.319841	0.0000
@TREND	0.075061	0.015656	4.794482	0.0000
D(REER)	-0.003789	0.001334	-2.839732	0.0082
D(INTR)	-0.065141	0.022799	-2.857170	0.0078
ECM(-1)*	-0.716093	0.133770	-5.353171	0.0000
R-squared	0.562251	Mean dependent var		0.077272
Adjusted R-squared	0.507533	S.D. dependent var		0.691841
S.E. of regression	0.485507	Akaike info criterion		1.517840
Sum squared resid	7.542932	Schwarz criterion		1.735532
Log likelihood	-23.08005	Hannan-Quinn criter.		1.594587
F-statistic	10.27532	Durbin-Watson stat		2.032928
Prob(F-statistic)	0.000018			

Source: Author's computations (2019), using EViews 10.0

From the above Table 4.3, real exchange rate volatility (REER) and interest rate (INTR) significantly influenced foreign reserves in the short-run. On the average, an increase in REER volatility would bring about 0.003789 deceleration in foreign reserves in the short-run. However, rising interest rate on average would bring about reduction in foreign reserves in the short-run. The speed of adjustment is correctly signed and highly significant with a practically zero probability and the practical implication of its estimated coefficient is that about 71.60% of disequilibrium in foreign reserves due to shock is corrected within a year.

The negative coefficients of REER and interest rates could be interpreted to mean that low interest rate in Nigeria propelled investors to divert from naira-denominated

to dollar-denominated assets. So, they exchanged naira for dollars, and their increased demand for dollars raised the naira-dollar exchange rate which automatically weighed down the foreign reserves. It is also known Nigeria have frequently used foreign exchange intervention (a monetary policy tool used by a central bank) in the foreign exchange market. The central bank of Nigeria, intervene in the foreign exchange market in order to build reserves, but this has often failed due to volatility in exchange rate over the years.

Long-run model

Before the study proceeded to the long-run modeling, the study first conducted a bounds test to ascertain the long-run cointegration relationship between the variables and the generated output is presented in the Table 4 below:

Table 4: Bounds test results

F-Bounds Test		**Null Hypothesis: No levels relationship**		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	6.492475	10%	3.47	4.45
K	3	5%	4.01	5.07
		2.5%	4.52	5.62
		1%	5.17	6.36

Source: Author's computations (2019), using EViews 10.0

From the Table 4.4, the study concludes that there is long run relationship between the dependent variable and the regressors because the computed F-statistic exceed the upper bound value I(1) at 5% level of significance, then the null hypothesis(no integration) is rejected and there is a prove of long-run cointegration. Hence, the study proceeded to the long-run modeling as shown below in Table 5.

Table 5: Estimated long-run parameters from ARDL (1,1,1, 0)

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
REER	-0.000678	0.001908	-0.355183	0.7250
INTR	-0.029245	0.053294	-0.548753	0.5874
GRRT	0.073860	0.031844	2.319457	0.0276

Source: Author's computations (2019), using EViews 10.0

From the Table 5, only interest rate significantly affected foreign reserves in the long-run. On the average, a percentage increase in interest rate would bring about 0.029245 increase in foreign reserves in the long-run. The exchange rate volatility has insignificant negative relationship with foreign reserves in the long-run.

Diagnostic tests

Diagnostic tests have been applied on the ARDL model and no evidence of serial correlation, heteroskedasticity was found. Jarque-Bera test suggests a normal distribution. The summary of the diagnostic test was presented in Table 6 below:

Table 6: Diagnostic test results

Test	**p-value**	**Decision**
Breusch-Godfrey Serial Correlation LM Test:	0.2678	No serial correlation
Heteroskedasticity Test: Breusch-Pagan-Godfrey	0.3690	No Heteroskedasticity
Jarque-Bera	0.4719	Normal distribution

Source: Author's computations (2019) using EViews 10.0

To establish the stability of the model the CUSUM test was applied to test for parameter stability. The decision rule is based on the blue line, that is, when the blue line is within the two red lines the model is stable, otherwise it is not. Based on the results reported in Figures 2and 3below, the model estimated is stable at 5 percent level, implying no issue of parameter instability during the period.

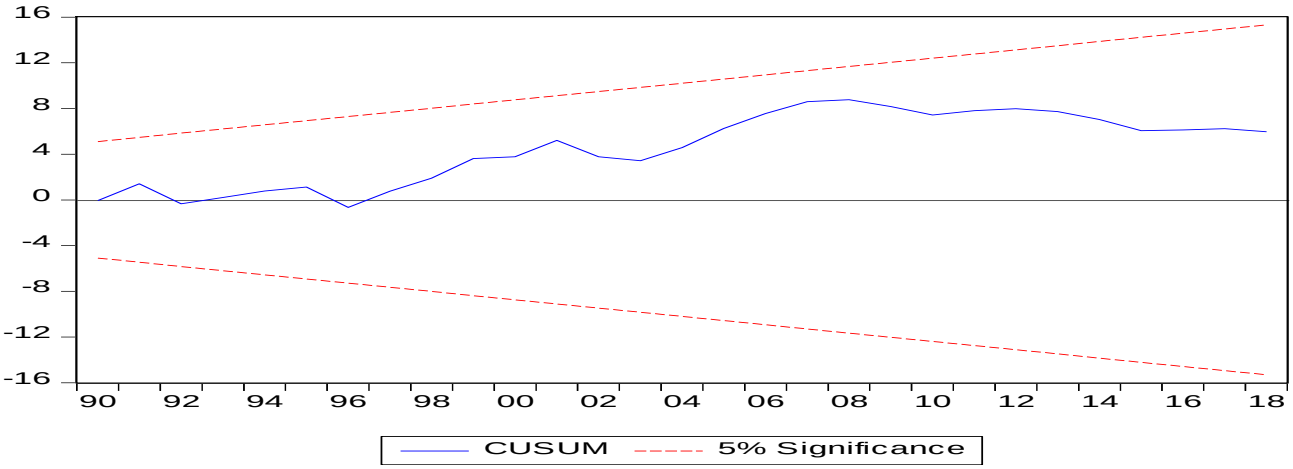

Figure 2: CUSUM test

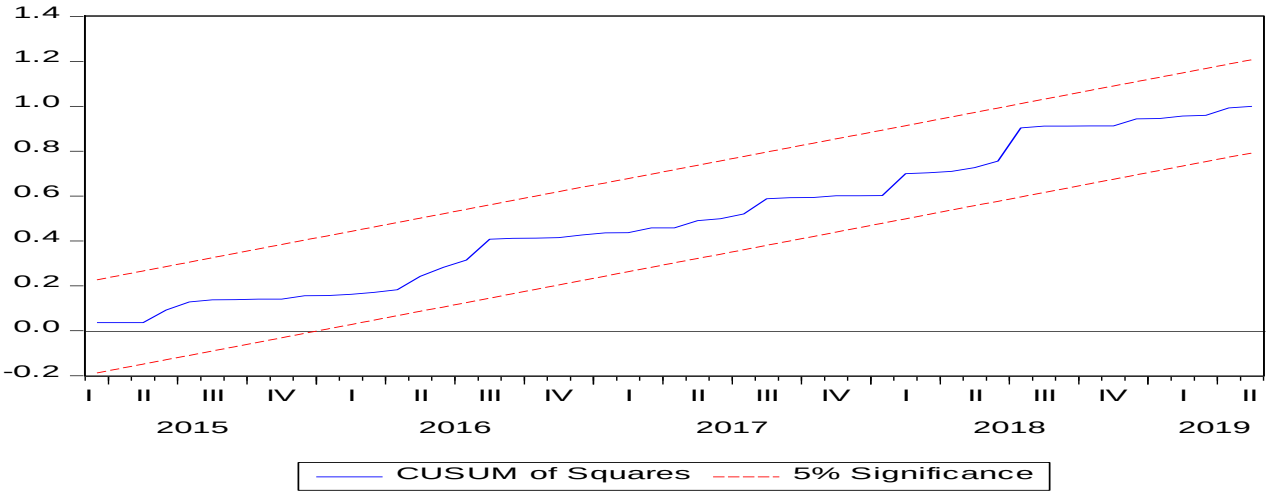

Figure 3: CUSUM of Squares test

CONCLUSION AND RECOMMENDATIONS

This study evaluated effect of exchange rate volatility on foreign reserves in Nigeria. Literature relevant to the subject matter were thoroughly reviewed. The model of the study hypothesized that foreign reserve (RESV) in Nigeria is a function of real exchange rate, real GDP growth rate and interest rate. The GARCH test showed that real exchange rate was highly volatile over the period of study. The bounds test for cointegration established evidence of a long-run relationship among the variables. The results of the estimated short-run coefficients based on Error Correction Model (ECM) indicated that exchange rate fluctuation had a negative and significant effect on foreign reserves amidst negative and significant interest rate estimate. Thus, a rise in exchange rate volatility (interpreted here to mean fluctuations of price adjusted Nigeria's Naira) caused foreign reserves to decelerate. The probability of the diagnostic tests conducted reinforced the

robustness of the model. On the basis of the empirical findings, regarding exchange rate volatility, the study recommends that government of Nigeria should make sure that Central Bank focuses primarily on interest rate control to ensure price and exchange rate stability which would ensure stability of exchange rate that would preserve foreign reserves of Nigeria.

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APPENDIX

Appendix 1: Annual time series data

YEAR	Foreign reserves (FRSEV) $ Billion	Real exchange rate (REER) Naira-Dollar	Real exchange rate volatility	Interest rate (INTR) proxy: monetary policy rate	Real GDP Growth rate (GRRT)
1981	2441.60	317.40		6.00	-13.12
1982	1043.30	325.50	8.10	8.00	-1.82
1983	224.40	385.30	59.80	8.00	-8.20
1984	710.10	531.20	145.90	10.00	-0.51
1985	1657.90	477.60	-53.60	10.00	7.86
1986	2836.60	267.64	-209.96	10.00	1.86
1987	7504.59	85.27	-182.37	12.75	0.17
1988	5229.10	85.68	0.41	12.75	5.87
1989	3047.62	76.30	-9.38	18.50	6.24
1990	4541.45	70.79	-5.51	18.50	10.42
1991	4149.30	60.01	-10.78	15.50	-0.56
1992	1554.61	49.78	-10.23	17.50	2.15
1993	1429.59	54.54	4.76	26.00	1.54
1994	9009.11	100.86	46.32	13.50	0.26
1995	1611.11	160.23	59.37	13.50	1.84
1996	3403.91	19.07	-141.16	13.50	3.89
1997	7222.22	19.22	0.14	13.50	2.80
1998	7107.50	19.88	0.66	13.50	2.43
1999	5424.60	53.76	33.88	18.00	0.52
2000	9386.10	58.25	4.49	14.00	5.23
2001	10267.10	70.58	12.33	20.50	6.25
2002	7681.10	85.13	14.55	16.50	12.74
2003	7467.78	106.68	21.55	15.00	8.68
2004	16955.02	126.69	20.01	15.00	9.45
2005	28279.06	143.78	17.10	13.00	6.55
2006	42298.11	148.33	4.55	10.00	6.30
2007	51333.15	155.75	7.42	9.50	6.82
2008	53000.36	90.31	-65.44	9.75	6.72
2009	42382.49	97.44	7.13	6.00	7.71
2010	32339.25	93.39	-4.05	6.25	8.71
2011	32639.78	89.82	-3.57	12.00	5.04
2012	43830.42	79.58	-10.24	12.00	4.04
2013	42847.31	74.20	-5.37	12.00	5.20
2014	34241.54	69.51	-4.70	13.00	5.86
2015	28284.82	70.83	1.32	11.00	2.71

2016	26990.58	80.36	9.53	14.00	-1.61
2017	39353.49	85.62	5.26	14.00	0.82
2018	42594.84	78.34	-7.28	14.00	1.89

Appendix 2: Unit root test results: ADF tests

Null Hypothesis: LOG(FRSEV) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.400464	0.5716
Test critical values:	1% level	-3.621023	
	5% level	-2.943427	
	10% level	-2.610263	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(LOG(FRSEV)) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.212991	0.0000
Test critical values:	1% level	-3.632900	
	5% level	-2.948404	
	10% level	-2.612874	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: REER has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.934551	0.3135
Test critical values:	1% level	-3.621023	
	5% level	-2.943427	
	10% level	-2.610263	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(REER) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.156971	0.0025
Test critical values:	1% level	-3.626784	
	5% level	-2.945842	

	10% level	-2.611531

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: INTR has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.212879	0.0271
Test critical values:	1% level	-3.621023	
	5% level	-2.943427	
	10% level	-2.610263	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: GRRT has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.641001	0.0006
Test critical values:	1% level	-3.621023	
	5% level	-2.943427	
	10% level	-2.610263	

*MacKinnon (1996) one-sided p-values.

Appendix 3: Unit root test results: Philip-Perron tests

Null Hypothesis: LOG(FRSEV) has a unit root
Exogenous: Constant
Bandwidth: 0 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.400464	0.5716
Test critical values:	1% level	-3.621023	
	5% level	-2.943427	
	10% level	-2.610263	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(LOG(FRSEV)) has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-7.303332	0.0000
Test critical values:	1% level	-3.626784	
	5% level	-2.945842	

	10% level	-2.611531

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: REER has a unit root
Exogenous: Constant
Bandwidth: 9 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.710165	0.4180
Test critical values:	1% level	-3.621023	
	5% level	-2.943427	
	10% level	-2.610263	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(REER) has a unit root
Exogenous: Constant
Bandwidth: 35 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-4.508317	0.0009
Test critical values:	1% level	-3.626784	
	5% level	-2.945842	
	10% level	-2.611531	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: INTR has a unit root
Exogenous: Constant
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-3.169741	0.0300
Test critical values:	1% level	-3.621023	
	5% level	-2.943427	
	10% level	-2.610263	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: GRRT has a unit root
Exogenous: Constant
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-4.661577	0.0006
Test critical values:	1% level	-3.621023	
	5% level	-2.943427	
	10% level	-2.610263	

*MacKinnon (1996) one-sided p-values.

Appendix 4: Long-run ARDL estimation

ARDL Long Run Form and Bounds Test
Dependent Variable: DLOG(FRSEV)
Selected Model: ARDL(1, 1, 1, 0)
Case 5: Unrestricted Constant and Unrestricted Trend
Date: 11/12/19 Time: 23:24
Sample: 1981 2018
Included observations: 37

Conditional Error Correction Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.210641	1.855057	2.808885	0.0088
@TREND	0.075061	0.017598	4.265223	0.0002
LOG(FRSEV(-1))*	-0.716093	0.174909	-4.094096	0.0003
REER(-1)	-0.000485	0.001433	-0.338702	0.7373
INTR(-1)	-0.020942	0.041161	-0.508798	0.6147
GRRT**	0.052891	0.023998	2.203943	0.0356
D(REER)	-0.003789	0.001562	-2.425601	0.0217
D(INTR)	-0.065141	0.032280	-2.018024	0.0529

* p-value incompatible with t-Bounds distribution.
** Variable interpreted as Z = Z(-1) + D(Z).

Levels Equation
Case 5: Unrestricted Constant and Unrestricted Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REER	-0.000678	0.001908	-0.355183	0.7250
INTR	-0.029245	0.053294	-0.548753	0.5874
GRRT	0.073860	0.031844	2.319457	0.0276

EC = LOG(FRSEV) - (-0.0007*REER -0.0292*INTR + 0.0739*GRRT)

F-Bounds Test Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	6.492475	10%	3.47	4.45
k	3	5%	4.01	5.07
		2.5%	4.52	5.62
		1%	5.17	6.36
			Finite Sample: n=40	
Actual Sample Size	37			
		10%	3.76	4.795
		5%	4.51	5.643
		1%	6.238	7.74

		Finite Sample: n=35	
	10%	3.8	4.888
	5%	4.568	5.795
	1%	6.38	7.73

t-Bounds Test — Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
t-statistic	-4.094096	10%	-3.13	-3.84
		5%	-3.41	-4.16
		2.5%	-3.65	-4.42
		1%	-3.96	-4.73

Appendix 5: Error correction mechanism and short-run ARDL estimation

ARDL Error Correction Regression
Dependent Variable: DLOG(FRSEV)
Selected Model: ARDL(1, 1, 1, 0)
Case 5: Unrestricted Constant and Unrestricted Trend
Date: 11/12/19 Time: 23:24
Sample: 1981 2018
Included observations: 37

ECM Regression
Case 5: Unrestricted Constant and Unrestricted Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.210641	0.979473	5.319841	0.0000
@TREND	0.075061	0.015656	4.794482	0.0000
D(REER)	-0.003789	0.001334	-2.839732	0.0082
D(INTR)	-0.065141	0.022799	-2.857170	0.0078
CointEq(-1)*	-0.716093	0.133770	-5.353171	0.0000

R-squared	0.562251	Mean dependent var	0.077272
Adjusted R-squared	0.507533	S.D. dependent var	0.691841
S.E. of regression	0.485507	Akaike info criterion	1.517840
Sum squared resid	7.542932	Schwarz criterion	1.735532
Log likelihood	-23.08005	Hannan-Quinn criter.	1.594587
F-statistic	10.27532	Durbin-Watson stat	2.032928
Prob(F-statistic)	0.000018		

* p-value incompatible with t-Bounds distribution.

F-Bounds Test — Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	6.492475	10%	3.47	4.45
k	3	5%	4.01	5.07

2.5%	4.52	5.62
1%	5.17	6.36

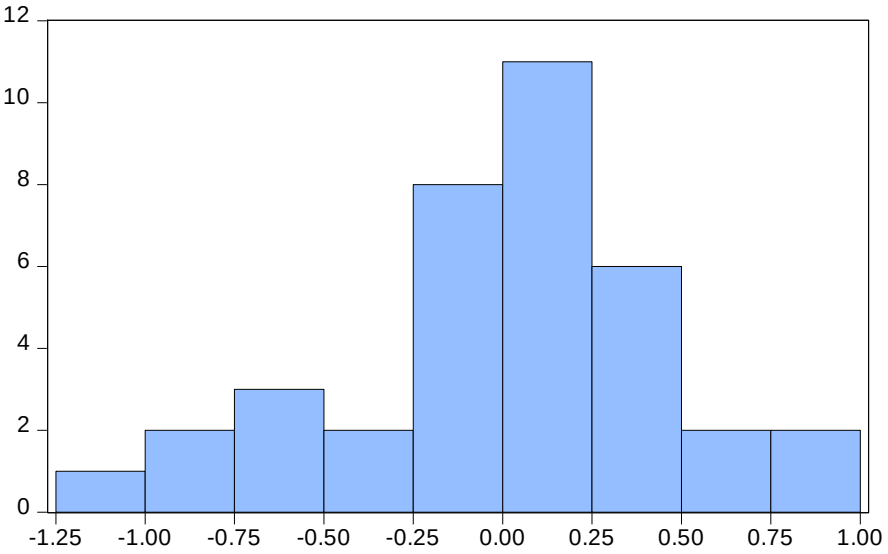
t-Bounds Test — Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
t-statistic	-5.353171	10%	-3.13	-3.84
		5%	-3.41	-4.16
		2.5%	-3.65	-4.42
		1%	-3.96	-4.73

Appendix 6: Diagnostic tests

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.383807	Prob. F(2,27)	0.2678
Obs*R-squared	3.440039	Prob. Chi-Square(2)	0.1791



Series: Residuals
Sample 1982 2018
Observations 37

Mean	4.04e-16
Median	0.036815
Maximum	0.823494
Minimum	-1.002772
Std. Dev.	0.457740
Skewness	-0.481506
Kurtosis	2.784032
Jarque-Bera	1.501636
Probability	0.471980

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.135268	Prob. F(7,29)	0.3690
Obs*R-squared	7.958301	Prob. Chi-Square(7)	0.3363
Scaled explained SS	4.360996	Prob. Chi-Square(7)	0.7374