Endogenous Structural Breaks and Real Exchange Rate Determination in Nigeria since Interbank Foreign Exchange Market (IFEM)

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Starting from Obaseki (1998), several authors have developed different models of Naira equilibrium real exchange rate in a bid to better understand its behavior, albeit without accounting for the possibility and effects of structural breaks in their models. This is counterintuitive, especially in view of exchange rate policy changes in Nigeria over the years and the occurrence of global shocks resulting from the 2008/09 financial crisis. This paper reexamines the concept of naira real exchange rate determination in the spirit of Edwards (1989), while allowing for the effects of endogenously determined structural breaks in the cointegrating vector. The results were revealing. First, three endogenous break dates were identified over the estimation period of 2000-2011, which were 2002:Q3, 2003:Q2 and 2009:Q3. Second, we found faster speed of adjustment to long run equilibrium after accounting for the effects of the identified structural breaks. Third, the model without structural breaks underestimated the misalignment level by about 250 basis points on the average. Fourth, the nominal exchange rate (an indicator of exchange rate policy) was found to be very crucial in steering the RER towards its long run equilibrium path. Fifth, the level of naira misalignment was found to be about 0.001 per cent since the introduction of WDAS, much lower than the 0.89 and 0.21 recorded during IFEM and RDAS, respectively. The study therefore calls for the retention of the current exchange rate policy (WDAS) in the country as a way of ensuring that the Naira is kept within its path of long run equilibrium.

Keywords: Real exchange rate, Cointegration, Structural breaks, Misalignment, Overvaluation, Undervaluation

JEL: F31, C22, E5

1.0 Introduction

The collapse of the Bretton Woods system of fixed exchange rates in March 1973 led many developed countries to adopt the flexible exchange rate system while most developing countries sustained their fixed exchange rate parities. However, some of these developing countries later abolished their fixed exchange rate system and embraced intermittent adjustments by implementing regimes such as the crawling pegs or the managed float. Consequently, the process of exchange rate determination in those countries, Nigeria inclusive, became the role and concern of monetary authorities rather than that of the market forces.

In Nigeria, the introduction of Structural Adjustment Programme (SAP) in 1986 and the consequent liberalization of the foreign exchange market led the Central Bank of Nigeria (CBN) to deploy various forms of managed floating regime. These ranged from the Second-tier Foreign Exchange Market (SFEM), which was introduced in September 1986 as a market-driven mechanism for foreign exchange allocation, to the subsisting Wholesale Dutch Auction System (WDAS) introduced on the 20th of February, 2006.

At the introduction of SFEM, the official nominal exchange rate of the Naira was N4.6064/US$ and had depreciated significantly by about 95.11 per cent to N94.8800/US$ prior to IFEM in September 1999. As at December 2012, the Naira average exchange rate stood at N157.3240/US$, implying that it had further depreciated by about 39.69 per cent since IFEM. It is therefore intuitive to ask the following empirical questions: The relevant emerging empirical questions include: are these substantial depreciations in the Naira exchange rate consistent with the dictates of economic fundamentals in real terms? Have the exchange rate policies of the government been able to deliver an appropriate and realistic value for the Naira? In view of the structure of the Nigerian economy (i.e. import dependency and reliance on crude oil exports for government revenue), these questions are of significant policy, economic and academic relevance.

At the global level, macroeconomists and international organizations such as the International Monetary Fund (IMF)[1] and World Trade Organization (WTO)[2] have also shown continued interest in the appropriated exchange rate arrangements of nations due to its roles in the adjustment of global imbalances and the allocation of resources in the domestic economy. Prolonged real exchange rate misalignment is also known to have caused macroeconomic imbalances such as current account problems and currency crisis (Xiaopu, 2002). It may also be a consequence of inappropriate macroeconomic policies and thereby signaling the need for a macroeconomic policy shift. In their work, Ghura and Grennes (1993) noted that the growing overvalued exchange rate that began in sub-Sahara Africa in the early 1980s contributed to the poor performance of the region during the period. Overall, the literature is replete with evidence showing that prolonged misalignment of the exchange rate confers significant costs on output growth in the medium to long term. Thus, Hinkle and Montiel (1999) concluded that the principal objective of any exchange rate policy is to steer the real exchange rate towards it long run equilibrium and avoid episodes of prolonged and substantial misalignment.

The IMF, through its Consultative Group on Exchange Rate (CGER) developed three methodologies for assessing the value of domestic currencies of member countries. These are the macroeconomic balance, external sustainability and equilibrium real exchange rate approaches. The latter, which relates the real exchange rate to a set of fundamentals (often referred to as the Behavioural Equilibrium Exchange Rate Model - BEER), represents the category under which

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[1] See IMF publication on methodology for CGER exchange rate arrangements released in 2006

[2] See WTO publication on effects of misalignments on trade rules released in 2010

most of the studies on Naira real exchange rate misalignments have been investigated[3]. However, these methodologies are being updated in line with changing economic dynamics. One of such inventions is the incorporation of structural breaks into the exchange rate models (Eng *et.al,* 2012). The argument in this regard is that exchange rate models that assume parameter constancy over fairly long estimation periods are subject to misspecification, due to structural changes. Such errors have grave consequences on the resulting estimates of the equilibrium real exchange rates and the associated misalignment levels. For a discussion on the implications of ignoring structural breaks when they do exist, see Aggarwal *et al* (1999), Andreou (2002), Sensier and Van Dijk (2004), Zainudin and Shaharudin (2011), amongst others.

In view of exchange rate policy changes in Nigeria as well as the effects of external shocks on the economy, which could potentially introduce structural breaks into the relationship between Naira RER and its determinants, it is intuitive to account for possible structural breaks in Naira RER determination models[4]. This study is motivated by the need to avoid the risks associated with ignoring structural breaks in Naira RER models, especially since IFEM and the occurrence of the 2008/09 global financial crisis. Thus, the broad objective is to obtain realistic Naira equilibrium RER values and the associated misalignment levels during 2000-2011, while accounting for the effects of possible structural breaks. To achieve this, we extended the traditional Behavioural Equilibrium Exchange Rate (BEER) model enunciated by MacDonald (1997) and Clark & MacDonald (1998) by introducing structural breaks into the cointegrating equation of Naira real exchange rate.

This study is different from existing empirical works in a number of ways. First, it incorporates the effects of structural breaks in Naira RER determination by endogenously detecting the presence and dates of such breaks, unlike Ononugbo (2005) which used exogenously determined breaks[5]. Second, the paper sets up two error correction models with a view to comparing the speeds of adjustment to long run equilibrium in models with and without structural breaks. Third, the role of nominal exchange rate (and by implication, the prevailing exchange rate policy) in the long run RER adjustment process is investigated via sensitivity analysis. Fourth, it assesses the implication of the identified structural breaks on the estimated real exchange rate misalignment levels.

The remainder of the paper is structured as follows. Section 2 reviews the related empirical literature, with special emphasis on the methodology used and major findings. Section 3 presents an overview of exchange rate policies in Nigeria since 1970 and the movements in exchange rates during the period. Section 4 presents the methodological framework for model estimation and analysis. Section 5 discusses the results, while section 6 concludes the paper.

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[3] For example, see Aliyu (2011), Omotosho and Wambai (2012), Agu (2002), Obaseki (1998), Ononugbo (2005)

[4] Most relevant empirical works on Nigeria failed to account for structural breaks in their exchange rate models

[5] Exogenously determined breaks have been criticized for arbitrariness (Eng *et. al,* 2012).

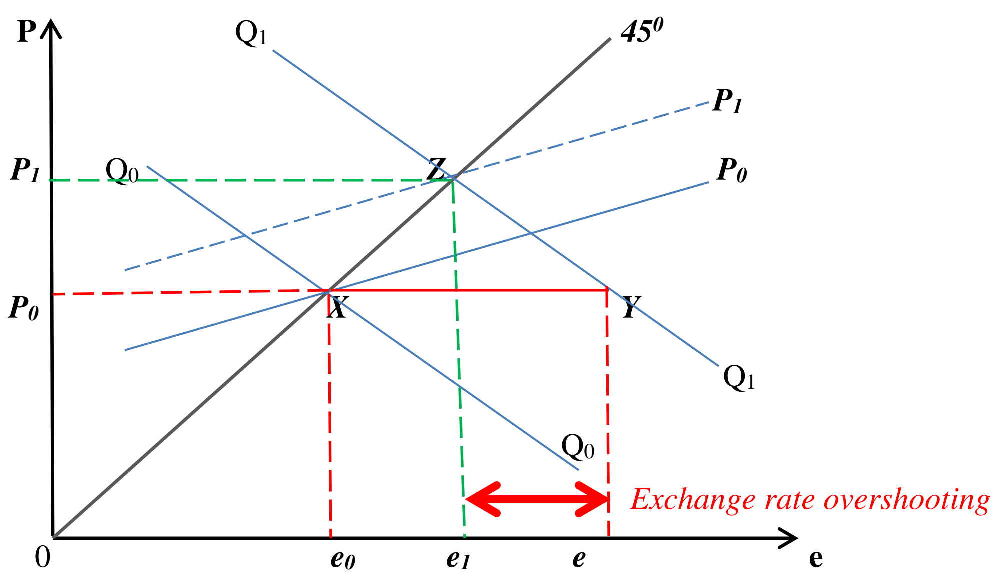
2.0 Theoretical Underpinnings and Review of Empirical Literature

The overshooting hypothesis on expectations and exchange rate dynamics provides a simple macroeconomic framework for understanding exchange rate movements within the ambit of rational expectations formation (Dornbusch, 1976). Largely based on the Mundell–Fleming model of the 1960s, the overshooting model assumes that prices of goods are sticky in the short run, prices of currencies are flexible, arbitrage is possible in asset markets based on the uncovered interest parity equation, and that expectations of exchange rate changes are rational. Thus, short run overshooting of exchange rates is generated by rational expectations which are in turn caused by monetary and other demand shocks.

A monetary policy shock leads the market to adjust to a new equilibrium between prices and quantities. However, since the prices of goods are sticky in the short run, adjustment to a new short run equilibrium level is achieved through shifts in financial market prices. In this regard, the foreign exchange market initially overreacts to the monetary shock and achieves a new short run equilibrium. In the medium term, the prices of goods begin to respond and the foreign exchange market is able to dissipate its overreaction while the economy begins its adjustment to the new long run equilibrium in all markets. Eventually, a new long-run equilibrium is attained in the domestic money market, the currency exchange market, and the goods market.

In Figure 1, the 45^0 line drawn through the origin indicates that the purchasing power parity holds in the long run. Schedule Q_0Q_0 depicts the money market equilibrium while P_0 shows the different combinations of exchange rates and price levels for which the goods and money markets are in equilibrium. Thus, the economy is at initial equilibrium at point X with long run exchange rate e_0 and price level P_0.

Figure 1. Dornbusch Overshooting Model with Monetary Expansion



A positive monetary shock shifts the money market schedule from Q_0Q_0 to Q_1Q_1. Since the exchange rates and assets markets are assumed to be more flexible than the goods market, the positive monetary shock raises money supply but leaves the price level temporarily fixed at P_0. The short run equilibrium is at point *Y* and the short run exchange rate is at *e*. In the long run, however, the price level adjusts upwards in response to the positive monetary shock in order to maintain money market equilibrium. This leads to a reduction in demand for real balances and the new long run equilibrium is at point *Z* with the exchange rate level of e_1. At point Z, both the goods and money markets are in equilibrium while the exchange rates and goods' prices have fully adjusted to the monetary shock. Thus, a positive monetary shock results in an overshooting of the exchange rate by the distance e_1e in the short run. The overshooting exchange rate model of Dornbusch highlights the role of exchange rate movements in equilibrating the economy following changes in monetary policy in an environment of sticky prices in the goods market. This model has been used by several authors as it provides a rough guide as to the variables to be included in exchange rate models. For instance, Sichei et al. (2005) found that the Dornbusch overshooting model underlie the behavior of the South African currency during 1994 – 2004.

Historically, empirical works on exchange rates have focused on four key areas while leveraging on the overshooting model. These are the determinants of exchange rates, the existence of long run relationship between the RER and its determinants, the behavior of actual RER relative to its long run equilibrium path and finally, the impacts of RER volatility and misalignment on other macroeconomic variables such as GDP, trade balance, exports and external reserves, amongst others. In terms of methodology, some researchers who have studied the determinants of exchange rates applied the Ordinary Least Squares (OLS) regression (for example, Ghura and Green, 1993, Cottani et al, 1990), while others have employed the theory of unit root, cointegration and error correction model (for example, Montiel 1997; Gelbard and Nagayasu, 1999; Baffes *et al*, 1997 and Feyzioglu, 1997). However, empirical literature on the exchange rate models with structural breaks is still growing and interest in it have rekindled, following the occurrence of the 2008/09 global financial crisis. This section presents a review of some existing relevant empirical works. First, country specific studies were reviewed followed by works based on cross country analysis.

In his work on the determinants of Venezuela's equilibrium real exchange rate, Zalduendo (2006) examined whether the continued use of exchange rate peg was justified, especially during a period of high earnings from oil exports. Applying Vector Error Correction (VEC) model on relevant variables such as oil price, productivity and macroeconomic policies, he found that oil price and declining productivity were the most crucial determinants of both the official and the parallel market rates of the Venezuelan Bolivar during 1950 - 2004. He also found a higher speed of convergence in the parallel market rates and noted that the Venezuelan government was able to accommodate sharp and persistent misalignments in the official segment of the market due to the availability of oil revenues in its coffers. He argued that the continued use of pegged exchange rate regime in Venezuela was unsustainable in the face of increasing oil price and higher oil export earnings.

In a similar study for South Africa, MacDonald and Ricci (2003) applied the Johansen cointegration estimation methodology (VECM) to estimate the equilibrium path of the Rand exchange rate during 1970 – 2002. Having identified the major fundamentals affecting the South African currency as real interest rate differentials, relative GDP per capita, real commodity prices, trade openness, fiscal balance and net foreign assets, they found that the Rand was undervalued by about 26 per cent in the early 2002. In terms of speed of adjustment to long run equilibrium, they found that about 8 per cent of exchange rate misalignment was eliminated every quarter.

Clark and MacDonald (1998) investigated whether the actual real effective exchange rate in US, Germany and Japan were consistent with their long run equilibrium paths between 1960 and 1996. They estimated a Behavioral Equilibrium Real Exchange Rate (BEER) using cointegration technique and calibrated values of the determinants based on HP filter. Of the three currencies, the Japanese Yen was found most misaligned (by about -17 per cent implying an undervaluation) while the German Mark and US Dollars were misaligned by 8 (overvaluation) and -1 per cent (undervaluation), respectively.

In a similar study for two developed countries (United States and Japan), but employing a stock-flow perspective that is based on macroeconomic balance approach, Faruqee (1995) applied the theory of cointegration with a view to identify the long-run determinants of real exchange rate in the countries over the postwar period. He identified net foreign assets and productivity differentials as having long run relationships with the US Dollar RER. However, for Japanese Yen, only productivity was found to cointegrate with the RER in the long run. Other studies that used cointegration and error correction techniques for investigating real exchange rate misalignment both at individual country and panel analysis include: Lim (2000) for Thailand; Montiel (1997) for Thailand, Indonesia, Malaysia, Philippines and Singapore; Ricci et al (2008) for a sample of 48 industrial countries and emerging markets; Choudhri and Khan (2005) for a group of 16 developing countries; Maeso-Fernandez *et al* (2004) for a group of 25 OECD countries; Stein (1995) for the United States; Dunaway *et al* (2006) for China; and Oscar (2012) for Gabon. These studies identified the major fundamentals driving movements in the currencies they examined and found varying levels of misalignments as well as speeds of adjustment to long run equilibrium. However, none of them accounted for the possibility of structural breaks in their modeling techniques.

The literature is still scanty in terms of exchange rate determination models with structural breaks. An attempt was made by Dabos and Juan-Ramon (2000) which empirically investigated the response of the Peso real exchange rate to increased capital flows in Mexico while incorporating structural breaks. Unlike the other studies reviewed above, the authors highlighted the possibility of parameter bias in exchange rate models which ignore structural breaks. After controlling for structural breaks in their error correction model, they obtained estimates of the long run equilibrium real exchange rate. Based on the model with structural break, the Peso was found to be overvalued by about 25 per cent on the eve of the 1994 Mexican currency crisis. However, the model without structural break showed that the Mexican currency was overvalued by about 12 per cent on eve of the crisis. For similar but not as detailed works, see Bussière *et al* (2010) and Eng *et al* (2012). The consensus amongst these authors was that structural breaks are an important factor to be taken into account when modeling exchange rates.

In terms of studies on Nigeria, Soludo and Adenikinju (1997) applied the techniques of co-integration and error correction model to determine the equilibrium real exchange rate of the Naira and its level of misalignment. While they did not provide their misalignment values in a time series form, they found that exchange rate misalignment affected the country's manufacturing investment negatively. Also, Agu (2002) adopted the reduced form equation to assess exchange rate misalignment in Nigeria and found that the Naira was overvalued by an average of about 1.4 per cent between 1970 and 1998. He also found that real exchange rate misalignment and its volatility affect trade. These studies did not dwell explicitly on their methodologies for obtaining naira equilibrium real exchange rates as their focus was on investigating the impact of misalignment on other macroeconomic variables of interest. It is however clear that the authors did not incorporate structural breaks in their analysis.

Another strand of empirical works on real exchange rate determination in Nigeria relates to the assessment of the value of the naira vis-à-vis its equilibrium level. Using the Purchasing Power Parity (PPP) approach, Obaseki (1998) showed that the Naira was overvalued by about 4.7 per cent during 1995 – 1998. In a more methodological paper, Ononugbo (2005) investigated long run cointegration between naira exchange rate and relative price levels in Nigeria and USA, while accounting for exchange rate regime change. He used the error correction model within the PPP framework and found that the naira nominal exchange rate during 1970 to 2003 followed the long run path suggested by the PPP. However, his results showed that the naira nominal exchange rate was overvalued by 9.48 per cent in 2003.

Suleiman and Muhammad (2011) also studied the long run relationship between naira real exchange rate and two fundamentals which are real oil price and productivity differentials between 1980 and 2010 using Johansen cointegration test and VECM. They found that oil price conferred positive impact on the exchange rate while productivity differential conferred negative effect. Their study also showed that the RER appreciation of 2000-2010 was driven by oil prices. They however didn't investigate whether the appreciation was in line with the long run equilibrium path. In another study by Nwude (2012), the factors that determine naira exchange rate were identified to include gross domestic product, balance of payments, reserves, consumer price index, deposit rate and lending rate. Using annual data from 1960 to 2011, he used the OLS method and found that there is no statistically significant relationship between the dependent variable and the RHS variables. It must be noted that the work by Nwude (2012) suffered from several methodological issues[6]. Besides, his exchange rate determinants were not soundly and theoretically selected.

In a more rigorous work, Aliyu (2011) investigated RER misalignment in Nigeria using the behavioural equilibrium exchange rate approach. He applied the Johansen's cointegration approach and vector error correction model and identified terms of trade, crude oil volatility, monetary policy performance and government fiscal stance as major determinants of the RER. His study showed that the Naira was undervalued between 2003Q3 and 2004Q4 and overvalued during 2005Q1 – 2006Q4. According to his study, the Naira was overvalued by about 5.9 per cent during 2005Q4, just before the introduction of WDAS in 2006Q1. In a similar but more recent work, Omotosho and Wambai (2012) found an exchange rate misalignment of 0.29 per cent for the naira during the period 2000-2011 adding that the RER appreciation of 2002-2008 and depreciation of 2009 were consistent with the long run equilibrium trend. They concluded that the naira real exchange rate oscillated quite closely around its equilibrium path during their study period.

Apart from the work of Ononugbo (2005), which accounts for exchange rate regime in his PPP model of naira exchange rate using exogenously determined breaks, no other study reviewed above incorporated structural breaks in their analysis. The events of the 2008/09 global financial crisis as well as the dynamics of exchange rate determination in Nigeria requires that structural breaks should be incorporated in any proper estimation of naira equilibrium exchange rate. As noted by Dabos and Juan-Ramon (2000) and Bussière et al (2010), ignoring structural breaks when they are present in economic relationships leads to parameter bias. Since the parameter estimates of the cointegrating regression are crucial input in the computation of the equilibrium RER, estimates of RER misalignment based on the biased parameter estimates may also be faulty. Surprisingly, while quite a lot has been done on the determinants of exchange rates in Nigeria, the author is not aware of any study which accommodates structural breaks while modeling RER of the Naira, especially following the introduction of the WDAS in 2006 and the occurrence of the 2008/09 global financial crisis. This study augments existing literature by extending the work of Omotosho and Wambai (2012) to accommodate the effect of structural breaks on the cointegrating equation of the Naira Behavioural Equilibrium Exchange Rate model.

3.0 Exchange Rate Policies and Trend in Nigeria[7]

Exchange rate policies in Nigeria have been targeted at avoiding substantial misalignments and achieving a realistic Naira exchange rate that is capable of addressing the basic problems of the country's external sector. These ranged from a fixed exchange rate regime prior to 1986 to

[6] The study failed to test and account for non-stationarity in the included variables.
[7] This section is extracted from an earlier paper by Omotosho and Wambai (2012) with few modifications

various forms of floating exchange rate system, following the liberalization of the foreign exchange market in 1986 (Table 1).

Table 1. Exchange Rate Regimes/Policy in Nigeria (1960 – 2013)

Period	Exchange Rate Regime/Method of Exchange Rate Determinantion
1960 - 1972	Fixed (Pegged to British pound sterling/US Dollars)
1973 - 1978	Managed float
1978	Basket of currencies approach
September 1986	Dual exchange rate system (Introduction of Second Tier FEM)
April 1987	Dutch Auction System (DAS) of bidding
July 1987	Single enlarged Foreign Exhange Market with various pricing methods
January 1989	Creation of Interbank Foreign Exchange Market (IFEM)
1994	Pegged exchange rate system
1995	Autonomous Foreign Exchange Market (AFEM)
October 1999	Reintroduction of IFEM
July 2002	Retail Dutch Auction System (rDAS) of foreign exchange management
February 2006 to Date	Wholesale Dutch Auction System (wDAS)

For instance, the Naira exchange rate (at N0.7143/$US) was adjusted in relation to the British pound with a one-to-one relationship between 1960 and 1967 while another fixed parity was maintained with the US dollar between 1967 and 1974, following the devaluation of the pound sterling in 1967. Between 1974 and 1976, the Naira exchange rate was pegged to either the U.S. dollar or the British pound sterling; depending on which of the two currencies was stronger in the foreign exchange market. Being conscious of the possibility of overvaluation, the government embarked on an unsystematic devaluation of the Naira towards the end of 1976, with a view to realigning its value. Thus, the value of the Naira was pegged to a basket of seven currencies of Nigeria's major trading partner countries.

Towards the end of 1985, the naira exchange rate was allowed to be determined by market forces in line with the requirements of the Structural Adjustment Programme (SAP)[8] of 1986. In September 1986, the Second-tier Foreign Exchange Market (SFEM) was introduced as a market-driven mechanism for foreign exchange allocation, while the first and the second tier markets were merged in July 1987. During this period, various pricing methods such as marginal, weighted average, and Dutch Auction System were adopted. The average annual official exchange rate, which was N2.0 per US dollar in 1986 depreciated rapidly to N4.0 per US$ and N9.9 per US$ in 1987 and 1991, respectively. The naira further depreciated to N17.3 per US$ and N22.1 per US$ in 1992 and 1993, respectively (Figure 2).

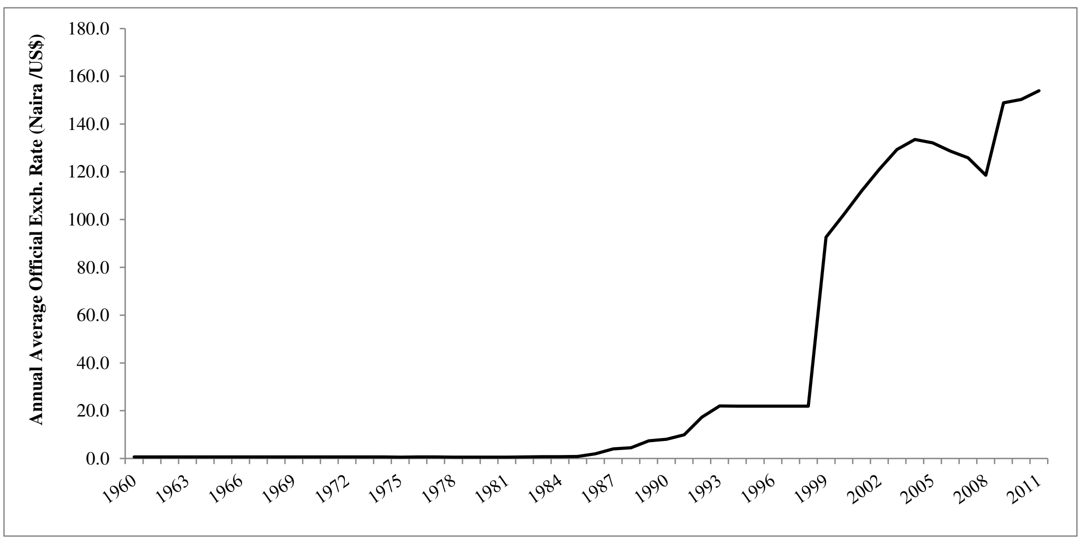
There was a policy reversal in 1994 when the naira exchange rate was again pegged. This policy led to an appreciation of the exchange rate to N21.9 per dollar. However, another era of liberalization in the foreign exchange market began in 1995 when the Autonomous Foreign

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

Exchange Market (AFEM) was introduced. Two exchange rates prevailed in the country during this era. The fixed exchange rate of N21.9 per dollar was applied to official transactions on debt service payments and national priority projects while the market determined AFEM rates were used for other transactions. This encouraged round tripping and other sharp practices associated with a subsidized official rate existing side by side a market determined AFEM rate. This made the monetary authority to abolish the fixed exchange rate system at the official segment of the market in 1999 and the AFEM rate remained the only recognized exchange rate.

The Inter-bank Foreign Exchange Market (IFEM) was introduced on October 25, 1999 to deepen the foreign exchange market but was abolished in July 2002 following the reintroduction of Retail Dutch Auction System (RDAS). From N92.7 per dollar in 1999, the naira depreciated to N121.0, N129.4, N133.50 and N132.15 per US dollar in 2002, 2003, 2004 and 2005, respectively.

Figure 2: Time Series Plot of Annual Naira/Dollar Exchange Rate (1960 - 2011)



The subsisting 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.

4.0 Methodology

Based on the behavioural equilibrium exchange rate approach, we estimate a naira real exchange rate function within the framework of cointegration and error correction model that incorporates structural breaks. The choice of an error correction model is based on the fact that it allows us measure the correction from Naira RER disequilibrium of the previous period. Since the approach permits the general-to-specific procedure, we are also able to get the best fit for the data. Lastly, it provides a framework for ensuring that errors in the long run relationship are not explosive. The data used are sourced from the Central Bank of Nigeria Statistical Bulettin and it covers the period 2000-2011. The steps and procedures adopted to estimate a structural-break-based error correction model for the Naira real exchange rate is outlined in this section.

The first step involves testing for stationarity and the presence of structural breaks in the included variables. The Augmented Dickey Fuller unit root test and Bai-Perron (1998) multiple breakpoint tests are used to test for the formal and latter, respectively. Since we are interested in both short and long run dynamics, a test for cointegration is conducted in stage 2 based on both Johansen (1988) and Gregory-Hansen (1996), which allows us to test for cointegration with single structural break. If there is evidence of structural breaks, a long run model is specified in stage 3 which incorporates the effects of the identified break points. In stage 4, the LSE-Hendry General to Specific (GETS) approach is adopted to arrive at a parsimonious error correction model. Finally, the Naira equilibrium RER is estimated based on robust cointegrating parameters obtained in stage 4 and the corresponding misalignment levels are computed in the final step.

4.1 Stationarity Test

In order to avoid the spurious regression problem, the Augmented Dickey-Fuller (ADF) unit root test is applied to the variables used in the RER model in order to ascertain their correct order of integration. The modeling approach adopted in this study requires that the non-stationary series are purged by appropriately differencing them. The ADF test for stationarity with constant and trend is conducted based on the specification:

$$\Delta y_t = \beta_1 + \beta_2 t + \omega y_{t-1} + \sum_{i-1}^{p} \varphi_i \Delta y_{t-i} + \mu_t \qquad (1)$$

$$Thus, if\ H_0: \omega = 0\ \sim I(1), and\ the\ variable\ is\ non-stationary$$

$$if\ H_1: \omega < 0\ \sim I(0), and\ the\ variable\ is\ stationary$$

4.2 Bai and Perron (1998) Test for Structural Breaks in the Included Variables

In order to investigate the presence of possible multiple structural breaks in the included variables, we apply the Bai and Perron (1998) test procedure. This methodology enables us detect unknown break dates in the variables endogenously by testing the null hypothesis of 'M' breaks against an alternative of 'M+1' number of breaks in a sequential manner. According to Carrion-i-Sylvestre and Sans´o (2006), the dynamic algorithm of Bai and Perron (1998) is appropriate for detecting breakpoints if the break date in a model is unknown. This is because the method minimizes the sum of squared residuals from Dynamic Ordinary Least Squares (DOLS) regressions over a closed subset of break fractions. The Bai and Perron test is based on a multiple linear regression with 'M' number of breaks given as:

$$y_t = x_t'\beta + z_t'\delta_j + \mu_t \qquad (2)$$

With $t = T_{j-1} + 1, \ldots, T_j, for\ j = 1, \ldots, m+1$. In the equation above, Y_t is the explained variable, x_t *(p x 1)* and z_t *(q x 1)* are vectors of the covariates, β and δ_j *(j=1, …., m+1)* are the vectors of coefficients for the covariates and μ_t is the error term. The *x* variables are those whose parameters do not vary across regimes while the *z* variables have regime specific coefficients, implying a partial structural change model. Treating the breakpoints as unknown, Bai and Perron estimated the break points (i.e. the indices $T_1, \ldots, T_m$) alongside the unknown regression coefficients based on least squares estimation method given that T observations are available on the variables y_t, x_t and z_t. Thus, for each m-partition, *(i.e.* $T_1, \ldots, T_m$*)* denoted as $\{T_j\}$, the coefficients β and δ_j are estimated by minimizing the sum of squared residuals in the equation below:

$$\sum_{i=1}^{m+1} \sum_{t=T_{i-1}+1}^{T_i} [y_t - x_t'\beta - z_t'\delta_i]^2 \qquad (3)$$

and the resulting estimates are $\hat{\beta}(\{T_j\})$ and $\hat{\delta}(\{T_j\})$. Substituting the resulting parameters into the objective function and denoting the resulting sum of squares as $S_T(T_1, \ldots, T_m)$, the estimated breakpoints $(\hat{T}_1, \ldots, \hat{T}_m)$ are such that:

$$(\hat{T}_1, \ldots, \hat{T}_m) = argmin_{T_1, \ldots, T_m} S_T(T_1, \ldots, T_m), \qquad (4)$$

and the minimization is effected over all partitions $(T_1, \ldots, T_m)$ such that $T_i - T_{i-1} \geq q$. This framework is used as the basis for several breakpoint tests[9]. For the purpose of this study, the sequential *M+1* break versus *M* test specification is adopted. The specification examines the relevance of the *M+1* structural break, having established *M* number of breaks. Both the individual included variables and the long run model (equation 16) are subjected to this test in order to have an insight into the presence and dates of structural breaks with a view to accommodating them in the error correction model.

[9] See Bai nd Perron (1998) for details

4.3 Cointegration Tests

This method was applied to test whether the included variables in the real exchange rate model share similar stochastic trends. The objective is to ensure that the linear combinations of the variables in equation (16) exhibit stable properties in the long run. This concept is crucial for this study because it encapsulates the existence of a long-run equilibrium to which the naira real exchange rate converges over time and the error term from the error correction model mimics the disequilibrium error (the distance that the system is away from equilibrium at any given time). This study used the Johansen (1988) multivariate cointegration test and the Gregory-Hansen (1996) cointegration test with structural breaks.

4.3.1 Johansen and Juselius Cointegration Test

Johansen (1988) argued that there is possibility of having more than one cointegrating relationships if more than two variables are included in the model. Thus, for n number of variables, there may be up to *n-1* cointegrating vectors governing the joint evolution of all the variables. In a model, given a set of *Y* variables (where $Y \geq 2$) that are assumed I(1) but cointegrated, a VAR with *k* lags of these variables can be specified as:

$$Y_t = \beta_1 Y_{t-1} + \beta_1 Y_{t-2} + \cdots + \beta_k Y_{t-k} + \mu_t \quad (5)$$

Where Y_t is non-stationary vector I(1), β_k are different matrices of coefficients and μ_t is a vector of innovations. To use the Johansen test, the VAR in (5) above can be rewritten as:

$$\Delta Y_t = \Pi Y_{t-k} + \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + \cdots + \Gamma_{k-1} \Delta Y_{t-(k-1)} + \mu_t \quad (6)$$

where $\Pi = \left(\sum_{i=1}^{k} \beta_i\right) - I_g$ and $\boldsymbol{\Gamma}_i = \left(\sum_{j=1}^{i} \beta_j\right) - I_g$. The test for cointegration in the variables in equation (6) is based on the rank of the Π matrix via its eigenvalues. If the variables are not cointegrated, the rank of Π will not be significantly different from zero. This study uses the maximum eigenvalue test statistic in equation (7) to test for cointegration under the Johansen approach:

$$\lambda_{max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \quad (7)$$

Where r is the number of cointegrating vectors under the null hypothesis and $\hat{\lambda}_1$ is the estimated value for the i^{th} ordered eigenvalue from the Π matrix. Based on the λ_{max}, a null hypothesis that the number of cointegrating vectors is r against an alternative of r+1 is tested. If the test statistic is greater than the critical value from Johansen's tables, the null hypothesis that there are no 'r' cointegrating vectors is rejected in favour of the alternative.

4.3.1 Gregory-Hansen (1996) Cointegration Test with Structural Breaks

As noted by Harris and Sollis (2003), the Engle and Granger (1987) approach to testing for cointegration tends to under-reject the null of no cointegration if there is a cointegration relationship that has changed at some (unknown) time during the sample period, implying low power. In view of the possibility of structural breaks in the included variables, the Gregory and Hansen (1996) residual based test for cointegration with regime shifts is employed. This is an extension of the Engle and Granger (1987) approach and it involves testing the null hypothesis of no cointegration against an alternative of cointegration with a single regime shift in an unknown date based on extensions of the traditional *ADF-*, Z_α and Z_t – test types. Gregory and Hansen developed four different models to test for cointegration with structural beaks. These are models of: (i) level shift, C (GH-1); (ii) level shift with trend, C/T (GH-2); (iii) intercept and slope shifts, C/S (GH-3); and (iv) intercept, slope and trend shifts, C/S/T (GH-4) and specified respectively as[10]:

$$y_t = \alpha_1 + \alpha_2 D_t + \delta X_t + \mu_t \qquad (8)$$

$$y_t = \alpha_1 + \alpha_2 D_t + \varphi t + \delta X_t + \mu_t \qquad (9)$$

$$y_t = \alpha_1 + \alpha_2 D_t + \delta_1 X_t + \delta_2 X_t D_t + \mu_t \qquad (10)$$

$$y_t = \alpha_1 + \alpha_2 D_t + \varphi t + \delta_1 X_t + \delta_2 X_t D_t + \mu_t \qquad (11)$$

Where y_t is a scaler variable, x_t is a vector of covariates, t is a time trend, parameters α_1 and $\alpha_2$are the respective intercept terms before and after the break, φ is the coefficient for time trend, $\delta_1$and δ_2 are the respective coefficients of the independent variables before and after the structural break and u_t is the disturbance term. The variables y_t and x_t are expected to be *I(1)* while μ_t should be *I(0)*. D_t is a dummy variable of the form:

$$D_t = \begin{cases} 0, if\ t \leq [T\tau] \\ 1, if\ t > [T\tau] \end{cases} \qquad (12)$$

Where the unknown relative timing of the break date is denoted as $\tau \in J$ and [:] denotes the integer part operator. The trimming region, J, may be any compact set of (0; 1). Since the change point or its date are unknown, the test for cointegration within this framework involves computing the usual statistics for all possible break points $\tau \in J$ and then selecting the smallest

[10] Due to software limitations, only equations (8) – (10) were estimated.

value obtained, since it will potentially present greater evidence against the null hypothesis of no cointegration. In this regard, the relevant statistics are the GH-ADF (τ), GH-$Z_\alpha(\tau)$ and GH-$Z_t(\tau)$, which are respectively represented as:

$$GH - ADF = \inf_{\tau \in J} ADF, \qquad (13)$$

$$GH - Z_\alpha = \inf_{\tau \in J} Z_\alpha, \qquad (14)$$

$$GH - Z_t = \inf_{\tau \in J} Z_t. \qquad (15)$$

The results of these tests will be used to corroborate the findings of the Johansen (1998) cointegration tests and detect the possible structural dates.

4.5 Error Correction Model

The third step involves estimating the cointegrating equation. Following Edwards (1989), MacDonald (1997), Clark and MacDonald (1998), it is now well admitted that, the dynamism of the real exchange rate arises from movements over time of the macroeconomic variables called "fundamentals". Thus, the Behavioral Equilibrium Exchange Rate (BEER) approach enunciated by MacDonald (1997) and Clark & MacDonald (1998) is extended by relating relevant fundamentals to the RER while also controlling for structural breaks in the cointegrating relationship. Drawing from Omotosho and Wambai (2012), the study selected seven economic variables to capture both transitory and structural movements in naira real exchange rate RER from 2000:Q1 to 2011:Q2. These are degree of openness to capture trade policy (DOO), relative productivity to capture Balassa-Samuelson effect (PRO), terms of trade to capture international price shocks (TOT), capital inflow (FDI), nominal exchange rate as an indicator of exchange rate policy (NER), total government expenditure to capture federal government fiscal stance (TGE) and interest rate differential (IRD). In its basic form, the Naira equilibrium real exchange rate model to be estimated is of the form[11]:

$$LRER_t = \alpha_0 - \beta_1 LTGE_t - \beta_2 LPRO_t + \beta_3 LNER_t - \beta_4 LIRD_t - \beta_5 LFDI_t + \beta_6 LDOO_t + \beta_7 LTOT_t + \varepsilon_t \qquad (16)$$

[11] To conserve space, no theoretical discussions on the relationship between real exchange rate and the included fundamentals are presented here. A treatment of this issue can be found in Omotosho and Wambai (2012). However, all the variables were converted to logs and the estimated parameters are interpreted as elasticities.

where LRER is the log of real exchange rate, LDOO is the log of degree of openness, LPRO is log of productivity, LTOT is log of terms of trade, LFDI is log of capital inflow, LNER is log of nominal exchange rate, LTGE is log of total government expenditure, LIRD is log of interest rate differential (LIRD) and ε_t is the random error. Equation 16 is estimated within the framework of the theory of cointegration and error correction model. This concept provides a framework for testing for and estimating long run (equilibrium) relationships among economic variables.

The inferred Gregory and Hansen equations for the Naira real exchange rate model are respectively specified as:

$$LRER_t = \alpha_1 + \alpha_2 D_t - \beta_1 LTGE_t - \beta_2 LPRO_t + \beta_3 LNER_t - \beta_4 LIRD_t - \beta_5 LFDI_t + \beta_6 LDOO_t + \beta_7 LTOT_t + \varepsilon_t \quad (17)$$

$$LRER_t = \alpha_1 + \alpha_2 D_t + \varphi_1 t - \beta_1 LTGE_t - \beta_2 LPRO_t + \beta_3 LNER_t - \beta_4 LIRD_t - \beta_5 LFDI_t + \beta_6 LDOO_t + \beta_7 LTOT_t + \varepsilon_t \quad (18)$$

$$LRER_t = \alpha_1 + \alpha_2 D_t + \varphi_1 t - \beta_1 LTGE_t - \beta_{11} LTGE_t D_t - \beta_2 LPRO_t - \beta_{22} LPRO_t D_t + \beta_3 LNER_t + \beta_{33} LNER_t D_t - \beta_4 LIRD_t - \beta_{44} LIRD_t D_t - \beta_5 LFDI_t - \beta_{55} LFDI_t D_t + \beta_6 LDOO_t + \beta_{66} LDOO_t D_t + \beta_7 LTOT_t + \beta_{77} LTOT_t D_t + \varepsilon_t \quad (19)$$

In order to account for possible long run endogeneities in the variables on the right hand side, the parameters in equation (16) are estimated based on the Fully Modified Ordinary Least Squares (FM-OLS) method of Phillips and Hansen (1990). In their work, Phillips and Hansen (1990) argued that even though the parameters estimated by the traditional least squares from a static regression are super consistent estimates of the cointegrating vector, they may suffer second order bias in finite samples. This is due to the fact that OLS regressions are not robust to long-run endogeneities in the regressors and it is the presence of such endogeneities that produce the bias. The FM-OLS allows for the estimation of cointegrating relations directly by modifying the traditional OLS with non-parametric corrections that take account of serial correlation caused by unit roots and system endogeneity caused by cointegration.

Following the results of the tests for unit roots, structural breaks and cointegration, we estimate an error correction model specified below:

$$\Delta Y_t = \alpha_0 + \sum_{i=0}^{s} \beta_i \, \Delta X_{t-i} + \sum_{j=1}^{q} \gamma_j \, \Delta Y_{t-j} + \rho \varepsilon_{t-1} + \mu_t \quad (20)$$

Where Δ denotes the first difference operator, $\mathcal{E}_t$ is the estimated residual from equation (2), s and q are the number of lag lengths[12], Y_t is the dependent variable (LRER) while X_t is the vector of exogenous variables (including the structural break dummies). 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.

4.6 Computation of RER Misalignment

The fourth stage of the empirical analysis relates to the computation of the equilibrium real exchange rate after which the misalignment levels are computed. Following Baffes *et al* (1997) steps for estimating the degree of real exchange rate misalignment, this section proceeds in three steps: first, the analytical model designed to identify the "fundamentals" of the real exchange rate is presented; second, the elasticity coefficient (long-run parameters, between the real exchange rate and its "fundamentals") is estimated; and third, we estimate the real exchange rate misalignment by combining the long-run parameters with a set of sustainable values for the "fundamentals" and calculate the deviations of the ERER from the actual RER.

In order to derive calibrated values of the exogenous variables, we used the Hodrick-Prescott filter with a smoothing parameter based on Ravn & Uhlig (2002) frequency rule. These calibrated values are then substituted into the cointegrating equation of stage three to obtain the medium term equilibrium RER. Finally, the percentage difference between the estimated equilibrium real exchange rates (e*) and the actual real exchange rate (e) is calculated in a time series perspective and this difference is taken to represent estimates of RER misalignment. Therefore, if:

$$e^* - e > 0 = \text{Overvaluation} \quad (22)$$

$$e^* - e < 0 = \text{Undervaluation} \quad (23)$$

$$e^* - e = 0 = \text{No Misalignment} \quad (24)$$

5.0 Results

5.1 Tests for Unit Root and Multiple Structural Breaks in the Individual Variables

Table 2 presents the results of the ADF unit root test conducted on the included variables. The results showed that all the variables are integrated of order one, implying the need to difference them once. In a second step, we search for multiple break dates in the included variables by specifying one period lags in the variables (i.e. a pure structural change AR (1) model) and

[12] We included two periods lag as suggested the VAR lag order lag order selection criteria (Final Prediction Error) and to maintain reasonable degrees of freedom

running the Bai and Perron (1998) procedure for multiple structural breaks on the coefficient of the autoregressive model. Table 3 reports the results. We found evidence for multiple structural breaks in the variables included (except degree of openness of the economy), an indication of the need to accommodate structural breaks in our modeling approach[13].

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

Variables	Levels		First Difference	
	ADF^c	ADF^{ct}	ADF^c	ADF^{ct}
LRER	-0.9876	-2.5742	-6.5929	-6.5132
LTGE	-1.9109	-2.1703	-6.5164	-6.4384
LPRO	-1.6119	-1.7734	-2.8192	-3.0884
LNER	-1.5260	-1.9052	-5.4876	-5.4398
LIRD	-1.7888	-2.0663	-4.0889	-4.0597
LFDI	-2.3035	-2.2785	-5.6286	-5.5874
LDOO	-2.5895	-2.5650	-6.9789	-6.9095
LTOT	-2.9052	-3.4014	-11.5094	-11.3724

ADF^c and PP^c represent unit root test with constant

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

**MacKinnon (1996) critical values with constant are -3.5885 (1%), -2.9297 (5%) and -2.6031 (10%)*

**MacKinnon (1996) critical values with constant and trend are -4.1809 (1%), -3.5155 (5%) and -3.1883 (10%)*

While a measure of government size (represented by total government expenditure as a ratio of gross domestic product) and the terms of trade recorded one structural break each at 2002Q1 and 2006Q4, respectively, productivity differential and interest rate differential witnessed four structural break points (common to these two variables are the breakpoints located during the global financial crisis of 2009). Also, the real and nominal exchange rates recorded three multiple breaks each, coinciding with periods of exchange rate policy changes and the global financial crisis.

Table 3: Results of Bai-Perron Multiple Breakpoint Tests on the Included Variables

Bai-Perron Multiple Breakpoint Tests on Included Variables[1]

Variable	No. of Breaks	Break Dates
LRER	3	2003Q3, 2005Q2, 2007Q4
LNER	3	2002Q3, 2007Q3, 2009Q1
LTGE	1	2002Q1
LTOT	1	2006Q4
LPRO	4	2002Q1, 2004Q3, 2006Q2, 2009Q3
LIRD	4	2001Q3, 2003Q1, 2005Q3, 2009Q1
LFDI	2	2003Q1, 2005Q1
LDOO	0	-

[1] ***Bai-Perron tests of L+1 vs. L sequentially determined breaks***

5.2 Tests for Structural Breaks in the Long Run Model

[13] For space, detailed explanations on economic developments surrounding the break dates are skipped. Suffice to say, however, that the break dates coincided with specific developments in the domestic and global economies.

In order to further test for the presence of structural breaks in the naira real exchange rate model, equation (16) was subjected to the Bai and Perron (1998) procedure for multiple structural breaks and allowing for variations arising from exchange rate policy changes. We found evidence of significant structural breaks in the model at 2003Q2 and 2009Q3 (Table 4). The 2009Q3 break date coincides with the period of the global financial crisis.

Table 4: Result of Structural Break Test

Multiple breakpoint tests
Bai-Perron tests of L+1 vs. L sequentially determined breaks
Sample: 2000Q1 2011Q2
Breakpoint variables: LNER
Non-breakpoint variables: LTGE LPRO LIRD LFDI2 LDOO LTOT
Break test options: Trimming 0.15, Max. breaks 5, Sig. level 0.05
Break Date: 2003Q2, 2009Q3

Sequential F-statistic determined breaks: 2

Break Test	F-statistic	Scaled F-statistic	Critical Value**
0 vs. 1 *	31.97081	31.97081	8.58
1 vs. 2 *	37.02389	37.02389	10.13
2 vs. 3	8.873866	8.873866	11.14

* Significant at the 0.05 level.
** Bai-Perron (Econometric Journal, 2003) critical values.

5.3 Tests for Cointegration

Based on the maximum eigenvalue unrestricted cointegration rank test of Johansen (1998), we found at most one cointegrating vector amongst the included variables, implying a single cointegrating equation. The result is presented in Table 5.

Table 5: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.6683	48.5587	46.2314	0.0277
At most 1	0.5517	35.2979	40.0776	0.1568
At most 2	0.4874	29.4076	33.8769	0.1558
At most 3	0.3189	16.9003	27.5843	0.5885
At most 4	0.2675	13.6941	21.1316	0.3907
At most 5	0.1485	7.0717	14.2646	0.4807
At most 6	0.0304	1.3571	3.8415	0.2440

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
** denotes rejection of the hypothesis at the 0.05 level*
***MacKinnon-Haug-Michelis (1999) p-values*

5.4 Tests for Structural Breaks in the Cointegrating Relationship

Table 6 reports the results of the Gregory-Hansen cointegration test conducted on the included variables based on equations (17) - (19). The ADF* and Z_t* statistics provided evidence of cointegration with three structural break points located at 2002Q3, 2003Q2 and 2009Q3.

Table 6: Gregory-Hansen Cointegration Test with Structural Breaks

Model	ADF*	Break Date	Z_t*	Break Date	Z_α*	Break Date
GH-1 (Constant)	-6.08945	2003Q2	-6.76994	2002Q3	-45.4751	2002Q3
GH-2 (Constant and Trend)	-6.87586	2003Q2	-6.94038	2003Q2	-45.9471	2003Q2
GH-3 (Constant and Slope)	-7.09214	2003Q2	-7.57823	2002Q3	-46.7449	2002Q3

The 5 per cent critical values are -5.50, -5.50 and -58.33 for the ADF, Zt* and Z α* tests, respectively (Table 1 of Gregory and Hansen, 1996)*

As observed earlier, the 2009Q3 break date coincided with the period of the last global financial crisis while the effect of transiting from IFEM to the RDAS was captured by the break point at 2002Q3.

5.5 Long Run Estimates (including Structural Break Dummies)

Table 7 reports long run elasticities of the real exchange rate to the explanatory variables based on the model with structural break (model 2) and the model without structural break (model 1). Degree of openness (LDOO), capital inflows (LFDI2), interest rate differential (LIRD), productivity (LPRO), and government size (LTGEGDP) exerted appreciation pressures on the real exchange rate. However, nominal exchange rate (NER) and terms of trade (LTOT) confer depreciation pressures, even though the LTOT was not statistically significant. The results also showed that the 2009Q2 and 2002Q3 structural break dates were significantly identified by the data while the 2003Q2 date was significant at the 10 per cent level. The included variables were correctly signed and significant, except for the terms of trade. In model 2, the nominal exchange rate recorded the highest elasticity (0.5402) and was followed by productivity differential (0.4292).

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

Dependent Variable: LRER

Variable	Model 1 (Without Breaks)	Model 2 (With Breaks)
C	7.1880*	6.5561*
LDOO	-0.1033*	-0.0552**
LFDI2	-0.0421**	-0.0637*
LIRD	-0.0196	-0.0535**
LNER	0.3888*	0.5402*
LPRO	-0.4638*	-0.4292*
LTGEGDP	-0.1796*	-0.1339*
LTOT	0.0631	0.0006
DUM2009Q2	-	-0.0764**
DUM2003Q2	-	-0.0372***
DUM2002Q3	-	0.0447*
R-squared	0.9820	0.9872
Adjusted R-squared	0.9786	0.9835
S.E. of regression	0.0321	0.0282
Durbin-Watson stat	1.6746	1.7687

Significant at 1 %, ** Significant at 5%, *** Significant at 10%

5.6 Results of the Error Correction Model and Computed Misalignment Levels

Having incorporated the identified structural breakpoints into the long run model presented in the Table 6, the obtained residuals were used to set up appropriate error correction models. Thus, the results of the error correction model (akin to equation 21) fitted to the data are presented in Table 8. These are FMOLS estimates of the parsimonious error correction naira real exchange rate model, which incorporates the identified structural breaks (model 2) and the one without breaks (model 1). The significant determinants of Naira real exchange rate included capital inflows (LFDI2), interest rate differential (LIRD), nominal exchange rate movements (LNER), productivity differential (LPROD), government size (LTGEGDP) and degree of openness of the economy (LDOO). The variables were correctly signed, with the real exchange rate being positively elastic to nominal exchange rate and negatively less elastic to productivity differential (largely in line with Aliyu, 2011 and Omotosho & Wambai, 2012). The positive relationship between real exchange rate and government size is consistent (though with lower elasticity) with the findings of Aliyu (2011). At 86.7 per cent, the adjusted R^2 obtained was satisfactorily high and implies an improvement over the naira real exchange rate model developed by Omotosho and Wambai (2002).

The coefficient of the error correction term (ECM1) was found to be negative and significant at 1 per cent, further providing evidence of a long-run cointegrating relationship among the variables. At -0.9308, the magnitude of the error correction coefficient implied a high speed of convergence of the real exchange rate to its long run equilibrium as about 93.08 per cent of disequilibrium in the real exchange rate is corrected within a quarter (model 2 of Table 8). The speed of adjustment was found to be higher in the model incorporating identified structural break dates (0.9308) compared to the model without structural breaks (0.78).

In order to evaluate the role of exchange rate policies in restoring the real exchange rate to its long run equilibrium, the nominal exchange rate (NER) variable was excluded from the parsimonious error correction model and the coefficient of the error correction term declined to -1.21, implying an explosive model and underscoring the relevance of NER in maintaining stability in the system. This is shown in the last column of Table 8. In addition, the explanatory power of the model declined significantly from 86.7 per cent to about 76.8 per cent[14]. This underscores the role of nominal exchange rate (managed largely by the monetary authority), and by implication, the role of exchange rate policy in ensuring that the real exchange rate is in equilibrium.

Table 9 presents the results of the tests for non-normality, autocorrelation and heteroscedasticity in the residuals of the error correction model. It shows that the model was quite adequate for inference. For instance, the Jarque Bera test for normality confirmed that the obtained residuals from the cointegrating regression are normally distributed. This suggests that the economic fundamentals that affect RER in a systematic manner were largely captured.

Table 8: Results of the Error Correction Model for the Naira Real Exchange Rate (With and Without Structural Break)

Dependent Variable: D(LRER)

Variable	Model 1 (Without Breaks)	Model 2 (With Breaks)	Model 3 (LNER Exclusive)
C	-0.0163*	-0.0101*	-0.0025
D(LRER(-1))		0.1070**	0.1498**
D(LFDI2)	-0.0553*	-0.0716*	-0.0765*
D(LFDI2(-1))		0.0282**	0.0238
D(LIRD(-1))	-0.0844*	-0.0724*	-0.0406
D(LNER)	0.4797*	0.4913*	
D(LNER(-1))	0.1823*		
D(LPRO)	-0.0370	-0.1227*	-0.1669**
D(LTGEGDP)	0.0917*	0.0732*	0.0829***
D(LTGEGDP(-1))	0.0605*	0.0502**	0.0936*
D(LDOO(-1))	-0.0665*	-0.0698*	-0.1173*
D(LTOT)	0.0288***		
ECM1(-1)	***-0.7776****	***-0.9308****	***-1.2116****
R-squared	0.8452	0.8674	0.7676
Adjusted R-squared	0.7968	0.8260	0.7042
S.E. of regression	0.0197	0.0182	0.0238
Durbin-Watson stat	1.9291	2.2751	2.2976

** Significant at 1 %, ** Significant at 5%, *** Significant at 10%*

Also, the Breusch-Godfrey test for serial correlation failed to reject the null hypothesis of no autocorrelation in the errors while the white test for heteroscedasticity also failed to reject the null hypothesis of homoscedasticity in the errors.

Table 9: Model Diagnostics Results

[14] The results of the error correction model excluding the nominal exchange rate is presented in the appendix.

Test	F-statistic	P Value
Jarque-Bera (Normality)	2.8683	0.2383
Serial Correlation (Q-Stat)	3.3752	0.4970
Heteroskedasticity (Squared Residuals)	1.3598	0.8510

The computed real exchange rate misalignment levels based on the error correction model with and without the structural breaks are presented in Table 10. It showed that the Naira real exchange rate was, on the average, misaligned by about -2.75 per cent during the estimation period based on the model with structural break. This was higher than the value reported in Omotosho and Wambai (2012), which reported a real exchange rate misalignment of 0.29, albeit without accounting for structural breaks. Also, the model without structural breaks yielded a misalignment level of -2.50 per cent during the same estimation period. The results seem to suggest that models of Naira real exchange rate determination ignoring structural breaks may underestimate the extent of misalignment.

In terms of the extent of real exchange rate misalignment prevailing at periods of different exchange rate policy arrangements in the country, the study found that the naira was undervalued during the IFEM and RDAS and overvalued since the introduction of WDAS, on the average.

Table 10: Estimates of Naira Real Exchange Rate Misalignment (2000-2011)

Period	Actual RER	Equilibrium RER (With Structural Break)	*Misalignment Level* (With Structural Break)*	Equilibrium RER (Without Structural Break)	*Misalignment Level* (Without Structural Break)*
2000Q1	257.98				
2000Q2	240.50	257.98	*7.27*	257.98	*7.27*
2000Q3	240.41	240.50	*0.04*	248.36	*3.31*
2000Q4	243.49	240.41	*-1.26*	246.66	*1.30*
2001Q1	249.94	243.04	*-2.76*	243.11	*-2.73*
2001Q2	239.92	242.42	*1.04*	240.99	*0.45*
2001Q3	223.67	237.01	*5.97*	235.29	*5.20*
2001Q4	229.88	231.07	*0.52*	232.39	*1.09*
2002Q1	223.66	224.33	*0.30*	233.23	*4.28*
2002Q2	223.84	217.38	*-2.89*	223.44	*-0.18*
2002Q3	231.77	218.60	*-5.68*	221.44	*-4.46*
2002Q4	236.64	234.44	*-0.93*	232.95	*-1.56*
2003Q1	240.86	240.19	*-0.28*	229.42	*-4.75*
2003Q2	218.66	232.49	*6.33*	219.95	*0.59*
2003Q3	204.52	209.16	*2.27*	214.71	*4.98*
2003Q4	206.71	207.56	*0.41*	207.40	*0.33*
2004Q1	212.85	211.27	*-0.74*	210.64	*-1.04*
2004Q2	205.59	209.39	*1.85*	210.69	*2.48*
2004Q3	199.66	205.17	*2.76*	206.80	*3.57*
2004Q4	191.72	193.96	*1.17*	196.47	*2.48*
2005Q1	185.33	183.52	*-0.97*	185.35	*0.01*
2005Q2	178.17	175.66	*-1.41*	174.08	*-2.29*
2005Q3	166.10	171.34	*3.16*	169.58	*2.10*
2005Q4	175.22	166.96	*-4.71*	166.19	*-5.16*
2006Q1	167.16	165.59	*-0.94*	164.69	*-1.48*
2006Q2	165.17	166.31	*0.69*	167.51	*1.42*
2006Q3	156.70	163.77	*4.51*	162.19	*3.50*
2006Q4	161.65	159.36	*-1.42*	159.92	*-1.07*
2007Q1	161.05	156.12	*-3.06*	157.58	*-2.15*
2007Q2	158.30	156.89	*-0.89*	157.70	*-0.38*
2007Q3	151.95	154.22	*1.49*	155.66	*2.44*
2007Q4	148.61	149.45	*0.57*	150.96	*1.58*
2008Q1	143.18	142.82	*-0.25*	142.21	*-0.68*
2008Q2	136.13	136.89	*0.56*	137.23	*0.81*
2008Q3	131.69	132.51	*0.62*	129.93	*-1.33*
2008Q4	130.99	131.13	*0.11*	130.22	*-0.59*
2009Q1	155.73	139.95	*-10.13*	136.16	*-12.57*
2009Q2	151.74	157.57	*3.85*	156.66	*3.24*
2009Q3	150.42	154.76	*2.89*	153.37	*1.96*
2009Q4	145.00	145.48	*0.33*	149.53	*3.12*
2010Q1	141.73	137.94	*-2.67*	145.36	*2.56*
2010Q2	137.46	139.36	*1.38*	140.44	*2.17*
2010Q3	133.49	134.96	*1.10*	137.88	*3.29*
2010Q4	131.92	130.22	*-1.29*	128.61	*-2.51*
2011Q1	130.15	130.15	*0.00*	128.98	*-0.90*
2011Q2	132.68	137.47	*3.61*	137.48	*3.62*
Period Ave.	***183.70***	***178.65***	***-2.75***	***179.10***	***-2.50***

**** A positive value signifies an overvaluation while a negative value signifies an undervaluation.***

6.0 Conclusion and Policy Recommendation

This study revisited the issue of real exchange rate determination in Nigeria over the period 2000–2011 by extending the Behavioural Equilibrium Exchange Rate (BEER) approach by incorporating structural breaks in the specified naira real exchange rate model. Based on the results presented in section 5, the following conclusions are drawn. Firstly, the Bai and Perron

(1998) and Gregory-Hansen (1996) procedures identified three distinct endogenously determined structural break points located at 2002Q3, 2003Q2 and 2009Q2. These break points coincide with the periods of exchange rate policy changes and global financial crisis. Accounting for the identified structural breaks, an error correction model was set up to capture both the short and long run relationships between naira real exchange rate and its determinants. Secondly, model results showed that capital inflows (LFDI2), interest rate differential (LIRD), nominal exchange rate (LNER), productivity (LPRO), government size (LTGEGDP) and degree of openness (LDOO) were the major determinants of real exchange rate during the estimation period. Overall, the estimated error correction model explained 86.7 per cent of variations in the naira real exchange rate.

Thirdly, on the average, the parsimonious model (with structural break) indicated that the naira real exchange rate was broadly in line with relevant economic fundamentals as the level of misalignment stood at 0.22 per cent. However, the model without structural breaks showed that the naira was misaligned by 0.29 per cent during the comparable period. This study therefore concludes that failure to account for structural breaks while modeling naira equilibrium real exchange rate leads to an overestimation of the misalignment level. This is consistent with the views of Aggarwal (1999), Andreou (2002) and Zainudin and Shaharudin (2011) who argued that ignoring structural breaks when they do exist leads to model misspecification. The parameter estimates are biased, thus leading to error in estimation and forecasts.

Fourthly, the sensitivity of the naira real exchange rate model to changes in exchange rate policy (as represented by movements in the nominal exchange rate) was tested by excluding the nominal exchange rate variable from the parsimonious error correction model. The results showed that exchange rate policies play a vital role in restoring the real exchange rate to its long run equilibrium following any shock. This was indicated by the deterioration in the explanatory power and speed of adjustment of the error correction model as a result of the exclusion of the nominal exchange rate variable.

Fifthly, even though the primary objective of this study was not to appraise the country's various exchange rate policies over time, it provided some insights as to how realistic the naira real exchange rate values were during the estimation period. Results based on the model with structural breaks revealed that the average misalignment levels during the periods of IFEM, RDAS and WDAS stood at -1.3, -0.1 and 0.1 per cent, respectively. Thus, the naira was undervalued during the IFEM and RDAS and overvalued during the WDAS regime. For instance, the actual real exchange rate averaged N146. 50/US$ during the WDAS period. This underscores the role of nominal exchange rate (managed largely by the monetary authority), and by implication, the role of exchange rate policy in ensuring that the real exchange rate is in equilibrium.

In view of the consequences of persistent real exchange rate misalignments on the economy and the role of exchange rate policy in restoring equilibrium following a shock, this study recommends that the current exchange rate determination arrangement (WDAS) should be retained. Also, in order to obtain realistic estimates of Naira equilibrium RER, the study strongly suggest that authors, researchers and policy economists should always endeavor to test for and accommodate possible structural breaks in their empirical models of real exchange rate determination.

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