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Real Exchange Rates and Real Interest Rates Differential: Evidence from Nigeria

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Abstract: The theoretical relationship of the long-run equilibrium between real exchange rates and interest rate differentials is essentially derived from the Purchasing Power Parity (PPP) and the uncovered interest parity. However, empirical evidence on this long-run relationship has rather been inconclusive. While several authors are able to establish the long-run relationship between real exchange rates and interest rate differentials other could not found this relationship. The reason for lack of relationship in some of the studies is as a result of omitted variables (Meese and Rogoff, 1988). Therefore, attempt is made in this study to evaluate this relationship between real exchange rate and interest rate differential for the case of Nigeria by controlling for foreign exchange reserves. The paper uses monthly data for the period 1993:1-2012:12 and applies Autoregressive Distributed Lags (ARDL) model. The estimates suggest the existence of long-run relationship between real exchange rate, interest rate differential and foreign exchange reserves. In the long run, the exchange rate coefficient has a positive effect on the foreign reserves. However, the effect of interest rate differential is negative and statistically significant. On the short run dynamics, the finding indicates a non-monotonic relationship between real exchange rate, interest rate differential and foreign exchange reserves. The out-of-sample forecast indicates a better forecast using ARMA model as all Theil coefficients are close zero for all the horizons used in the model.

Keywords: Interest rate differential; Real exchange rate; Foreign reserves; Autoregressive distributed Lag (ARDL).
JEL Classification: F30; F41; C20

1. Introduction

The theoretical relevance of the relationship between the real exchange rate and interest rate differential has been substantially discussed in the interest rate parity theory. This can be found in the work of Mundell (1963) Fleming (1962) and Dornbusch (1976). The theoretical relationship of the long-run equilibrium between real exchange rates and interest rate differentials is essentially derived from the Purchasing Power Parity (PPP) and the uncovered interest parity. However, empirical evidence on the long-run relationship between real exchange rates and interest rate differential has rather been inconclusive. Meese and Rogoff (1988), Edison and Pauls (1933) could not establish cointegration between real exchange rates and real interest rate differential. MacDonald (1997), Edison and Melick (1999) and Bautista (2006) on the other hand, find a long- run relationship between these two variables.

Meese and Rogoff (1988) suggest that the reason for lack of long-run relationship between real exchange rates and interest differential might be as a result of an omitted variable. This conclusion by Meese and Rogoff (1988) motivates others like Blundell-Wignall and Browne (1991), Edison and Pauls (1933) to use the cumulated current account as a third variable in their studies. While Blundell-Wignall and Browne (1991) and Wu (1999) are able to establish a long-run relationship, Edison and Pauls (1933) could not find any cointegration even when a third variable is introduced.

This study, however, uses foreign exchange reserves as a third variable. The choice of this variable is based on the observation by Jin (2003) and Narayan and Smyth (2006). They observe that foreign exchange reserve is more representative of the fundamental variables. This variable according to Jin (2003) has the capacity of capturing all the effects of the variables mentioned by Montiel (1999) and it is more appropriate than the cumulated current account. It is also interesting to note that Nigerian foreign reserves has been on the steady increase over the last decades from US$ 5.5 billion in 1999 to US$62.4 billion in 2008. This amount, however, declined to US$34.8 billion in 20009 and later increased to US$46.5 billion in 2013. (Central Bank of Nigeria, 2013) This indicates that the Nigerian foreign reserve although susceptible to volatility has been on the steady increase and quite appropriate to serve as a control variable.

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In 1986, Nigeria introduced the Structural Adjustment Programme (SAP), which is a structural reform policy package that is based on liberalisation and deregulation of the domestic economy. The policies paved way for the abolishment of capital accounts, deregulation of interest rates, adoption of flexible exchange rates, and other wide range reforms in both the money and capital markets. Given this level of reforms, Thomas (2012) observes that Nigeria is second most open capital account economy in Sub-Saharan Africa after South Africa[1]. All these reforms together with the availability of time-series data provide the necessary motivation for this study. Asea and Reinhart (1995), Thomas (2012) are some of the major empirical works on real exchange rate and interest rate differential in Africa. However, in Nigeria, most studies have been on exchange rate misalignments and stability, evolution exchange rate in Nigeria, and assessment of exchange rate policies. This can be found in the work of Obadan (2002), Obadan (2006), Aliyu (2011) and Ozsoz and Akinkunmi (2012).

This paper is different from the previous studies on exchange rate determination in Nigeria and hence its contribution to literature in the following ways: 1) Not only limited work exists in this area but this is the first major work on Nigeria that specifically evaluates the relationship between real exchange rates, foreign exchange reserves and real interest rate differential. 2) This study accounts for structural breaks at the unit root level and incorporates the significant dummies into the estimates of the short-run dynamics. 3) The study further estimates the out-of-sample forecasts using the random walk model (RDWM).

This paper therefore examines the long-run relationship between real exchange rate, real interest rate and foreign exchange reserves for Nigeria. The study applies the Autoregressive Distributed Lags (ARDL) model. One important reason for using this model is that the ARDL model can be applied irrespective of the order of integration whether a variable is integrated of order one I(1) or I(0).

One clear finding of this study is the existence of a long-run relationship between the real exchange rate and interest rate differential and the foreign exchange rate reserves. This finding is consistent with most theoretical predictions of monetary models of exchange rate determination. It is also consistent with the empirical findings of Narayan and Smyth (2006) respectively.

Following this introduction, section 2 presents a brief overview of the Nigerian real exchange rate, interest rate and foreign reserves. Section 3 is the literature review and theoretical framework. Section 4 consists of data and econometric methodology. Section 5 covers the presentation of the empirical results and section 6 is the conclusion.

2. Overview of Nigerian Real Exchange Rates, Real Interest Rates, and Foreign Reserves

Prior to 1986, the Nigerian economy was characterized by a significant level of excessive regulated policies, which resulted in severe macroeconomic instability- low growth, balance of payment deficits, high unemployment, and inflation. The government’s response to this development was the adoption of Structural Adjustment Programme (SAP) in 1986. The main focus of the programme include: -restructuring and diversifying the productive base of the economy; achieve fiscal and balance of payment viability; the adoption of a realistic exchange rate policy coupled with the liberalization of the external trade and payment system.

Before 1986, Nigeria operated a fixed exchange rate system, which was designed to achieve balance of payments equilibrium, a stable exchange rate and preserve the value of external reserves. This policy was accompanied by nominal exchange rate appreciation which encouraged cheap imports and later created balance of payments crisis and fast depletion of external reserves. It also led to capital flight and discouraged non-oil exports and helped to sustain the manufacturing sector over dependence on imported inputs. Obadan (2006).

The adoption of a market determined exchange rate was introduced in 1992 after the merger of both first and second-tier foreign exchange markets. The essence was to address the major challenges of fixed exchange rates. This includes achieving a realistic exchange rate determined by market forces; more efficient resources allocation through the substantial reduction of wasteful transaction, and stimulation of non-oil exports.

Since the introduction of market determined exchange rate, the monetary authorities have adopted different management strategies. Foreign Exchange Market (FEM) was introduced when both the first and second tier foreign exchange markets were merged in July 1987. The FEM has two important components: the official foreign exchange market and the autonomous foreign market. By 1989, the Interbank Foreign Exchange Market was introduced, leading to the merger of both official and autonomous markets. The system was later abandoned in1990 but reintroduced in 1999.

The Dutch Auction System (DAS) was first introduced in 1987 as a management strategy of the flexible foreign exchange. It was reintroduced in 1990 and again in 2002 as a retail DAS. Meanwhile, a wholesale DAS has been in operation introduced since 2006.

It is interesting to note that since the introduction of a floating exchange regime, the Naira has witnessed continued decline against the major currencies particularly the US dollar. Some of the factors responsible for the depreciation of the Nigerian Naira include: weak productive base of the economy; import dependent production structure; expansionary fiscal and monetary policies; excessive demand for foreign exchange in relation to supply, etc (Okafor, 2009).

[1] Thomas,(2012) clearly shows that South Africa is the most open economy in the Sub-Saharan Africa when it is measured by the openness of capital account and this is followed by Nigeria. Evidence is provided in table 1 of the paper. (pp.6)

Prior to 1986 that is during pre-SAP period the Nigerian monetary authorities were operating a fixed interest rate mechanism. The Central Bank of Nigeria fixed the interest rates and other financial intermediation charges. They set the maximum lending rate, which ultimately affects the level of credit expansion. Sectoral credit allocation was also set by the monetary authorities. The fixed interest rate regime was however characterised by series of problems among which include: inefficient use of capital due to artificial low cost of bank credit; acute scarcity of loanable funds in the systems because banks would prefer to invest their funds in Treasury Bills than lend below their average cost of funds. Okafor (2009).

These problems paved the way for the adoption of a deregulated interest rate and abolition of sectoral allocation. Interest rate deregulation was introduced in August 1987.[2] Under this market determined rate, the monetary authorities set the rules for the operators and ensure they operate within the rules. Some important management strategies include Open Market Operation (OMO), rediscount rate, liquidity ratio, and, bank cash reserve ratio.

It is important to note that the current interest rate management has also been confronted with a lot of challenges among which includes: expansionary fiscal operation of the three tiers of government, oligopolistic banking sector, time inconsistency, structural rigidities and developing financial system. (Okafor, 2009).

Gupta and Agarwal (2004) observe that one of the important factors affecting foreign exchange is the exchange rate reserves. However, the extent of the influence depends on the exchange rate regimes. In Nigeria, foreign reserves are held mainly: (a) to support and maintain confidence in the monetary and exchange rate management, (b) for servicing debt obligations (c) to finance government expenditure, (d) to provide a source of income as the reserves can be invested in income generating instruments e.g. TBs, bonds and time deposits. (Nda, 2009).

As shown in figure 1 in the appendix, the Nigerian external reserves have mostly been on the steady increase. Nigerian external reserves are mainly derived from oil revenues which account for more than 90% of foreign exchange earnings. However, the Nigerian external reserves have over the years been confronted with a lot of challenges the most important ones include: volatility of foreign exchange inflows, lack of diversification of the productive base of the economy, and structure of the Nigerian Fiscal Federalism. (Central Bank of Nigeria, 2013).

3. Literature Review

Jin (2003) evaluates the dynamics of real interest rates, real exchange rates and the balance of payments for China. Using Vector Autoregression (VAR) and after taking into account institutional changes, his findings indicate a long-run relationship between real exchange rates and foreign reserves. He further shows non-monotonic and significant interactions between the three variables in the study. Narayan and Smyth (2006) also use China to examine the relationship between the real exchange rate, foreign exchange reserve and interest rate differential. It covers the period 1980:1 to 2002:7. They, however, apply the ARDL model (bound test) and their finding shows evidence of a long-run relationship between the three variables.

Wu (1999) applies Johansen VAR techniques and establishes a long-run relationship between the real exchange rate and the expected interest rate differential for Germany and Japan respectively. Also the error correction model in the out-of sample forecast is found to be statistically significant. Wee and Ying (2006) using monthly data (1985:5 to 1996:5) and also applying the Johansen VAR maximum likelihood to examine the long-run relationship between the real exchange rate and real interest differential for the case of Malaysia. The result suggests the existence of a long-run relationship.

Hoffmann and MacDonald (2009) use a VAR-based present value approach to examine the relationship between the real exchange rate and real interest rate differential for the U.S. and G-7 countries. They establish a significant relationship between the two variables. The sample period of the study covers the period 1978q2 to 2007q3.

Byrne and Nagayasu (2010) also obtain a long-run relationship using structural breaks and cointegration approach in both US and UK relationship and in the global context. Bleaney and Laxton (2003) also confirm this relationship using measures of real interest rates derived from indexed bonds and conclude that previous studies are probably attributable to errors in estimating inflation expectation.

MacDonald and Nagayasu (2000) establish a long-run relationship in their study using a panel cointegration technique. They cover a floating exchange rate period for 14 industrialised countries covering the period 1976-1997. Mark and Moh (2005) examine the relationship between the real exchange rate and real interest rate differential using a panel data technique and accounting for nonlinearities. The study uses a monthly data observation covering the period 1978:9 to 2002:4 for Japan, Canada, Germany, U.K and U.S. applying a standard pricing relationship in which interest rate differential is assumed to follow a non-linear process. The evidence suggests a relationship between the two variables in the short-run or horizon than in the long horizon.

Other studies use a non linear approach to evaluate the relationship between the real exchange rate and interest rate differential. For example, Nakagawa (2002) examines the empirical relationship between the real exchange rate and real interest rate differential for the US dollar against Germany Mark, Japanese Yen, British Pound and Canadian Dollar. The paper uses monthly and quarterly observations for the period 1974 to 1997 and after incorporating nonlinear real exchange rate adjustment, they establish a link between the real exchange rate and interest rate differential.

[2] It should be noted that after the deregulation of the interest rate in August 1987, it was later followed by series of policy reversals. In 1991, the interest rates were recapped but a year later it was deregulated again. However, fixed interest rate were again reintroduced from 1994-1998

Kanas (2005) applies a multivariate regime switching approach for the period 1921 -2002. The study was characterised by different nominal exchange rate regimes. However, based on the volatility regime dependence, the results suggest the existence of relationship between UK and US real exchange rate and real interest rate differential. Sollis and Wohar (2006) also obtain some evidence of a relationship between the real exchange rate and interest rate differential by using a non-linear approach. They apply a threshold cointegration framework. When a threshold cointegration is found to exist, they establish stronger mean reversion. Bautista (2006) examines both the volatility and correlation between the real exchange rate and real interest differential using a multivariate GARCH approach. By applying the Dynamic Conditional Correlation (DCC model), he obtains a positive time-varying correlation during the pegged regime and a negative correlation throughout the flexible period for the Asian countries.

3.1. Theoretical Model

The relationship between the real exchange rate and real interest rate differential can be derived from two major components: a) the purchasing power parity (PPP), which is a hypothesis based on the assumption of constant equilibrium real exchange rate, and (b) the uncovered interest rate parity (UIP) hypothesis. It shows that the expected change in the exchange rate should equal the interest rate differential. Therefore putting these two hypotheses together based on Mundell-Fleming-Durnbush models, we will be able to obtain the real exchange rate and interest rate differential relationship.

According to Jin (2003), many empirical works have been conducted to confirm the validity of this relationship but evidence in general has really failed to confirm this relationship.

However, the first component to the building of this relationship is the PPP hypothesis whose interpretation according to Chortareas and Driver (2000) depend on the prices, and these prices are assumed to be sticky or flexible. Meanwhile, the conventional interpretation of the PPP hypothesis is that it is assumed to show a constant equilibrium of the real exchange rate:

$$E_t \bar{q}_{t+1} = \bar{q}_t \tag{1}$$

Where the constant equilibrium real exchange rate for period t is given by $\bar{q}_t$, the real exchange rate is defined as:

$$\bar{q}_t \equiv et + P_t^* - P_t \tag{2}$$

Where et is the nominal exchange rate expressing a unit of foreign currency in terms of domestic currency. P_t^* and P_t are logarithms of foreign and domestic price level respectively.

The second component is the uncovered interest rate parity (UIP), which is given as follows:

$$E_t e_{t+1} - e_t = i_t - i_t^* \tag{3}$$

Where i_t and i_t^* show both home and the foreign nominal interest rate at period t for a period ahead. However, we can obtain the real terms by subtracting expected inflation from both sides of equation (3), which resulted in equation 4 as follows:

$$E_t(q_{t+1} - q_t) = r_t - r_t^* \tag{4}$$

Where r_t and r_t^* denote domestic and foreign expected real interest rate

According to Chortareas and Driver (2000), testing for UIP might be complicated because it is difficult to obtain expected exchange rates, nominal or real exchange rates. Therefore, one way to solve the problem is to combine the PPP and UIP and then make assumptions about how real exchange rates adjust to disequilibrium.

$$E_t(q_{t+1} - \bar{q}_t) = \theta(q_t - \bar{q}_t), 0 < \theta < 1 \tag{5}$$

Where θ indicates the speed of adjustment and the higher the value of θ the slower is adjustment of real exchange rate to its long-run equilibrium. Solving equation 4 for

$E_t(q_{t+1})$ and then putting equations 1 and 5 gives the following:

$$q_t = \alpha(r_t - r_t^*) + \bar{q}_t \tag{6}$$

Where $\alpha = 1/(\theta - 1) < -1$

4. Data and Measurement

This article uses three variables: real exchange rates, real interest rate differential and foreign exchange reserves. It utilises monthly data covering the period 1993:01- 2012:12. All the data are obtained from the International Financial Statistics (IFS) of the International Monetary Fund. For the real exchange rates, the paper uses the real effective exchange rates, which is defined as trade weighted real effective exchange rate. It is based on domestic currency to the US dollar. The proxy has been found to be a good measure since it adjusted for inflation. This variable has been used in the work of Jin (2003) Narayan and Smyth (2006), and Kasman and Duygu (2008). The real interest rate differential is obtained, using the lending rate (Nigeria), lending rate (USA), Consumer Price Index (CPI) of both Nigeria and United States.

4.1. Econometric Methodology

This section starts with the specification of unit root models. The study applies the popular Augmented Dickey-Fuller (ADF) test, and the KPSS test developed by Kwiatkowski *et al.* (1992). However, empirical evidence has shown that these tests particularly the ADF test displays low power of probability and some size distortions. Therefore, due to these problems with conventional unit root tests, this study further applies unit root test with structural break.

The application of structural break tests in unit root has become popular in applied time-series ever since Nelson and Plosser (1982) studied the evidence of unit root hypothesis using macroeconomic variables. Many studies have since then been undertaken with a structural break test in unit root, among which include Perron (1989), Zivot and Andrews (1992) and Perron and Vogelsang (1992). The Perron (1989) work provides the critique of Nelson and Plosser (1982) findings, using the same macroeconomic data and with the exogenous method; he establishes that most variables do not exhibit any evidence of a unit root. He, however, indicates that series exhibit trend stationary process coupled with structural breaks. This approach of exogenous determination of structural break has however been criticised by Zivot and Andrews (1992) as they proposed sequentially Dickey-Fuller unit root test, treating the break points as unknown, i.e. it allows structural break points to be endogenously determined. The Zivot and Andrews (1992) model is specified as follows:

$$\text{Model A: } y_t = \mu^A + \theta^A DU_t + \beta^A t + \alpha^A y_{t-1} + \sum_{j=1}^{k} cj\Delta y_{t-j} + \varepsilon_t$$

$$\text{Model B: } y_t = \mu^B + \beta^B t + \gamma^B DT_t^* + \alpha^B y_{t-1} + \sum_{j=1}^{k} cj\Delta y_{t-j} + \varepsilon_t$$

$$\text{Model C: } y_t = \mu^c + \theta^C DU_t + \beta^C t + \gamma^C DT_t^* + \alpha^C y_{t-1} + \sum_{j=1}^{k} cj\Delta y_{t-j} + \varepsilon_t \quad (7)$$

The Zivot and Andrews (1992) develop a three model (A, B, and C) approach for testing the endogenous structural breaks of individual series. Model A presents the sudden change at level of the series and Model B gives the unknown break point at slope of the series or at the trend function. Model C allows sudden changes both at the level and slope of the trend function of the time series.

The dummy variables both at the level and the slope are indicated by DU_t and DT_t^* respectively. Where $DU_t = 1 \text{ if } t > T_B; 0$ otherwise; $DT_t^* = t - T_B \text{ if } t > T_B, 0$ otherwise and K is the optimal lag. The three equations are then sequentially estimated over the possible break points. The break points are usually obtained at the point where t-statistics is minimised. For lag selection, we also follow the general to specific procedure by setting the lag length at K=8. The lag length is chosen in such a way that the first t-statistics is greater than 1.645 (10% significance)

In order to establish the level of a long-run relationship between the variables of interest, this study applies the autoregressive distributed lag (ARDL) model of Pesaran *et al.* (2001). The advantage of using the ARDL model is that the order of integration is not necessary for cointegration to be established. Therefore, irrespective of whether the variables are I (1) or I (0), the ARDL model can easily be applied. Another advantage is once the order of the series has been established the relationship can easily be estimated with ordinary least square method.

The specification of the ARDL model following Pesaran *et al.* (2001) is presented in the vector autoregression (VAR) of order P below:

$$Z = \alpha + \sum_{i=1}^{p} \beta_i Z_{t-i} + \varepsilon_i \quad (8)$$

Where Z_t represents the vector of Y_t and X_t respectively Y_t is the dependent variable and X_t is the vector matrix of the explanatory variables Explanatory variables can be I(1) or I(0) but the dependent variable is expected to be I(1) Pesaran *et al.* (2001).

To obtain the long-run relationship between these three variables the model can be estimated in an unrestricted error correction model (UECM)

$$\Delta \ln REER_t = \alpha_0 + \sum_{k=1}^{n1} \alpha_1 \Delta \ln REER_{t-k} + \sum_{k=1}^{n2} \alpha_2 \Delta \ln FRES_{t-k} + \sum_{k=1}^{n3} \alpha_3 \Delta RIRP_{t-k}$$
$$+ \alpha_4 \ln REER_{t-1} + \alpha_5 \ln FRES_{t-1} + \alpha_6 RIRP_{t-1} + \xi D_t + ECM_t + \varepsilon_t \quad (9)$$

Where α_4 α_5 α_6 are the long-run multipliers, D_t is the vector of dummy variable, representing the exogenous variable, ECM_t is the error correction or the loading factor, it measures the level of deviation from the long-run equilibrium. The short-run dynamics of the model is captured by the lagged values of the dependent variable and the current and lagged values of the independent variables.

The estimation procedure involves two stages: the first stage is the estimation of OLS technique and the second stage involves the testing of the long-run relationship. This is achieved by restricting all estimated coefficients of lagged level variables to zero. That is testing the null hypothesis that: $H_0 : \alpha_4 = \alpha_5 = \alpha_6 = 0$ against the alternative $H_1 : \alpha_4 \neq 0$, $\alpha_5 \neq 0, \alpha_6 \neq 0$ Two asymptotic critical values are used in order to establish the presence of cointegration. The first set corresponds to the lower bound value, which are for I (0) variables and the second set is meant for I (1) regressors. Meanwhile, the mutually cointegrated has its critical values lie between the two values for I (0) and I (1) respectively.

Therefore, if the computed F-statistics is greater than the upper bound critical value; we reject the null hypothesis of no cointegration and accept the alternative that there is existence of cointegration. However, if the F-statistics is less than the lower bound critical value, we do not reject the null of no cointegration and conclude that there is no cointegration. If on the other hand, the computed F-statistics falls within the two upper and lower bond critical values, the result is regarded as inconclusive. The estimation is performed based on the lag selection using AIC and SBC selection criteria respectively.

4.2. Out-of-Sample Forecast

Meese and Rogoff (1988) explained that ARMA model or random walk model is the best in estimating real exchange rate out-of-sample forecast particularly for the short horizon. This paper also follows the work of Meese and Rogoff (1988) to use ARMA models to estimate out-of sample forecast for real exchange rate. To estimate this, we compute the Root Mean Square Error (RMSE) and Mean Average Error (MAE) and these are specified as follows:

Root Mean Squared Error (RMSE):

$$\sqrt{\sum_{t=T+1}^{T+h} (\hat{y}_t - y_t)^2 / h} \quad (10)$$

Mean Absolute Error (MAE):

$$\sum_{t=T+1}^{T+h} \left| \hat{y}_{t-} y_t \right| / h \quad (11)$$

Both the Root Mean Square Error (RMSE) and Mean Average Error (MAE) depend on the scale of the dependent variables. These relative measures are based on minimum error, i.e. the smaller the error the better the forecasting ability of that model. For this study, the last two years (24 months) were used for the out-of-sample dynamic forecast estimation.

Re-estimation was sequentially performed for every data point from 2010 onward. Our forecast horizons estimate covers the period 3, 6, 9, and 12 months respectively.

5. Results and Empirical Analysis

This section comprises the test of unit root; the establishment of cointegration, using the ARDL bound tests and the analysis of short-run dynamics.

Table 1 presents the results of the unit root test using the Augmented Dickey Fuller (ADF) and the KPSS tests respectively. They are estimated with constant and constant with the trend. Evidence from the table suggests that the real exchange rate and foreign exchange reserves are integrated of order one, I(1) while real interest rate differential is integrated of order, I(0).

Table-1. Unit root test on Variables of Interest

	Level		**first difference (with constant)**	
Variables	ADF	KPSS	ADF	KPSS
LREER	-1.371	1.561***	-15.49***	0.136
LFRES	-1.296	1.898***	-10.20***	0.218
RIRD	-4.03 6***	0.096	-10.59***	0.0960***
	Level		**first difference (with constant and trend)**	
Variables	ADF	KPSS	ADF	KPSS
LFEER	-1.486	0.353***	-15.48***	0.0684
LFRES	-2.069	0.174***	-10.20***	0.0478
RIRD	-4.025***	0.0967	-10.580***	0.0817

The asterisk *, and ** implies 1%, and 5%, levels of significance respectively.

Table 2 below shows a consistent result with the conventional unit root test shown in table 1 except with real exchange rate. Evidence from the Zivot and Andrew unit root test indicates that we are unable to reject null hypothesis of no unit root test. However, the interest rate was I(0) under the ADF and KPSS respectively, and the Zivot and Andrew test could detect one structural break indicate I(1) under model B. Exchange rate also tends to exhibits I(0) based on model C result. However, overall, we conclude that real exchange rate, foreign exchange reserves are I (1) while real interest rate differential is I (0). The break dates for foreign exchange, indicate 1991:1 for both models A and C respectively, while model B indicates 2001:1. The same break dates are found for foreign reserves for models A and B (2008:12) while model C indicates 2005:11. The interest rate differential indicates the break dates as 2004:4 for model A, 2002:4 for model B and 1998:8 for model C respectively.

Table-2. Zivot and Andrew Unit root test for one break

	Exchange rate			Foreign Reserves			Interest rate		
Models	A	B	C	A	B	C	A	B	C
TB	1999:1	2001:1	1999:1	2008:12	2008:12	2005:11	2004:4	2002:4	1998:8
K	1	1	1	3	6	6	2	1	2
t-stat	-2.221	-3.710	-7.498***	-2.883	-2.709	-2.963	-4.483	-4.101	-4.549

The asterisk *, and ** implies 1%, and 5%, levels of significance respectively. The critical values for the ZA test: Model A : -5.34, -4.80 and -4.58; Model B: -480, -4.42, -4.11 Model C: -5.57, -5.08 and -4.82 at the 1%, 5% and 10% levels, respectively. TB= break points, K=optimal lag

Table 3 is the presentation of bound test for the long-run relationship between the three variables. The estimation of bound test is performed using the three models. Model A has real exchange rate as dependable variable while Models B and C have foreign reserves and interest rate differential as dependable variables respectively. Evidence from the table indicates that we cannot reject null the hypothesis of no cointegration for both models A and C. The computed F statistics for model A is lower than both the lower and upper critical bound values. The computed F statistics is 1.621 which is less than 3.74 and 5.06 at 1% critical values for both lower and upper critical bound values or 2.86 and 4.01 at 5% critical values for both lower and upper critical bound values respectively. Model B indicates that there is long-run relationship between exchange rate, foreign reserves and real interest rate differential. Evidence from the table shows that computed F statistics of 5.599 is greater than 5.06 of upper bound critical value. Result from Model C is however inconclusive at 5% critical bound values. The computed F statistics is 2.951 and this is greater than the lower critical bound value of 2.86 but less than the upper critical bound value of 4.01. Using the AIC and SC selection criteria, lags 6 and 2 are selected respectively.

Table-3. Bound test for Cointegration

	Variables	**Computed F statistics**	**Critical value**	**Lower Bound Value I (0)**	**Upper Bound Value I (1)**
Model A	LREER LFRES RIRD	**1.621**	1%	3.74	5.06
Model B	LFRES LREER RIRD	**5.599**	5%	2.86	4.01
Model C	RIRD LREER LFRES	**2.951**	10%	2.45	3.52

Once the long-run relationship has been established using the ARDL model, model B is selected to estimate the long-run coefficients as shown in table 4. This is because it is the model with the evidence of cointegration or long-run relationship. Estimate from the table suggests a positive relationship between real exchange rate and foreign reserves. However, real interest rate differential indicates a negative relationship and statistically not significant.
The coefficient of real exchange rate and foreign reserves is positive and statistically significant at 1% level. However, interest rate differential is negative and statistically not significant. This result implies that a depreciation of domestic real exchange rate will lead to an increase in exports and ultimately increase in foreign exchange reserves for Nigeria.

Table-4. Estimated Long- Run Coefficients

Variables	Coefficient	t- statistics
Constant	24.778	27.77***
LREER	1.249	24.79***
RIRD	-1.035	-1.346

5.1. Short-run dynamics

The short-run analysis is presented in two ways: first is the presentation of unrestricted error correction estimates without a dummy and a second presentation is with dummy variables. Table 5 presents the results of UECM estimates without a dummy while LFRES serves as the dependable variable. Following the Hendry general to specific framework, table 5 indicates that most of the lags are statistically significant either at 1% and 5% per cent respectively.

The table indicates that the dependable variable, foreign reserves exhibit significant autoregression. While 1 and 2 months lags of foreign reserves tend to have a positive and statistically significant effect on foreign reserves, 3 and 4 months lags exhibit a negative and statistically sisgnificant effect at 1% and 5% levels respectively. Exchange rate shows that 2 and 6 months lags have a negative and statistically significant effect on the foreign reserves at 5 % level. Interest rate differential indicates a non-monotonic effect on foreign exchange reserves a 3 month lag has a negative and statistically significant effect at the 5 % level and this is followed by a positive coefficient which is also significant but marginally at 10% level of significance.

The adjustment or loading factor which captures the deviation from the long-run equilibrium has the expected sign (negative) and statistically significant at 5%. The Lagrange Multiplier (LM) test suggests the presence of no serial autocorrelation.

Table 6 shows the UECM estimates with a dummy variable. The break points endogenously identified using Zivot- Andrew tests are incorporated into the short-run dynamics of the ARDL model. The result is similar to the one obtained in table 5. It indicates that most of the lags of the three variables are statistically significant at 1% and 5% respectively. Only the dummy of interest rate differential that is statistically significant at 5% the two dummies are not statistically significant. However, the speed of adjustment is negative and statistically significant at 1% level. The $\overline{R}^2$ is good and LM test indicates that there is no presence of autocorrelation.

The coefficients of the lagged error correction terms for both models indicate a slow convergence to long-run equilibrium.

Table-5. UECM estimates: LFRES as dependent variable without dummy

Regressor	Coefficient	t- statistics
Δ LFRES $_{t-1}$	0.193	2.563**
Δ LFRES $_{t-2}$	0.257	3.745***
Δ LFRES $_{t-3}$	-0.294	-4.247***
Δ LFRES $_{t-4}$	-0.036	-0.519
Δ LFRES $_{t-5}$	-0.126	-2.015**
Δ LFRES $_{t-6}$	0.063	1.018
Δ LREER $_{t-2}$	-0.149	-2.226**
Δ LREER $_{t-4}$	-0.048	-0.703
Δ LREER $_{t-5}$	-0.043	-0.651
Δ LREER $_{t-6}$	-0.163	-2.381**
Δ RIRD $_{t-3}$	-0.005	-1.935*
Δ RIRD $_{t-6}$	0.005	1.607
Constant	0.018	2.297**
ECT $_{t-1}$	-0.102	-2.221**
$\overline{R}^2$	0.269	
LM test	0.408	

Table-6. UECM estimates: LFRES as dependent variable with dummy

Regressor	Coefficient	t- statistics
Δ LFRES $_{t-1}$	0.2572	3.383***
Δ LFRES $_{t-2}$	0.2005	3.146***
Δ LFRES $_{t-3}$	-0.3044	-4.554***
Δ LFRES $_{t-5}$	-0.1444	-2.311**
Δ LFRES $_{t-6}$	0.0543	0.933
Δ LREER $_{t-2}$	-0.0990	-1.430
Δ LREER $_{t-4}$	-0.0566	-0.846
Δ LREER $_{t-6}$	-0.1488	-2.210**
Δ RIRD $_{t-3}$	-0.0006	-2.204**
Δ RIRD $_{t-6}$	0.0005	1.795
Constant	0.0231	1.272
D 1999:1	0.0121	0.590
D 2008:12	0.0331	1.446
D 2004:4	-0.0636	-2.506**
ECT $_{t-1}$	-0.1920	-3.191***
$\bar{R}^2$	0.223	
LM test	0.896	

Table 7 presents out-of-sample forecast based on ARMA model. The one month ahead horizons estimates are for 3, 6, 9, and, 12 months respectively. Both the RMSE and MAE show a better forecast ability as both of them are quite less than one. The Theil coefficients indicate a better fit as all the coefficients are very close to zero.

Table-7. Out-of sample forecast: Random Walk Model

Horizon: One Month Ahead	RMSE	MAE	Theil Coefficient
3	0.029569	0.020864	0.000746
6	0.149506	0.139835	0.000590
9	0.106261	0.084575	0.001367
12	0.126993	0.107686	0.001254

6. Conclusions

The article examines the relationship between real exchange rate, interest rate differential and foreign exchange reserves. The study covers the period 1993:01 -2012:12 and uses Autoregressive Distributed Lags (ARDL) model of Pesaran *et al.* (2001). This article establishes a long run relationship between real exchange rate, interest rate differential and foreign exchange reserves. This finding is consistent with most theoretical predictions of monetary models of exchange rate determination. It is also consistent with the empirical findings of (2003), and Narayan and Smyth (2006) respectively. Another important finding is that in the long run, the exchange rate coefficient has a positive effect on the foreign reserves. This positive effect is statistically significant at 1% level. The effect of interest rate differential is however negative and statistically not significant. On the short run dynamics, the finding indicates a non monotonic relationship between real exchange rate, interest rate differential and foreign exchange reserves. The out-of-sample forecast indicates a better forecast using ARMA model as all Theil coefficients are nearly zero for all the horizons used in the model.

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Figures

Figure-1. Trend of interest rate differential.

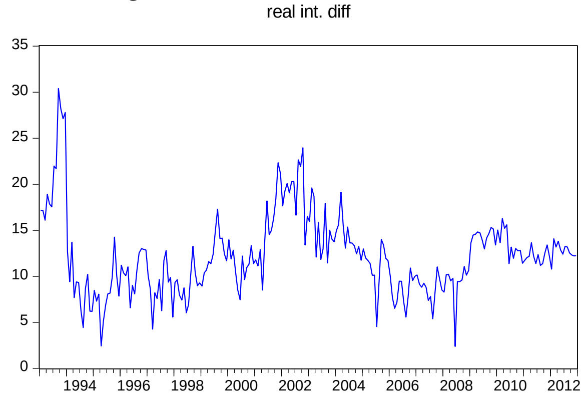

Figure-2. (LFRES): Trend of log of foreign exchange reserves

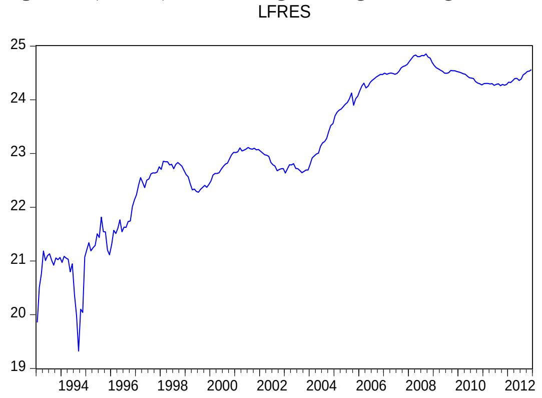

Figure-3.(LEXCH). Trend of log of real exchange rate