[CBN Journal of Applied Statistics (JAS)](https://dc.cbn.gov.ng/jas)

Volume 8 | Number 1 Article 1

6-2017

Exchange Rate Misalignment under Different Exchange Rate Regimes in Nigeria

Sunday N. Essien
Central Bank of Nigeria

Stephen O.U. Uyaebo
Central Bank of Nigeria

Babatunde S. Omotosho
Central Bank of Nigeria

Exchange Rate Misalignment under Different Exchange Rate Regimes in Nigeria[1]

Sunday N. Essien, Stephen O. U. Uyaebo and Babatunde S. Omotosho[2]

This study examines the dynamics of naira real exchange rate (RER) during the period 2000Q1 – 2016Q1 as well as the extent to which it deviated from its long run equilibrium path. To achieve this, we adopt the Behavioural Equilibrium Exchange Rate (BEER) model approach and incorporate the effects of an endogenously determined breakpoint in the cointegrating vector of the RER model. We found empirical support for the existence of a long-run relationship between RER and its determinants that is subject to a structural break in 2011Q1. Also, model results showed that exchange rate policy, productivity and interest rate differentials are significant determinants of real exchange rate movements. In terms of the levels of RER misalignment under different exchange rate policies considered, model results indicated that the naira was overvalued by 1.22 per cent during IFEM regime of 2000 – 2002; overvalued by 0.35 per cent during rDAS (2002 – 2006); undervalued by 0.39 per cent during wDAS (2006 - 2013) and undervalued by 0.25 per cent in the period succeeding the wDAS till March, 2016. Overall, the naira was found to be overvalued by 0.15 per cent during the sample period, implying a subsidy of 0.15 kobo per dollar.

Keywords: Real Exchange Rate, Structural Break, Misalignment, Exchange Rate Regime

JEL Classification: F31

1.0 Introduction

The issues of exchange rate and its management are of serious concern to economic agents, especially in developing countries. Amongst others, this concern stems from the fact that exchange rate policies determine the ability of countries to take full advantage of international trade. The policy makers' objective in this regard is to ensure that movements in the

[1] The views expressed in this paper are solely those of the authors and do not necessarily represent those of the Central Bank of Nigeria. The authors acknowledge the comments of the anonymous reviewers.

[2] Statistics Department, Central Bank of Nigeria, Tafawa Balewa Way, Abuja
Corresponding author's Email: bsomotosho@cbn.gov.ng, bsomotosho@gmail.com

exchange rate reflect the dictates of prevailing macroeconomic fundamentals.

A successful exchange rate policy is expected to facilitate the achievement of external and internal balances in the economy, in which case the exchange rate is said to be in equilibrium. However, a currency is termed misaligned when its exchange rate departs from its long run equilibrium path. Thus, an exchange rate is said to be “undervalued” when it depreciates more than its equilibrium, and “overvalued” when it appreciates more than its equilibrium value.

Exchange rate misalignment, especially in the form of exchange rate overvaluation has been identified as one of the obstacles to sustained economic growth (Ghura and Grennes, 1993). On the one hand, a persistent real exchange rate undervaluation could lead to economic overheating, which puts pressure on domestic prices and misallocates resources between tradable and non-tradable sectors. On the other hand, continuous real overvaluation reflects unsustainable macroeconomic conditions within an economy, which could make such an economy vulnerable to speculative attack and currency crisis.

The avoidance of prolonged real exchange rate misalignment requires that the policy makers have proper understanding of real exchange rate dynamics and an idea of realistic estimates of the equilibrium real exchange rate (i.e. a rate that guarantees internal and external balance in an economy). As a guide, the International Monetary Fund’s Consultative Group on Exchange Rate (CGER) developed three methodologies for evaluating the value of its member countries’ domestic currencies. These are the macroeconomic balance, external sustainability and equilibrium real exchange rate approaches. The third methodology, which is often referred to as the Behavioural Equilibrium Exchange Rate Model (BEER) approach, estimates the ‘ideal’ exchange rate based on a set of macroeconomic fundamentals believed to be driving the economy.

The BEER approach has enjoyed wider application in developing countries. However, most of the studies that have been conducted in this regard in Nigeria failed to take cognisance of the effects of exchange rate policy shifts on their modelling approaches, including the possibility of structural breaks[3]. Failure to account for structural breaks when they are indeed present has been known to cause misspecification errors in BEER models, resulting in biased real exchange rate misalignment estimates (Andreou, 2002; Zainudin and Shaharudin, 2011). While Omotosho (2012) accounted for structural break, his empirical analysis predates the reintroduction of IFEM policy in November 2013. This paper incorporates more recent developments and pins down the estimated misalignment levels to the different exchange rate policies implemented during the sample period.

We obtain quarterly estimates of naira equilibrium real exchange rate for the period 2000 – 2016 and compute percentage deviations of the actual real exchange rate from the estimated equilibrium in the time domain. The computed deviations are interpreted as estimates of real exchange rate misalignment and summarised under the different exchange rate regimes/policies implemented within the sample period.

The paper is organised into six sections. In Section 2, we present some stylized facts on exchange rate policies in Nigeria in order to motivate our modelling approach especially with regards to the investigation of structural break. Section 3 reviews related empirical literature. Section 4 presents the analytical framework for the study while Section 5 discusses the results. Section 6 concludes.

2.0 Exchange Rate Policies and Trend in Nigeria[4]

Various exchange rate policies have been implemented in Nigeria ranging from a fixed exchange rate regime prior to 1985 to various forms of floating systems, following the liberalization of the foreign exchange market in 1986. Towards the end of 1985, the government allowed the exchange rate to be determined by market forces in consonance with the tenets of the Structural Adjustment Programme (SAP)[5]. The Second-tier Foreign Exchange Market (SFEM) was introduced in September 1986 as a market-driven mechanism for foreign exchange allocation, while the

---

[3] These include Aliyu (2011), Atanda and Iyekoretin (2012) and Ibrahim (2013). They failed to accommodate structural break in their models. Such omission has been known to introduce bias into the estimates of real exchange rate misalignment.

[4] This section is extracted from an earlier paper by Omotosho and Wambai (2012) with few modifications

[5] Nigeria's exchange rate regime since SAP could be strictly referred to as a managed float system.

first and the second tier markets were merged into an enlarged foreign exchange market in July 1987. Other policies that have been implemented prior to 2000 include the Autonomous Foreign Exchange Market (AFEM), introduced in 1995 and the Inter-bank Foreign Exchange Market (IFEM), which was introduced on October 25, 1999.

As indicated in Table 1, the Retail Dutch Auction System (RDAS) was reintroduced in July 2002. The policy saw the exchange rate depreciating from N92.7 per dollar in 1999 to N121.0, N129.4, N133.50 and N132.15 per US dollar in 2002, 2003, 2004 and 2005, respectively.

Table 1: Exchange Rate Regimes/Policies in Nigeria (1999 – 2015)

Exchange Rate Regime/Method of Exchange Rate Determination	Date
Reintroduction of IFEM	October 1999
Retail Dutch Auction System (rDAS)	July 2002
Wholesale Dutch Auction System (wDAS)	February 2006 - October, 2013
Retail Dutch Auction System (rDAS)	October 2 - 31, 2013
Interbank Foreign Exchange Market (With CBN Interventions)	November 2013

In response, the Wholesale Dutch Auction System (WDAS) was introduced on the 20th of February, 2006 to further liberalize the foreign exchange market, reduce the dependence of authorized dealers on CBN for foreign exchange and achieve convergence in exchange rates. This led to an appreciation of the exchange rate from its level of N132.15/US$ in 2005 to N128.65/US$, N125.83/US$ and N118.57/US$ in 2006, 2007 and 2008, respectively. Following the impacts of the global financial crisis on the economy, depreciation pressures mounted on the naira as its exchange rate moved to N148.91/US$, N150.30/US$ and N153.90/US$ in 2009, 2010 and 2011, respectively. These led to the reintroduction of IFEM in November 2013 while the CBN continued to intervene in the market.

In 2014 the rate was adjusted to partially agree with interbank rate in order to constrain the activities of speculators. The exchange rate was more or less fixed in 2015 with the commencement of order-based two-way quote system. During this period, a lot of demand could not be met by the market and such demands were channelled to the parallel market, leading to a widening arbitrage premium. In June, 2016, the CBN embraced a more flexible exchange rate regime in order to enhance efficiency and facilitate a liquid and transparent foreign exchange market.

3.0 Review of Empirical Literature

The literature is replete with works by different researchers who have investigated the issue of real exchange rate equilibrium and the associated misalignment levels for different countries using different methodologies. For instance, Hansen and Roeger (2000) investigated the real effective equilibrium exchange rates for some industrial countries focusing on medium term equilibrium exchange rates. Using annual data for 1980-1999, their results showed that the currencies of Germany, Finland, Sweden, Denmark and Canada, neutral for US, Italy, Austria, Netherlands, Belgium and Greece were misaligned while those of Japan, France, Spain, Portugal, Ireland and the UK were largely in line with the path dictated by economic fundamentals.

In another cross country study but using the BEER approach, Egert and Lahreche-Revil (2003) studied the equilibrium real and nominal exchange rates for five selected Central and Eastern European countries (Czech Republic, Hungary, Poland, Slovakia and Slovenia). They found that the gap between the observed and estimated equilibrium real exchange rates differs across the countries. While Czech Republic, Poland and Slovakia were found to have experienced an excessive appreciation of real effective exchange rate, Hungary and Slovenia showed little sign of overvaluation.

Hossfeld (2010) analysed the Equilibrium Real Effective Exchange Rates and Real Exchange Rate Misalignments of the US and her 16 major trading partners, namely Australia, Belgium, Canada, China, France, Germany, Ireland, Italy, Japan, Korea, Mexico, Netherlands, Spain, Sweden, Switzerland and the UK. Using quarterly data from 1986Q1 to 2006Q4, they applied the Behavioural Equilibrium Exchange Rate approach to develop the equilibrium real exchange rates for the different currencies. The result showed strong evidence for the Balassa-Samuelson-effect, implying that productivity matter for exchange rate movements. The study also identified varying degrees of real exchange rate misalignments for the countries.

Using a different approach, Ivanova (2007) examined the equilibrium real exchange rate in Russia from 1995 to 2006 using the partial - equilibrium version of the trade-balance approach. Having estimated the equilibrium real exchange rate, it was found that the degree of currency overvaluation in Russia was between 25 to 40 per cent, before the

August 1998 crisis. Furthermore, the result revealed that the currency was undervalued during 2004 - 2006 given the surge in oil prices and pro-active exchange rate policy of the Bank of Russia.

While the studies reviewed so far focus largely on developed countries, it is important to note that cases of real exchange rate misalignments have also been investigated and established in less developed countries. For instance, Eita and Sichei (2014) evaluated Namibia's equilibrium real exchange rate using quarterly data for the period 1998 to 2012 using the BEER approach and found that the Namibian currency experienced periods of undervaluation and overvaluation during the study period. Also, Hosni and Rofael (2015) investigated Real Exchange Rate (RER) misalignments in Egypt during 1999Q1 to 2012Q4. However, they used three different approaches, namely the Purchasing Power Parity (PPP) approach; the Fundamental Equilibrium Exchange Rate (FEER) approach and the Behavioural Equilibrium Exchange Rate approach of Edwards (1989). The study found evidence of varying misalignment levels during the estimation period and called for devaluation in the REER of between 9 to 13 per cent for the Egyptian products not to lose their competitiveness in the international markets.

Oscar (2012) applied the simple OLS method to investigate the extent to which the CFA franc was misaligned prior to the devaluation of January 1994, using data on Gabon. The study employed variables such as government spending, trade policy, trade balance and terms of trade. The result lends empirical support for an undervaluation of CFA franc by about 5.74 per cent during 1980 – 1985 and 7.78 per cent overvaluation during 1986 – 1993. Based on these findings, the study concluded that the CFA franc devaluation was justified.

On the effects of real exchange rate misalignment on other macroeconomic variables, such as exports, Jongwanich (2009) investigated the relationship between real exchange rate misalignment and export performance in Asian developing countries during 1995 - 2008. The study showed that the currencies that were overvalued before the crisis became undervalued in the aftermath of the crises and concluded that RER misalignment had negative impact on export performance in the countries.

In Nigeria, quite a number of studies have also been conducted to determine naira equilibrium real exchange rate and its level of misalignment. For instance, Agu (2002) estimated a reduced form equation to obtain estimates of the equilibrium real exchange rate and thereafter assessed the extent of exchange rate misalignment. The study found empirical support for naira misalignment to the tune of about 1.4 per cent during 1970 – 1998. Aliyu (2011) also investigated RER misalignment in Nigeria using the BEER approach. The variables included in the model were terms of trade, crude oil volatility, monetary policy performance and government fiscal stance. The study also found evidence of undervaluation between 2003Q3 and 2004Q4 and overvaluation during 2005Q1 – 2006Q4. Omotosho and Wambai (2012) found that the naira was misaligned by 0.29 per cent during the period 2000-2011.

Atanda and Iyekoretin (2012) examined the determinants of Nigeria's real exchange rate dynamics from 2008 to 2011 using Vector Error Correction model. Their results showed that higher oil price leads to appreciation of the naira, while money supply growth and increase in real interest rate differentials weakens the real Naira/Dollar rate. In a related study, Oriavwote and Oyovwi (2012) found that capital flow, price level and nominal effective exchange rate are important determinants of the real effective exchange rate in Nigeria during 1970 - 2010.

Some other studies have also focused on the effect of real exchange rate misalignment on the economy. For instance, Ibrahim (2013) estimated the equilibrium real exchange rate for Nigeria using data for the period 1960 to 2011 and found evidence of currency misalignment which impacted negatively on the inflow of FDI to the country. Also, Omotosho (2015) estimated a naira real exchange rate misalignment of 0.03 per cent during 1990Q1 to 2011Q2 and showed that real exchange rate misalignment is one of the leading indicators of currency crisis.

4.0 Data and Methodology

This section presents the analytical procedure employed to generate the naira equilibrium real exchange rate as well as the data used for the analysis. The sources of data are also discussed.

4.1 Methodology

In its basic form, the Naira equilibrium real exchange rate model estimated is of the form[6]:

$$LRER_t = \propto_0 - \beta_1 LTGE_t - \beta_2 LPRO_t + \beta_3 LNER_t - \beta_4 IRD_t + \varepsilon_t \quad (1)$$

where LRER is the log of real exchange rate, LTGE is log of total government expenditure, LPRO is log of productivity, LNER is log of nominal exchange rate, IRD is interest rate differential and ε_t is the random error.

To estimate the equilibrium real exchange rate as specified in equation (1), the Behavioural Equilibrium Exchange Rate (BEER) approach enunciated by Clark and MacDonald (1998) was extended by controlling for structural breaks in the cointegrating relationship. Thus, we estimated equation (1) within the framework of cointegration and error correction modelling while accommodating structural break. Thus, in addition to the Johansen (1998) cointegration test, Gregory and Hansen (1996) cointegration test with structural break was employed to test for the existence of long run relationship amongst the included variables.

The inferred Gregory-Hansen equations for our real exchange rate model are as follows[7]:

$$LRER_t = \alpha_1 + \alpha_2 D_t - \beta_1 LTGE_t - \beta_2 LPRO_t + \beta_3 LNER_t - \beta_4 IRD_t + \varepsilon_{t1} \quad (2)$$

$$LRER_t = \alpha_3 + \alpha_4 D_t + \varphi_1 t - \beta_5 LTGE_t - \beta_6 LPRO_t + \beta_7 LNER_t - \beta_8 IRD_t + \varepsilon_{t2} \quad (3)$$

$$LRER_t = \alpha_5 + \alpha_6 D_t + \varphi_2 t - \beta_9 LTGE_t - \beta_{10} LPRO_t + \beta_{11} LNER_t - \beta_{12} IRD_t - \beta_{13} LTGE_t D_t - \beta_{14} LPRO_t D_t + \beta_{15} LNER_t D_t - \beta_{16} IRD_t D_t + \varepsilon_{t3} \quad (4)$$

[6] The selection of the variables included in the model as well as the methods for measuring the relevant data draws from Omotosho and Wambai (2012) and Clark and MacDonald (1998). This study is also limited in terms of the number of the right hand side variables that could be included as the critical values published in Gregory and Hansen (1996) allows for a maximum of four independent variables. The signs assigned to the variables included in the model are based on a priori expectation from theory discussed in section 4.2.

[7] Equation 2 represents the Gregory-Hansen model with intercept shift (GH-1). Equation 2 represents the Gregory-Hansen model with intercept shift and trend (GH-2). Equation 3 represents the Gregory Hansen model with regime shift (GH-3).

where LRER, LTGE, LPRO, LNER and IRD are as previously defined. Time trend is denoted as t, parameters $\alpha_1 - \alpha_6$ are the respective intercept terms before and after the break, $\varphi_1 - \varphi_2$ are the coefficients for time trend, $\beta_1 - \beta_{12}$ are the respective coefficients of the independent variables before the breakpoint, $\beta_{13} - \beta_{16}$ are the coefficients of the independent variables after the structural break and $\varepsilon_{t1} - \varepsilon_{t3}$ are the respective disturbance terms. The included variables are expected to be *I(1)* while the disturbance terms should be *I(0)*. D_t is a dummy variable of the form:

$$D_t = \begin{cases} 0, if\ t \leq [T\tau] \\ 1, if\ t > [T\tau] \end{cases} \tag{5}$$

The unknown relative timing of the break date is denoted as $\tau \in J$ and [:] denotes the integer part operator. The test for cointegration within this framework involves computing the usual statistics for all possible break points $\tau \in J$ and selecting the smallest value obtained, since it will potentially represent the strongest evidence for rejecting the null hypothesis of no cointegration. The relevant statistics are the GH-ADF (τ), GH-$Z_\alpha(\tau)$ and GH-$Z_t(\tau)$.

Following the results of the tests for unit roots, structural breaks and cointegration tests, an appropriate error correction model specified below will be estimated:

$$\Delta Y_t = \alpha_0 + \sum_{i=0}^{s} \beta_i \Delta X_{t-i} + \sum_{j=1}^{q} \gamma_j \Delta Y_{t-j} + \rho\varepsilon_{t-1} + \mu_t \tag{6}$$

where Δ denotes the first difference operator, $\mathcal{E}_t$ is the estimated residuals from the selected Gregory-Hansen model of equations 2 - 4, s and q are the number of lag lengths, Y_t is the dependent variable (LRER) while X_t is the vector of exogenous variables. If the system is stable, the coefficient ρ will be negative and statistically significant. Moreover, the value of ρ measures the speed of adjustment of the dependent variable to the value implied by the long run equilibrium relationship.

4.2 Data

The study utilised data on four economic variables to capture both transitory and structural movements in naira real exchange rate from

2000Q1 to 2016Q2. These are productivity (PRO), nominal exchange rate (NER), total government expenditure (TGE) and interest rate differential (IRD). All the variables (except interest rate differentials) were log-transformed.

Real Exchange Rate (RER) is computed as the official Naira/Dollar nominal exchange rate (NER) multiplied by the ratio of Consumer Price Indices in the United States and Nigeria. A decrease in RER indicates an appreciation while an increase denotes depreciation. The NER was sourced from the CBN statistical bulletin while the CPI for Nigeria and the United States were sourced from the IMF's International Financial Statistics (with a base period of November 2009). Nominal Exchange Rate (NER) represents a policy instrument by the CBN to influence real exchange rate in a particular direction and it is sourced from the CBN Statistical Bulletin. A nominal depreciation of the nominal exchange rate will depreciate the real exchange rate and vice versa.

Productivity Differential (PRO) represents the domestic supply side factor, often referred to as the "Balassa-Samuelson effect". While it is difficult to have a comprehensive measure of this variable, we proxy it by Gross National Product divided by population. As in Zalduendo (2006), we compare the ratios for Nigeria and the US. Data on GNP and population for Nigeria and U.S. were sourced from the CBN Statistical Bulletin and the IMF International Financial Statistics, respectively. An increase in productivity is expected to lead to an appreciation of the equilibrium real exchange rate.

Interest Rate Differential (IRD) is computed as the difference between interest rate in Nigeria and the United States. An increase in domestic interest rate attracts foreign capital inflows, thereby appreciating the domestic currency. Data on interest rate in Nigeria is sourced from the CBN statistical bulletin while that of the US was obtained from the IMF International Financial Statistics.

Total Government Expenditure (TGE) represents the fiscal stance of government and it is computed as the ratio of total government expenditure to nominal GDP. An increase in government expenditure especially in the area of non-tradables increases the prices of non-tradable goods, causing the RER to appreciate. Data on the variables were sourced from the CBN statistical bulletin.

5.0 Results

This section presents and discusses the results of the estimated models as well as the computed real exchange rate misalignment levels. The estimated misalignment levels are summarised under the four exchange rate policies that were in place during the sample period.

5.1 Unit Root Test Results

The results of the unit root test presented in Table 2 indicated that all the variables are integrated of order one, as there was no evidence to reject the null of unit root in the series at levels at 5% level of significance.

Table 2: Results of Augmented Dickey-Fuller Unit Root Test

Variables	Levels		First Difference	
	ADF^{c}	ADF^{ct}	ADF^{c}	ADF^{ct}
LRER	-1.3776	0.3836	-7.9219	-7.8743
LTGE	-0.7413	-2.2780	-8.1148	-8.0928
LPRO	-0.8843	-2.2818	-8.3555	-8.3258
LNER	-0.6965	-2.0267	-7.0750	-7.0213
IRD	-2.6727	-2.6608	-8.0926	-8.0246

ADF^{c} and ADF^{ct} represent unit root test with constant and constant with trend

MacKinnon (1996) critical values with constant are -3.5366 (1%), -2.9077 (5%) and -2.5914 (10%)

MacKinnon (1996) critical values with constant and trend are -4.1079 (1%), -3.4816 (5%) and -3.1687 (10%)

In order to account for the bias in the unit root test due to the possible presence of structural breaks in the series, a breakpoint unit root test was conducted and the results are presented in Table 3.

Table 3: Results of Augmented Dickey-Fuller Breakpoint Unit Root Test

Variables	Levels		First Difference	
	ADF^{c}	Break Date	ADF^{c}	Break Date
LRER	-2.3637	2004Q2	-9.4164	2009Q1
LTGE	-4.0261	2011Q2	-9.0931	2012Q1
LPRO	-2.1940	2010Q2	-8.6875	2009Q1
LNER	-3.0073	2008Q4	-8.9753	2009Q1
IRD	-3.5811	2010Q1	-9.0989	2005Q2

ADF^{c} represent unit root test with constant

**Vogelsang (1993) critical values with constant are -4.9491 (1%), -4.4437 (5%) and -4.1936 (10%)*

The results confirmed the incidence of structural breaks in the series at different quarters in the sample period. Despite accounting for structural breaks, all the variables remained non-stationary at level. Consequently, the variables were included in the estimated model in their first differenced form.

5.2 Tests for Structural Breaks in the Long Run Model

In view of the evidence of structural breaks in the individual series, we proceed to further test for the presence of structural breaks in the long run naira real exchange rate model using the Bai and Perron (1998) procedure. Owing to the various exchange rate policies implemented during the sample period, the nominal exchange rate was allowed to be the breakpoint variable while the remaining three were treated as non-breakpoint variables. The results of the test presented in Table 4 showed that three break points were identified at 2003Q1, 2009Q1 and 2014Q1.

Table 4: Result of Structural Break Tests in Equation (1)

Breakpoint Variable	**Non-Breakpoint Variable**	**No. of Breaks Identified**	**Break Date**
LNER	LTGE, LPRO, IRD	3	2003Q2, 2009Q1, 2014Q1

Break Test	**F-statistic**	**Scaled F-statistic**	**Critical Value****
0 vs. 1 *	63.67	63.67	8.58
1 vs. 2 *	35.91	35.91	10.13
2 vs. 3 *	25.88	25.88	11.14
3 vs. 4	7.39	7.39	11.83

** Significant at the 0.05 level*

*** Bai-Perron critical values (Econometric Journal, 2003)*

5.3 Cointegration Test Results

In the next step, a test for cointegration amongst the included variables was conducted using the maximum eigenvalue unrestricted cointegration rank test of Johansen (1998). The results presented in Table 5 failed to find evidence of cointegration amongst the variables. This could be due to the presence of structural breaks in the cointegrating relationship as indicated by the Bai and Perron (1998) test results presented in Table 3. Thus, we proceed by employing the Gregory and Hansen cointegration test, which is robust to the presence of structural breaks in cointegrating relationship amongst variables. The results of the test are presented in Table 6.

Table 5: Johansen Cointegration Test Results

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	Critical Value	Prob.**
None	0.3851	30.1537	33.8769	0.1306
At most 1	0.3127	23.2524	27.5843	0.1630
At most 2	0.2128	14.8368	21.1316	0.3005
At most 3	0.0664	4.2594	14.2646	0.8310
At most 4	0.0177	1.1100	3.8415	0.2921

Max-eigenvalue test indicates no cointegrating eqn(s) at the 0.05 level

** denotes rejection of the hypothesis at the 0.05 level*

***MacKinnon-Haug-Michelis (1999) p-values*

As shown in Table 6, the included variables share common stochastic trends in the long run, showing that structural breaks are accounted for in the cointegrating relationship. The model with shifts in intercept and slope (GH-3) presented the strongest evidence against the null of no cointegration in the variables. The Gregory and Hansen model with structural breaks in both intercept and slope (GH-3) was therefore identified as the auxiliary model for the cointegration test with the breakpoint date being 2011Q1.

Table 6: Gregory-Hansen Cointegration Test Results

Model		ADF*	Break Date	Z_t*	Break Date	Z_α*	Break Date
GH-1 (Constant)	Test Statistic	-5.5377	2012Q2	-5.5313	2012Q1	-42.8772	2012Q1
	Critical Value (5%)	*-5.5600*		*-5.5600*		*-59.4000*	
GH-2 (Constant and Trend)	Test Statistic	-5.7221	2003Q2	-5.8801	2006Q2	-43.339	2006Q2
	Critical Value (5%)	*-5.8300*		*-5.8300*		*-65.4400*	
GH-3 (Constant and Slope)	Test Statistic	-7.469	2011Q1	-7.5281	2011Q1	-59.0993	2011Q1
	Critical Value (5%)	*-6.4100*		*-6.4100*		*-78.5200*	

At the 5 per cent significance level, the *ADF* and Z_t statistics were larger than the critical value of -6.41 in absolute terms, indicating that the variables are cointegrated subject to a structural break in 2011Q1. Thus, our modelling strategy accommodated the identified breakpoint in order to avoid misspecification error.

5.4 Long Run Model

The long run elasticities of the real exchange rate to changes in the included variables are reported in Table 7 (akin to the Gregory and Hansen equation with intercept and slope change). The results showed that interest rate differential (IRD), nominal exchange rate (LNER), productivity (LPRO), and total government expenditure (LTGE) are significant determinants of the real exchange rate in the long run. However, in view of the non-stationary characteristics of the variables in the model, the results of the long run model are interpreted with caution.

Table 7: OLS Long Run Elasticity Estimates of the Naira RER Model

Variable	Coefficient	P-value
C	7.0231	0.0000
@TREND>55-2	-4.6409	0.1457
LIRD	0.0333	0.0005
LNER	0.3879	0.0002
LPRO	-0.3972	0.0000
LTGE	-0.1221	0.0006
(@TREND>55-2)*LIRD	0.0629	0.3479
(@TREND>55-2)*LNER	0.2397	0.1910
(@TREND>55-2)*LPRO	0.3269	0.2207
(@TREND>55-2)*LTGE	0.2106	0.0977
R-squared	0.9740	
Adjusted R-squared	0.9698	
S.E. of regression	0.0480	

5.5 Error Correction Model

The error correction model presented in Table 8 was estimated based on the residuals obtained from the Gregory and Hansen model with intercept and slope shifts presented above. The results showed that the included variables account for about 72.5 per cent of variations in naira real exchange rate during the sample period.

Table 8: Results of the Error Correction Model for the Naira RER

Variable	Coefficient	P-Value
C	-0.0197	0.0000
D(LRER(-1))	0.0272	0.0834
D(IRD)	0.0140	0.0437
D(LNER)	0.9176	0.0000
D(LPRO)	-0.0449	0.0007
ECM(-1)	*-0.1759*	*0.0368*
Summary Statistics		
R-squared	0.7247	
Adjusted R-squared	0.7006	
S.E. of regression	0.0253	
Model Diagnostics		
Jarque-Bera (Normality)	0.2924	0.8640

The variables identified as the significant determinants of naira real exchange rate model in the short run include, interest rate differential (IRD), nominal exchange rate (LNER) and productivity (LPRO).

Most of the variables were correctly signed. The naira real exchange rate is negatively elastic to changes in productivity, implying that an improvement in the country's productivity is associated with real exchange rate appreciation. On the other hand, an exchange rate policy that is consistent with increased nominal exchange rate leads to depreciation in the real exchange rate. The positive coefficient estimated for interest rate differential is in line with the findings of Atanda and Iyekoretin (2012). The error correction term (ECM (-1)) turned out negative as expected and significant. At -0.18, the size of the ECM implied a relatively low speed of convergence of the real exchange rate to its long run equilibrium.

This indicates that about 18.0 per cent of disequilibrium error in the real exchange rate is corrected within a quarter. The Jarque-Bera test confirms the normality of the residuals from the error correction model.(THE ESSENCE OF THE Jarque-Bera test IS NOT FOR MODEL ADEQUACY)

5.6 Computed RER Misalignment Levels

The estimates of real exchange rate misalignment presented in Table 9 indicated that the naira was on the average overvalued by 0.15 per cent in real terms during the period 2000Q2 – 2016Q1. Over the 64 quarters of the sample period for the study, 43 incidences of overvaluation and 21 incidences of undervaluation were identified.

At an average misalignment level of 0.15 per cent, each dollar sold during the sample period was subsidized by about 15 kobo. Four periods of prolonged exchange rate overvaluation (i.e. real exchange rate overvaluation spanning over 4 quarters) were noticeable, namely: 2004/05, 2009/10, 2013/14 and 2015/16. On the other hand, episodes of real exchange rate undervaluation were relatively short, not exceeding two quarters, except during the last three quarters of 2002 and the first three quarters of 2007 (Figure 1).

Table 9: Estimates of Naira Real Exchange Rate Misalignment

Period	Actual RER	Equilibrium RER	*Misalignment (%)*	*Remarks*
2000Q2	245.98	261.49	*6.30*	*Overvaluation*
2000Q3	241.31	245.01	*1.53*	*Overvaluation*
2000Q4	252.96	241.59	*-4.50*	*Undervaluation*
2001Q1	253.67	251.07	*-1.02*	*Undervaluation*
2001Q2	241.70	250.83	*3.78*	*Overvaluation*
2001Q3	226.72	240.75	*6.19*	*Overvaluation*
2001Q4	233.46	228.04	*-2.32*	*Undervaluation*
2002Q1	230.00	234.21	*1.83*	*Overvaluation*
2002Q2	229.31	228.54	*-0.34*	*Undervaluation*
2002Q3	237.16	227.25	*-4.18*	*Undervaluation*
2002Q4	239.29	233.85	*-2.28*	*Undervaluation*
2003Q1	245.25	234.98	*-4.19*	*Undervaluation*
2003Q2	221.62	237.74	*7.27*	*Overvaluation*
2003Q3	208.43	217.27	*4.24*	*Overvaluation*
2003Q4	212.98	206.29	*-3.14*	*Undervaluation*
2004Q1	215.42	211.08	*-2.01*	*Undervaluation*
2004Q2	208.32	210.51	*1.05*	*Overvaluation*
2004Q3	202.35	204.10	*0.86*	*Overvaluation*
2004Q4	193.53	197.56	*2.08*	*Overvaluation*
2005Q1	188.84	189.33	*0.26*	*Overvaluation*
2005Q2	180.29	185.18	*2.71*	*Overvaluation*
2005Q3	167.80	175.69	*4.70*	*Overvaluation*
2005Q4	175.94	163.80	*-6.90*	*Undervaluation*
2006Q1	168.78	172.13	*1.99*	*Overvaluation*
2006Q2	167.61	165.91	*-1.02*	*Undervaluation*
2006Q3	158.07	163.97	*3.73*	*Overvaluation*
2006Q4	163.65	154.67	*-5.49*	*Undervaluation*
2007Q1	164.16	159.28	*-2.97*	*Undervaluation*
2007Q2	160.42	159.95	*-0.29*	*Undervaluation*
2007Q3	153.09	156.42	*2.17*	*Overvaluation*
2007Q4	147.25	149.84	*1.76*	*Overvaluation*
2008Q1	145.82	144.82	*-0.69*	*Undervaluation*
2008Q2	139.04	143.84	*3.45*	*Overvaluation*
2008Q3	132.93	138.10	*3.88*	*Overvaluation*
2008Q4	130.77	132.40	*1.25*	*Overvaluation*
2009Q1	158.08	130.66	*-17.34*	*Undervaluation*
2009Q2	154.56	156.62	*1.34*	*Overvaluation*
2009Q3	152.37	152.74	*0.24*	*Overvaluation*
2009Q4	146.55	150.63	*2.79*	*Overvaluation*
2010Q1	143.80	145.25	*1.01*	*Overvaluation*
2010Q2	139.08	142.41	*2.39*	*Overvaluation*
2010Q3	135.20	138.36	*2.33*	*Overvaluation*
2010Q4	133.63	135.02	*1.04*	*Overvaluation*
2011Q1	132.73	133.58	*0.64*	*Overvaluation*
2011Q2	134.39	128.49	*-4.40*	*Undervaluation*
2011Q3	129.65	129.69	*0.03*	*Overvaluation*
2011Q4	128.97	125.69	*-2.54*	*Undervaluation*
2012Q1	126.28	125.78	*-0.40*	*Undervaluation*
2012Q2	123.33	125.27	*1.58*	*Overvaluation*
2012Q3	122.04	122.16	*0.10*	*Overvaluation*
2012Q4	118.37	120.66	*1.94*	*Overvaluation*
2013Q1	117.52	117.41	*-0.09*	*Undervaluation*
2013Q2	115.78	117.48	*1.47*	*Overvaluation*
2013Q3	114.36	115.61	*1.10*	*Overvaluation*
2013Q4	111.29	112.82	*1.38*	*Overvaluation*
2014Q1	109.98	110.56	*0.53*	*Overvaluation*
2014Q2	109.25	109.42	*0.15*	*Overvaluation*
2014Q3	107.30	108.25	*0.89*	*Overvaluation*
2014Q4	106.69	107.01	*0.30*	*Overvaluation*
2015Q1	129.01	106.93	*-17.12*	*Undervaluation*
2015Q2	126.67	129.35	*2.11*	*Overvaluation*
2015Q3	122.77	126.00	*2.64*	*Overvaluation*
2015Q4	119.25	122.87	*3.03*	*Overvaluation*
2016Q1	114.17	118.67	*3.94*	*Overvaluation*
Average	**165.11**	**165.36**	***0.15***	***Overvaluation***

As summarised in Table 10, empirical estimates showed that the first regime of Interbank Foreign Exchange Market (IFEM) spanning October 1999 to June 2002 was associated with 1.22 per cent overvaluation while its second round of implementation during November 2013 – May 2016 was associated with an undervaluation of about 0.25 per cent.

It is important to note that the real exchange rate was overvalued from November 2013 to May 2016, except for the sharp undervaluation that was recorded in the first quarter of 2015 (Figure 1). The substantial undervaluation occurred when the rDAS segment of the foreign exchange market was closed (18th of February, 2015) and the published official foreign exchange market rate became the interbank rate.

Table 10: Summary of Naira RER Misalignment Levels

Exchange Rate Regime/Policy	Period	Actual RER	Equilibrium RER	Misalignment Level (%)
Interbank Foreign Exchange Market (IFEM)	Oct. 1999 - Jun. 2002	239.46	242.39	1.22 (*Overvaluation)*
Retail Dutch Auction System (rDAS)	Jul. 2002 - Jan. 2006	209.33	210.06	0.35 (*Overvaluation)*
Wholesale Dutch Auction System (wDAS)	Feb. 2006 - Oct. 2013	142.58	142.03	0.39 (*Undervaluation)*
Interbank Foreign Exchange Market *(with CBN Interventions)*	Nov. 2013 - May 2016	115.52	115.23	0.25 (*Undervaluation)*

On the other hand, the rDAS policy of exchange rate management in place during July 2002 – January 2006 was associated with a real exchange rate overvaluation of 0.35 per cent. However, the wDAS policy of February 2006 to October 2013 was associated with a real exchange rate undervaluation of 0.39 per cent. Overall, study findings seem to suggest that the wDAS policy of exchange rate management implemented during 2006 – 2013 and the subsequent adoption of IFEM helped to steer the real exchange rate towards its long run path.

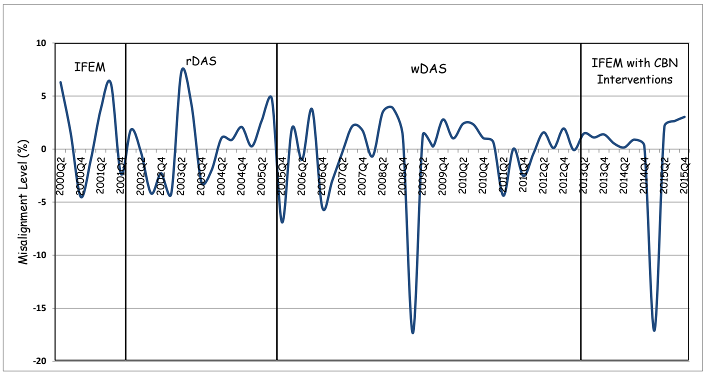

Figure 1: Computed Naira RER Misalignment Levels

6.0 Conclusion

This paper obtained estimates of naira real exchange rate misalignment during the period 2000-2016 and pinned down the estimated misalignment levels to the different exchange rate policies implemented in the sample period. Intuitively, we extended the Behavioural Equilibrium Exchange Rate (BEER) approach to the determination of equilibrium real exchange rate by incorporating structural breaks in the specified naira real exchange rate model. This was motivated by the policy changes that occurred within the sample period.

A linear cointegration test conducted amongst the included variables based on the Johansen approach failed to establish the existence of long run relationship, necessitating the implementation of a test that is robust to the presence of structural break. The Gregory and Hansen cointegration approach, which is robust to structural breaks, indicated that the variables were cointegrated albeit with a shift in the cointegrating relationship in 2011Q1. Model results showed that the identified breakpoint was correctly identified. Furthermore, findings from the estimated error correction model of naira RER indicated that interest rate differentials, nominal exchange rate and productivity were significant determinants. Notably, an improvement in the country's productivity is expected to lead to an appreciation in the real exchange rate. The model explained about 70.0 per cent of variations in the dependent variable.

Having extracted cycles from the right hand side variables using the HP filter, same were substituted into the naira real exchange rate model to obtain estimates of the equilibrium real exchange rate. The resulting computations showed that the extent of deviation of the actual real exchange rate from its long run equilibrium (real exchange rate misalignment) averaged 0.15 per cent during the study period. During the period 2001Q2 – 2016Q1 (a total number of 64 quarters), 43 quarters of overvaluation were identified while the remaining 21 quarters were associated with real exchange rate undervaluation. The results seem to suggest that the country was more tolerant of real exchange rate overvaluation than undervaluation.

During the sample period, four distinct exchange rate policies were implemented, namely: IFEM, rDAS, wDAS and an IFEM with CBN interventions. Our results suggested that the period of IFEM with interventions (November 2013 – May 2016) was associated with the least misalignment level (0.25 per cent undervaluation), followed by the period of rDAS policy with a misalignment level of 0.35 per cent. On the other hand, the initial implementation of IFEM in the early 2000s was associated with 1.22 per cent overvaluation, implying that each dollar bought/sold during the period was subsidised by about 1.22 naira. It is hoped that the flexible exchange rate policy implemented in June 2016 will lead to a correction of the naira RER, which was estimated to be overvalued by about 3.94 per cent in the first quarter of 2016.

References

Agu, C. (2002). Real exchange rate distortions and external balance position of Nigeria: Issues and policy options. *Journal of African Development*, *5*(2), 20-47.

Aliyu, S. U. R. (2011). Real exchange rate misalignment: An application of behavioural equilibrium exchange rate to Nigeria. *Central Bank of Nigeria Occasional paper*, No. 41

Andreou, E., & Ghysels, E. (2002). Detecting multiple breaks in financial market volatility dynamics. *Journal of Applied Econometrics*, 17(5), 579-600.

Atanda, M. S., & Iyekoretin, O. F. (2012). Estimating the determinants of Nigeria's real exchange rate dynamics. *Asian African Journal of Economics and Econometrics*, *12*(2)

Bai, J., & Perron, P. (1998). Estimating and testing linear models with multiple structural changes. *Econometrica*, 47-78

Clark, P. B., & MacDonald, R. (1998). Exchange rates and economic fundamentals: A methodological comparison of BEERs and FEERs. *IMF Working Papers,* WP/98/67

Edwards, S. (1989). *Real exchange rates, devaluation, and adjustment: exchange rate policy in developing countries*. Cambridge, MA: MIT press.

Egert, B., & Lahreche-Revil, A. (2003). *Estimating the fundamental equilibrium exchange rate of Central and Eastern*

European countries: The EMU enlargement perspective (Vol. 5). CEPII.

Eita, J. H., & Sichei, M. M. (2014). Estimating Namibia's equilibrium real exchange rate. *The International Business & Economics Research Journal (Online)*, *13*(3), 561

Ghura, D., & Grennes, T. J. (1993). The real exchange rate and macroeconomic performance in Sub-Saharan Africa. *Journal of Development Economics*, *42*(1), 155-174.

Gregory, A. W., & Hansen, B. E. (1996). Residual-based tests for cointegration in models with regime shifts. *Journal of econometrics*, *70*(1), 99-126.

Hansen, J., & Roeger, W. (2000). Estimating the real equilibrium exchange rates" *Economic Papers,* No. 144

Hosni, R., & Rofael, D. (2015). Real exchange rate assessment in Egypt: Equilibrium and misalignments. *Journal of Economics and International Finance*, *7*(4), 80

Hossfeld, O. (2010). Equilibrium real effective exchange rates and real exchange rate misalignments: Time series vs. panel estimates. *FIW Working Paper,* No. 65

Ibrahim, W. (2013). Equilibrium real exchange rate and capital flows in Nigeria (1960-2011). *Arabian Journal of Business and Management Review (Oman Chapter)*, *2*(10), 20.

Ivanova, N. (2007). Estimation of the equilibrium real exchange rate in Russia: Trade-Balance approach. *CEFIR/NES Working Paper*, (102).

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, *12*(2-3), 231-254.

Jongwanich, J. (2009). Equilibrium real exchange rate, misalignment, and export performance in developing Asia. *ADB Economics Research Paper Series,* No. 151.

Omotosho, B. S. (2012). Endogenous structural breaks and real exchange rate determination in Nigeria since Interbank Foreign Exchange Market (IFEM). *CBN Economic and Financial Review*, *50*(3).

____________ (2015). Is real exchange rate misalignment a leading indicator of currency crises in Nigeria?. *CBN Journal of Applied Statistics*, *6*(1), 153-179.

Omotosho, B. S., & Wambai, M. U. (2012). Is the Naira-US Dollar real exchange rate misaligned. *CBN Economic and Financial Review*, *50*(2).

Oriavwote, V. E., & Oyovwi, D. O. (2012). The determinants of real exchange rate in Nigeria. *International Journal of Economics and Finance*, *4*(8), 150.

Oscar, K. (2012). Estimating the real exchange rate misalignment: Case of Gabon. MPRA, downloadable at http://mpra.ub.uni-muenchen.de/39625/

Phillips, P. C., & Hansen, B. E. (1990). Statistical inference in instrumental variables regression with I (1) processes. *The Review of Economic Studies*, *57*(1), 99-125

Williamson, J. (1994). *Estimating equilibrium exchange rates*. Peterson Institute.

Zainudin, R., & Shaharudin, R. S. (2011). An investigation of structural breaks on spot and futures crude palm oil returns. *Australian Journal of Basic and Applied Sciences*, *5*(9), 1872-1885.

Zalduendo, J. (2006). Determinants of Venezuela's equilibrium real exchange rate. *IMF Working Papers*, No. WP/06/74.