Systemic Estimation of Monetary Variables, Oil Price and Naira Real Exchange Rate Dynamics

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Abstract
This paper estimates Naira real exchange rate equilibrium viz-a-viz the US Dollar and its determinants by examining the existence of a significant long –run relationship between exchange rate, money (M2) supply, interest rate differentials and external reserves on high frequency data series over a 4-year period from 2008-2011. Vector Error Correction model was used to generate threshold for misalignment of exchange rate in this study. Empirical findings reveal that a rise in oil price leads to a real appreciation of the Naira, while M2 growth and rise in real interest rate differentials undermine real Naira/Dollar rate.
Keywords: Real exchange rate, exchange rate misalignment, currency overvaluation, co-integration, unit roots test, vector error correction, the Balassa-Samuelson effect and causation tree.
JEL Classification: A10, B22, C01, C32, F31

1.0 Introduction

The attainment of exchange rate equilibrium remains one of the core objectives of macroeconomic theory. The other goals: price stability, full employment and balance of payment equilibrium, often have conflicting outcomes among each other. Historically, marked fluctuations in exchange rate continues to be a major source of concern to resident economic agents including those in the academic, business and government.

Exchange rate performs dual role of maintaining international competitiveness and serving as nominal anchor for domestic prices. Hence, effective research on behavior of exchange rate in both the short and long term becomes essential not just because it is the price for international transactions, but more also its role as a medium of clearance for most macroeconomic structural parameters. These are terms of trade, assessing competitiveness, net foreign assets, balance of trade, and capital market depth and also it's imperative for the conduct of monetary policy.

Literally, exchange rates are prices at which currencies trade for each other and can be classified into nominal and real exchange rates. While nominal exchange rate measures the relative price of two currencies – say Naira and US Dollar, real exchange rate captures the relative price of two goods – tradable goods in relation to non-tradable goods. It should aptly be pointed out that changes in nominal exchange rates (appreciation/depreciation) would have same directional impact on the real exchange rate.

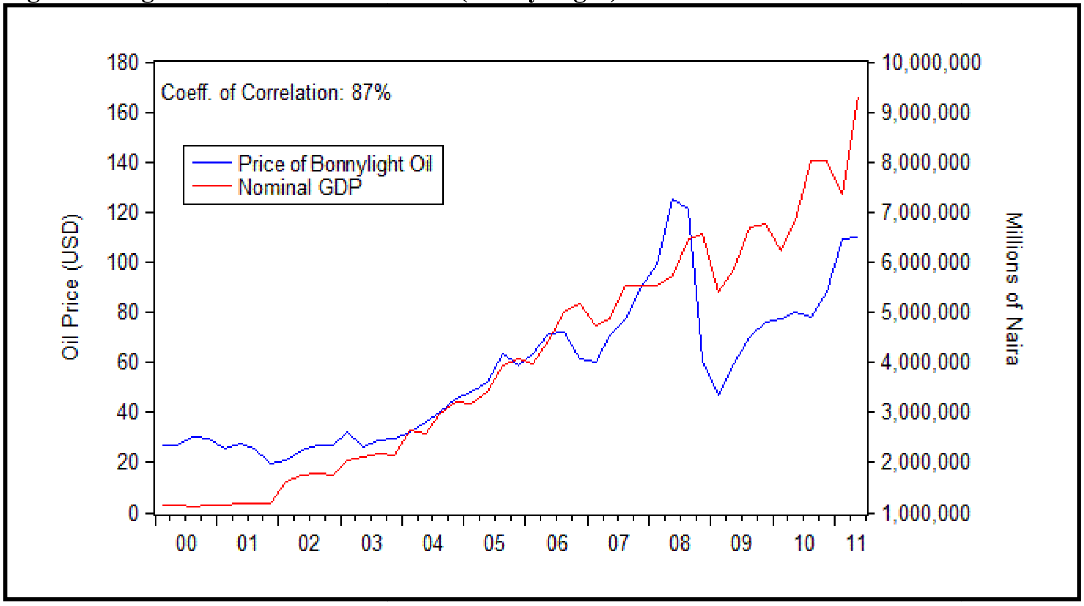
Historically, the Nigerian economy has had its footing on two sectors (Agriculture and Petroleum Industry) with each having commanding height at various times as the mainstay of the economy. It follows now that government activities will almost grind to a halt if oil money is not available to it. The dominance of crude oil as the main source of foreign exchange earners has made Nigeria a frightfully open mono-cultural economy whose fate is extremely tied to the development in the oil sector.

In line, related research in economics have posited that oil exporting countries, on the average, face more volatility in their current accounts and fiscal positions compared to non-oil producing countries. It was observed that there exist a strong positive correlation between Nigeria's nominal GDP growth and crude (bonny light) oil price.

The relationship shows that increases in international oil price would result in a phenomenal rise in the size of the country's domestic GDP. Today, oil revenue accounts for more than 80% of the country's foreign exchange earnings. When oil revenue fell as they did dramatically in Nigeria between 1980 and 1986, the economy was left with an unsustainable import and capital intensive production structure.

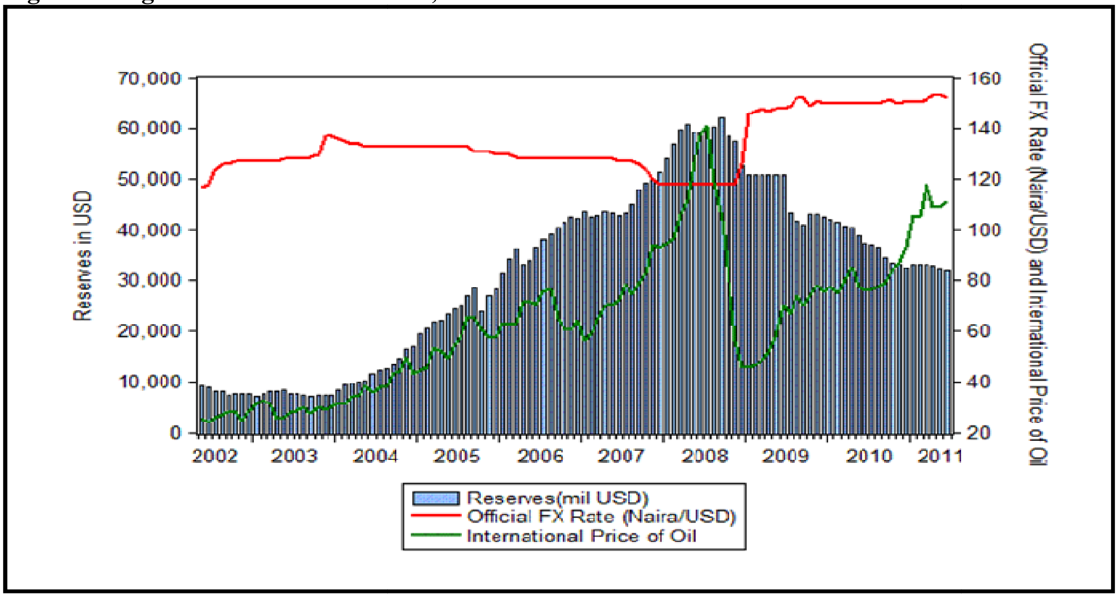
Furthermore, as depicted in figure 2, an upward trend in oil price influences positively accretion to Nigeria's foreign (external) reserves, while the converse holds during period of massive output glut or downturn in global economic environment. We know that external reserves acts as a buffer to support currency during times of massive capital outflow, from the schema, at the start of the full recovery in the oil market, prices of oil rose precipitously by about 46.3% to $120 per barrel between end-2008 and 2011. Albeit the remarkable rise, external reserves position continues to dwindle. The divergence may have been due to the exchange rate strategy (managed float system) adopted by the monetary authority during the period, amongst other reasons.

Figure 1: Nigeria's GDP and Crude Oil (Bonny Light) Price



Source: Authors' Computation

Figure 2: Nigeria's External Reserves, Oil Price and Official FX Rate



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In their extensive work, Coudert and Couharde (2007) observed that pegged exchange rates are often more prone to risk of overvaluation, because their real exchange rates have a tendency to appreciate. They estimated real equilibrium exchange rates using methodology of currency misalignments that took into account a Balassa-Samuelson effect and the impact of net foreign assets. They concluded that pegged currencies are prone to been overvalued than currencies that were allowed to float. In line, Calvo and Reinhart (2002) reported that adopting floating exchange rates regime often amplify shocks in emerging economies and never help to cushion weakness in currency in times of volatility.

Obadan (2001) listed some factors which led to the depreciation of the Naira in late 1990s as import-dependent production structure, fragile export base and fiscal imbalance. Other factors are sluggish capital inflow, excess demand for foreign exchange, round tripping by FX dealers as well as weak balance of payment position. Using the generalized autoregressive conditional heteroskedasticity model (GARCH), Mordi (2006) confirmed the high volatility of the Naira exchange rate between 1994 and 1998, covering the periods of marked regulation and guided-deregulation introduced in 1995 in Nigeria.

This study attempts to explain the impact of selected macroeconomic variables on exchange rate dynamics by employing econometric techniques of Vector Error Correction Model to estimate the Naira/USD real exchange rate equilibrium (RERe). The co-integration technique is used to establish the existence of a long run relationship between RER and its determinants. RERe time series trend will then be derived from the estimated RER model. Following this, we attempt to capture misalignment in exchange rate will be ascertained by comparing the estimated RER with the RER data in levels. Against the backdrop, this study seeks to examine the influence of macroeconomic factors on the management of the country's exchange rate.

Following this introduction, section two is a review of related literatures on exchange rate management in Nigeria, while section three houses the theoretical framework, followed by model specification and implemented methodology. Implication of results for policy as well as conclusion will be discussed in the last section.

2.0 Review of Related Literature on Exchange Rate

Interestingly, attention to effective exchange rate management has remained central in global economics and more for developing economies been that their currencies are highly dependent on proceeds from the export of narrow inelastic commodities. Ever since oil (and other natural resources) made an unexpected intrusion into these economies, it has been seen as a major abiding irony. These non-tradable commodities have overthrown the tradable commodities which is a more stable FX source like agricultural produce and thus often resulting in currency crises in these countries. This is the so-called Dutch Disease syndrome. The Dutch disease is an economic phenomenon that affects countries upon the discovery, extraction and exportation of large amounts of natural resources (Stoke, 2005). This poses problems for monetary and fiscal policy coordination and for exchange rate management.

Hence, assessing and estimating exchange rate model of resource rich countries is a popular discussion among scholars on the back of volatility in prices of these commodities at the international market. Oil exporting countries, like Nigeria, tied their currency to the US Dollar and in consequence, witnessed a one-to-one effect of oil price movements on their domestic currency due extensively to the monetization of proceeds, fluctuation in oil price at the international market. This makes these currencies extricably determined by factors outside monetary authorities' control. This more than often causes divergence in both nominal and real exchange rates.

Dornbusch (1976) addressed shortcomings of Mundell (1964) and Flemming (1962) model in his capital mobility concept of an open economy. He focused on short and long run determinants of exchange rates. Edwards (1988) revisited Balassa (1964) and Samuelson (1964) models and highlighted other real determinants of the real exchange rate (RER) and hence redefined the concept of equilibrium in theory of international economy. Researches on the impact and significance of monetary variables on exchange rates policies is seen in Meese and Rogoff (1988), Froot and Rogoff (1994) and Clarida and Gali (1994). Till date, there is no agreement by researchers on the magnitude of distortion/swings that can affect the RER.

Zalduendo (2006) adopted a Vector Error Correction (VEC) model in explaining the effects of oil prices on factors underlying the equilibrium real exchange rate using time series data for Venezuela. He contended that crude oil price plays a significant role in determining the equilibrium exchange rate. The correlation coefficient was also found to be highly positive.

Lee et al (2008) considered productivity differentials, external (BOP) imbalances and terms of trade as part of their explanatory variables using a panel co-integrating analysis for 48 countries. He discovered that foreign assets and government consumption are important determinants of the real exchange rates across the sampled countries.

Balvers and Bergstrand (2002) contended that government expenditure (financed by lump-sum taxes) influences real exchange rates potentially via a resource-withdrawal channel and a consumption-tilting channel. They estimated exchange rate using structural equations derived a 2-country general equilibrium model and the theoretical relationships among the real exchange rate, relative private consumption, relative government consumption, and tradables and non-tradables production. The result suggests that government expenditure influence real exchange rates approximately equally via the resource-withdrawal and consumption-tilting channels and that government and private consumption are complements in utility.

Rogoff (1996) reported mixed empirical results to support Balassa-Samuelson effect on real exchange rates. Edison and Melick (1999) could not identify any co-integrating relationship between real exchange rates and differentials in real interest rate. Most empirical work on open economy has focused on the role of nominal price distortions and effects of exchange rate misalignment on relative price of goods (Benigno and Benigno (2003), Clarida, Gali and Gertler (2002), Devereux and Engel (2003), Corsetti and Pesenti (2005) and Gali and Monacelli (2005)). Devereux and Engel (2006, 2007) discussed the implications for monetary policy of misalignments that arise from dual role of the exchange rate in goods and asset markets.

3.0 Theoretical Framework

Generally, the prices of non-tradable goods rise faster than that of the tradable goods due mainly to the relatively higher productive rate. The output growth often exceeds that of the tradable goods[1].

The following assumptions have huge imperative for ascertaining whether there exist misalignment between the Naira and U.S. Dollar real exchange rate during the sample period. The peculiar structural composition of the Nigerian economy is also taken into cognizance in the analysis. The assumptions include:

1) There are two countries with tradable and non-tradable goods, amidst a respective competitive labour market. Hence, the reward to factors (capital and labour) is the same as their marginal productivities.
2) Non tradable goods sector have higher relative productivity with smaller gestation time.
3) There is perfect mobility of workers between both tradable and non-tradable sectors.
4) Purchasing power parity is valid only for tradable goods and not for prices of non-tradable goods across both countries.
5) The tradable and non tradable production functions are of the form:

$$Y_{tradables} = A_{tradables} f(K_{tradables}, L_{tradables}) \qquad (1)$$

$$Y_{non\text{-}tradables} = A_{non\text{-}tradables} f(K_{non\text{-}tradables}, L_{non\text{-}tradables}) \qquad (2)$$

Again both production functions satisfy the following conditions:

a) Constant return to scale (CRS) assumption (see box 1);
b) Positive and diminishing returns to private inputs (see box 1);
c) Inada Condition: the Inada presents the limit of the first derivatives of $f(*)$ with respect to both inputs. It follows that as size of inputs increases so will marginal product tends towards zero. This succinctly explains the limiting behavior of input variations in both sectors. The inada condition is summarized (see appendix 4).

3.1 Analysis of the model:

The similarities of the production functions in equation (1) and (2) make it possible for the representation of the production function in its intensive form:

$$y_i = A_i \; f(k_i) \qquad (3)^2$$

Where i is the number of goods and services considered in the model - the tradable and non-tradable

$$\frac{dY_i}{dK_i} = A_i \; f'(k_i) \qquad (4)^3$$

$$\frac{dY_i}{dL} = A_i \; [\, f(k_i) - f'(k_i)k_i \,] \qquad (5)$$

Equations (4) and (5) suggest that the marginal productivities of inputs, capital (K) and labour (L), equals the product of their rewards and the technical knowledge, A_i. Having specified the reward of inputs, the following expression presents the profit maximization in the form of:

$$\pi = \sum_{t}^{\infty} \frac{1}{(1+r)^t} [P_i * Y_i - C_i] \qquad (6)$$

Equation (6) is the profit/value function of the economy over its lifetime; $\frac{1}{(1+r)^t}$ is the discount expression

[1] The pioneers of the development of the tradable and non-tradable goods model were James Meade, Salter W.E and Swan T., in their write up titled, "The Price Adjustment and the Australian Balance of Payments," Economic Record, November 1956; and "Internal and External Balance: The Role of Prices and Expenditure Effects", Economic Record, August 1959.

[2] From equation (1) the output-labour ratio is achieved by deflating the production function by labour inputs, $Y_i = A_i \; f(K_i, L_i)$; the output-labour ratio is of the form $\frac{Y_i}{L_i} = A_i \; f(\frac{K_i}{L_i}, 1)$; thus the reduced or intensive form of the production function defines the output in its intensive form as a function of the technical knowledge, A_i, and the capital stock per unit of labour or the capital stock in its intensive form, k_i, $y_i = A_i \; f(k_i)$.

[3] Differentiating the production function (intensive form) using the function of a function procedure $\frac{dy}{dx} = \frac{dy}{du} * \frac{du}{dx}$ see "Fundamental methods of mathematical economics" by Alpha C. Chiang for further worked examples on chain rule (function of a function) and its application.

with r denoting the discount factor, P_i is the prices of goods and services, Y_i is the corresponding output of goods and services. Hence, $P_i * Y_i$ is the revenue equation of the firm and C_i is the cost function which depends on the cost expended on both factor inputs, capital (K) and labour (L)[1].
The profit function can be re-written as:

$$\pi = \sum_{t=1}^{\infty} \frac{1}{(1+r)^t} \{P_i * A_i\, f(k_i) - w_1 K - w_2 L\} \qquad (7)$$

In equation (7), w_1 is the rental price of capital and w_2 is the wage of workers, hence, as activities of the firm move towards the long run (close to infinity) capital holdings or value of capital is equal to zero. This is the transversality condition for investment.
Following this assumption we can rewrite equations (4) and (5) as follows:

$$\frac{d\pi}{dK} = P_i * A_i\, f'(k_i) - w_1 \quad = 0$$

$$w_1 = P_i * A_i\, f'(k_i) \qquad (8)$$

Similarly,

$$w_2 \quad = P_i * A_i\, \{f(k_i) - f'(k_i)k_i\} \qquad (8')$$

By convention, it follows that the prices of factor inputs can be classified according to the array of broad categories of commodities produced in economy namely tradable and non-tradable goods/services. The input prices in the tradable goods sector can be of the form:

$$w_{1(tradables)} = P_I * A_I\, f'(k_I)$$

$$w_{2(tradables)} \quad = P_I * A_I\, \{f(k_I) - f'(k_I)k_I\}$$

The non-tradable goods sector is as follows:

$$w_{1(non-tradables)} = P_J * A_J\, f'(k_J)$$

$$w_{2(non-tradables)} \quad = P_J * A_J\, \{f(k_J) - f'(k_J)k_J\}$$

Furthermore, a geometric average for respective prices in both domestic and international trade was assumed, with θ and $(1-\theta)$ assigned as weights for both tradable and non-tradable goods.
The domestic and international prices can be rewritten as follows:

$$P_d \quad = P^{\theta}_{d(tradables)} * P^{(1-\theta)}_{d(non-tradables)} \qquad (9)$$

$$P_f \quad = P^{\theta}_{f(tradables)} * P^{(1-\theta)}_{f(non-tradables)} \qquad (10)$$

Where P_d stands for domestic prices of goods and services and P_f represents the foreign prices of goods and services. Following the assumption of perfect mobility of labour in both tradable and non-tradable productive sectors, equating the prices of goods and services in both sectors becomes feasible. Thus;

$$P_d \quad = (1)^{\theta} * P^{(1-\theta)}_{d(non-tradables)} = P^{(1-\theta)}_{d(non-tradables)}$$

$$P_f \quad = (1)^{\theta} * P^{(1-\theta)}_{f(non-tradables)} = P^{(1-\theta)}_{f(non-tradables)}$$

$$P_{d(tradables)} * A_{d(tradables)}[f(k_i) - f'(k_i)k_i] = \delta = P_{d(non-tradables)} * A_{d(non-tradables)}[f(k_i) - f'(k_i)k_i]$$

$$P_{f(tradables)} * A_{f(tradables)}[f(k_j) - f'(k_j)k_j] = \delta = P_{f(non-tradables)} * A_{f(non-tradables)}[f(k_j) - f'(k_j)k_j]$$

Similarly;

$$P_{d(non-tradables)} = \frac{A_{d(tradables)}[f(k_i) - f'(k_i)k_i]}{A_{d(non-tradables)}[f(k_i) - f'(k_i)k_i]} \qquad (11)$$

[1] The cost equation is the sum of all expenses incurred on the recruitment of factor inputs for the creation of output, that is, $C_i = f(Q_i)$, for simplicity, economists specifies the cost equation in this form; $C_i = w_1 K + w_2 L$ where w_1 and w_2 represent the input prices respectively.

$$P_{f(non-tradables)} = \frac{A_{f(tradables)}[f(k_j) - f'(k_j)k_j]}{A_{f(non-tradables)}[f(k_j) - f'(k_j)k_j]} \tag{12}$$

Using the purchasing power parity assumption in the tradable goods market, the real exchange rate (RER) can be defined as:

$$RER = \beta_k * \left(NER * \left(\frac{P_f}{P_d} \right) \right) \tag{13}$$

Where RER and NER are the exchange rate in real and nominal terms respectively, assuming that NER is approximately unity equation (13) therefore becomes;

$$RER = \beta_k * \left(\frac{P_f}{P_d} \right) \tag{14}$$

Substituting equations (11) and (12) in (14) it follows that the RER becomes:

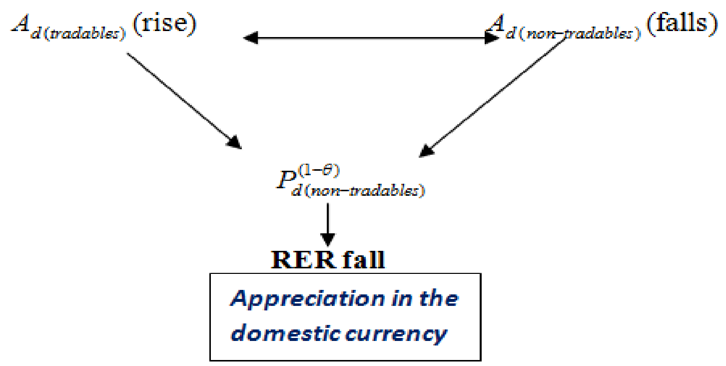
$$RER = \beta_k * \left(\frac{\dfrac{A_{f(tradables)}[f(k_j) - f'(k_j)k_j]}{A_{f(non-tradables)}[f(k_j) - f'(k_j)k_j]}}{\dfrac{A_{d(tradables)}[f(k_i) - f'(k_i)k_i]}{A_{d(non-tradables)}[f(k_i) - f'(k_i)k_i]}} \right)^{1-\theta} = \beta_k * \Re_k \tag{15}$$

Equation (15) depicts the Balassa-Samuelson effect; where $0 \leq \theta \leq 1$. The Balassa-Samuelson effect contended that a rise in productivity of non-tradable goods relative to tradable goods often buoys the domestic economy. The resultant effect is a decrease in RER, and as RER declines, nominal exchange rate falls leading to an appreciation of the domestic currency. In other words, the home country witnesses an appreciation in its currency relative to other foreign currency baskets.

3.2 Theoretical Causation of the Balassa-Samuelson Effect

An increase in technological progress and technical knowledge of foreign tradable goods and services, results in a rise in the foreign prices of non-tradable goods and services which in turn leads to the rise in the RER position and automatically generates depreciation in the domestic currency. Similarly, the same result emerges when technical knowledge level declines for foreign tradable goods. This causes the prices of foreign non tradable to rise simultaneously which lead to a fall in the RER value and by implication an appreciation in the domestic currency. Presenting this description with flow chart, it then follows that:

Figure 3: Causation Tree of the Balassa-Samuelson (B-S) effect



3.3 Justification of Data Inclusion

Real exchange rate misalignment is the difference between the estimated real and actual exchange rate. The paper shall consider the following data set for the calculation of the estimated real exchange rate. Variable selection was inferred from literature, country specific characteristics, as well as the unique nature of the Nigerian economic transmission mechanism. These include oil prices, productivity, fiscal spending, foreign reserves, and broad money supply and interest rate differentials with major trading partners particularly the United Sates.

I. **Oil prices:** Movement in oil price at the international market **is** positively related to Nigeria's GDP (see appendix 1). For this study, oil price would serve as a proxy for Nigeria's term of trade. The choice was due to the sole dependency on oil trade for bulk of the country's foreign exchange source. Oil export continues to account for over 80% of the county's total export basket and by extension Nigeria's term of trade.

II. **Productivity:** Higher oil output is also seen as determinant of equilibrium exchange rate. According to the Balassa-Samuelson effect, an increase in the wages of the non–tradable sector due to rise in production would limit amount of resources devoted to the tradable industry. Remotely, a higher tradable sector output can have result in the strengthening of oil-exporter's currency.

III. **Direction of Fiscal Spending:** Growth theorist postulated that a rise in government spending on the non-tradable sub-sector will on the long run guarantee a stable domestic currency. This is against the expectation of boost in capacity utilization and exports. This is often seen as a more stable source of foreign exchange. We expect this impact to be negative as over 60% is often allocated for recurrent expenditure each year.

IV. **Foreign Reserves:** External reserves have close connection with exchange rate determination. Economic theory postulates that increases in demand for foreign currency amidst slower accretion to external reserves invariably results in depreciation of the local currency.

V. **Money Supply:** For this analysis, broad money (M2) will be used. An increase in money supply raises the chance for speculative activity at the interbank market. These attacks, if wide-spread, might undermine currency equilibrium in the process.

VI. **Interest Rate Differentials:** Real interest rate differential between Nigeria and major trading partners have influence on real Naira exchange rate. Existing research has established positive relationship between the real exchange rate and real interest rate. It is expected that an increase in the real interest rate will lead to an appreciation of local exchange rate**,** via carry trade dynamics.

4.0 Methodology

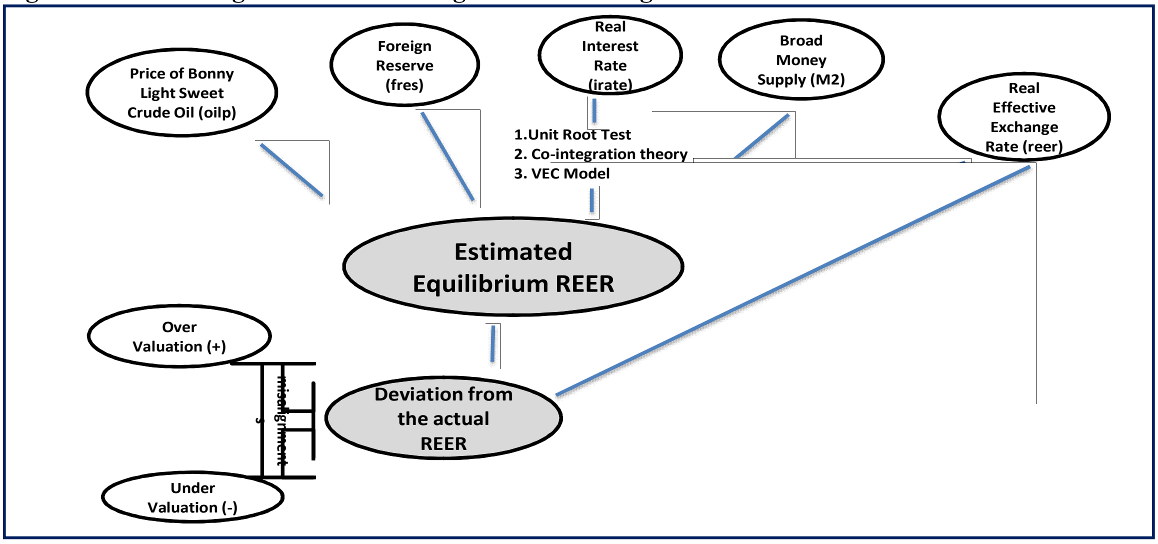
The premium between the official exchange rate and that of the parallel market remains noticeable, despite measures adopted by the Nigerian apex bank to narrow the arbitrage premium. Amongst such measures to achieve convergence was the CBN's 2-way quote arrangement to increase the supply of foreign exchange to satisfy eligible demand and by extension conserve the dwindling external reserves. The aim is to attain a realistic exchange rate for the Naira.

Mordi (2006) contended that analysis of Nigeria's exchange rate movement from 1970 to 2005 showed that there exists a causal relationship between movement in exchange rate and macroeconomic aggregates namely inflation, fiscal deficit/GDP ratio and GDP growth. Lack of depth at both the interbank and parallel market could induce speculative attack as a result of FX scarcity due to increases in demand.

Short term distortion in demand and supply dynamics often has a far-reaching impact on exchange rate movement. The weak manufacturing base also has a widespread impact on stability of the exchange rate and its contribution to the pool of foreign exchange resources is negligible. This is due to the inherent structural weakness of the economy. Hence, estimating real equilibrium exchange rate is a major thrust of this paper.

Co-integration techniques will be employed to generate estimated real exchange rate time series for the selected determinants of Naira's exchange rate. The model was specified in real form with chosen variables required to pass our fundamental criteria of high frequency (monthly data). Nigeria's brand of crude oil bonny light prices would be introduced as determinant, alongside, external reserves, broad money M2 and interest rate differentials. Two variables were not high frequency data and hence dropped – namely productivity differentials and fiscal spending. Time series techniques would be extensively used, unit root test for stationarity of variables, co-integration and the vector error correction (VEC) model would be employed to test the joint hypothesis of both the rank order and the deterministic properties the variables. The flow chart below is a schema of the interaction among different methodologies.

Figure 4: The Linkage Between Exchange Rate Modeling and Estimation



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4.0 Empirical Results

4.1 Unit Root Test

This paper employed the Augmented Dickey Fuller (ADF) method for stationarity testing. The result is reported in Table 1. The lag length was determined by the Schwarz information criterion. The variables were found to be stationary at first difference, with the exception of real effective exchange rate and interest rate differentials which were stationary at levels. Engel and Granger (1987) stated that the linear combination of non-stationary series are not reliable for short term estimate, but if such a stationary linear combination exists in the long run, the non-stationary time series are said to be co-integrated.

Table 1: The Augmented Dickey Fuller (ADF) Test

Variables	Level Series	P-Values	First Difference Series	P-Values
Actual REER				
CBN REER (in logs; log(reer)	-3.0153	0.0426**	-3.9871	0.0039*
Explanatory factors of REER				
M2 (in logs; log(M2))	-1.1061	0.7122	-11.7367	0.0000*
Foreign Reserves in USD terms (in logs, log(fres))	-1.2618	0.6458	-5.528	0.0000*
Price of Bonny Light Oil (in logs; log(oilp))	-1.081	0.722	-9.4925	0.0000*
Interest Rate Differentials (irate)	-4.5363	0.0004*	-8.4617	0.0000*

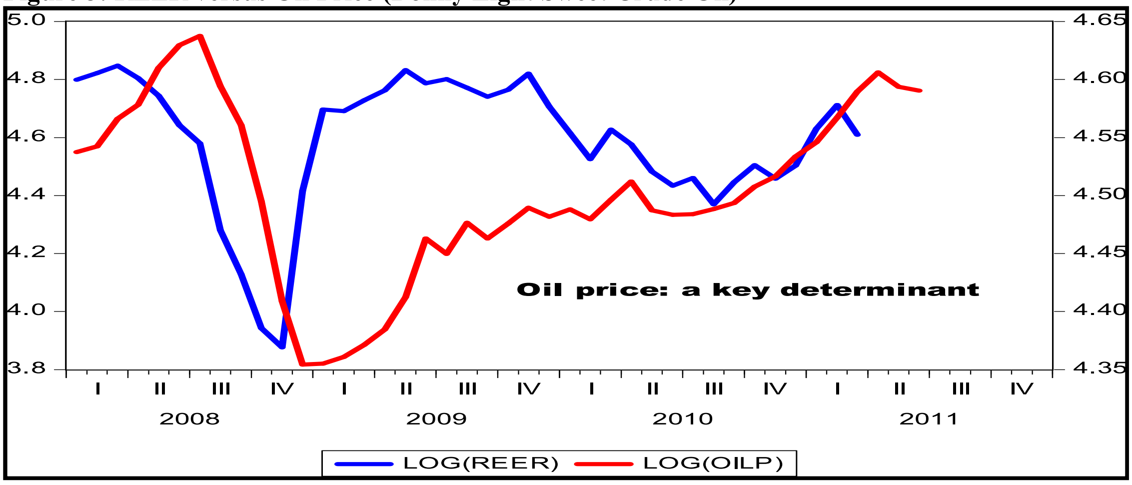
*, ** and *** represent 1%, 5% and 10% significant levels based on Mackinnon (1996) one sided p-values.
Lag lengths are chosen using Schwarz criterion.

Since the variables are of different order of integration, I (1) and I (0), the search of a long term relationship among the respective variables becomes vital. Data series in this model may rule out the assumption of deterministic trend with no intercept as the series do not have a mean of zero. The co-integration test (see Appendix II) result suggests that variables in the model are co-integrated with real exchange rate. The normalized estimators' values were significant as denoted by their respective probability values. The co-integrating vectors conform to prescription of economic theory in terms of sign.

4.2 Estimating The REER Through VEC Modeling

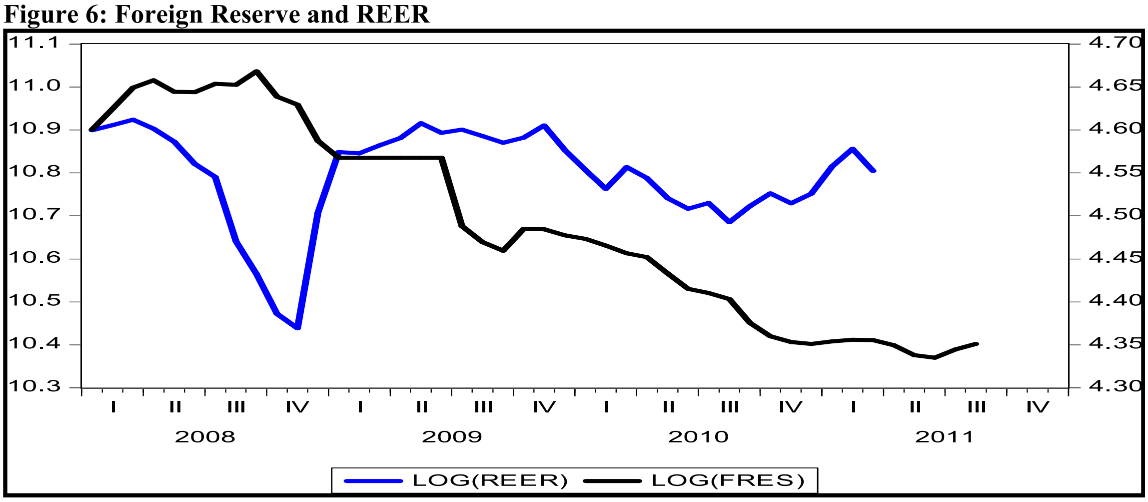
Figure 3 shows that oil price effectively dictate the direction of real exchange rate movement in Nigeria. The post financial crisis fall-out further indicates the ever-present influence of crude oil price on external reserves. In essence, oil price tended to track movements in the real effective exchange rate over the sample period (1970 – 2011). Again, this is indicative of Nigeria's oil dependency status.

Figure 5: REER versus Oil Price (Bonny Light Sweet Crude Oil)



Source: Authors' Computation

Figure 6: Foreign Reserve and REER



Source: Authors' Computation

The remarkable relationships may be spurious as depicted by the co-integrating vectors and the graphs (all variables in log). Hence, a Vector Error Correction (VEC) Model was employed to estimate the equilibrium REER. A VEC model is VAR in first difference, but with corrective restrictions based on co-integration concept. The real exchange rate VEC model can be stated as follows:

Equation 1:

$$\begin{aligned}\Delta\log(reer)_t = {} & [\alpha_{11} * (\beta'_{11} * \log(reer)_{t-1})] + \beta'_{12} * \log(m2)_{t-1} + \beta'_{13} * \log(fres)_{t-1} + \beta'_{14} * \log(oilp)_{t-1} \\ & + \beta'_{15} * (irate)_{t-1} + \beta'_{16} + \varphi_{11} * \Delta\log(reer)_{t-1} + \varphi_{12} * \Delta\log(reer)_{t-2} + \varphi_{13} * \Delta\log(m2)_{t-1} \\ & + \varphi_{14} * \Delta\log(m2)_{t-2} + \varphi_{15} * \Delta\log(fres)_{t-1} + \varphi_{16} * \Delta\log(fres)_{t-2} + \varphi_{17} * \Delta\log(oilp)_{t-1} \\ & + \varphi_{18} * \Delta\log(oilp)_{t-2} + \varphi_{19} * \Delta(irate)_{t-1} + \varphi_{20} * \Delta(irate)_{t-2} + \psi_{211}\end{aligned}$$

Where α denotes the adjustment parameters, β are the co-integrating vectors and φ is the two dimensional group that holds the short run parameters. Table 2 shows the findings from the VEC model alongside its co-integration results.

Table 2: Real (Naira) Exchange Rate Results

Estimates of the real exchnage rate modeling

REER (in logs; log(reer))	1
Oilp prices (bonny light; in logs -log(oilp))	0.1054**
	[0.0583]
M2 (in logs; log(m2))	0.0285**
	[0.0407]
Real interest rate differentials(irate)	-0.0012***
	[0.0003]

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Error correction diagnostic statistics

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R-squared	0.7268
Adj. R-squared	0.6227
Sum sq. resids	0.0101
S.E. equation	0.0224
F-statistic	6.9836
Log likelihood	76.7185
No. of observations	120

****

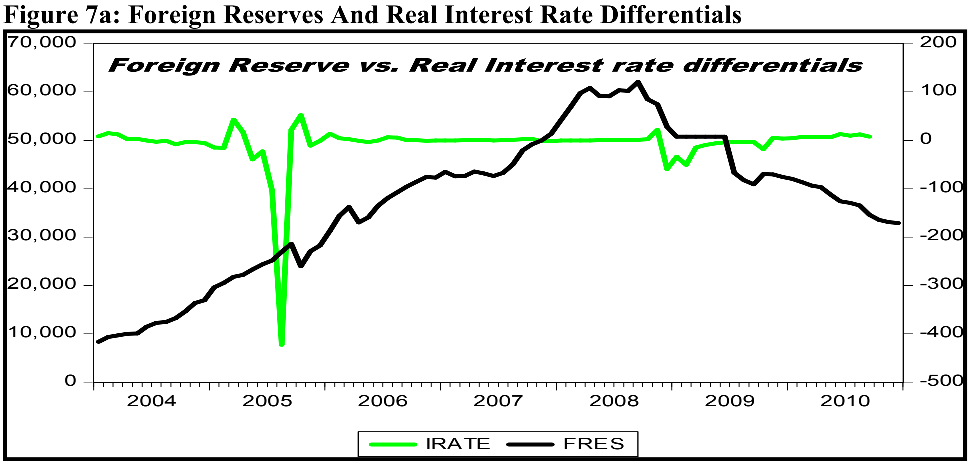
, ** and * represent significant at 10%, 5% and 1% levels. Values in [ ] stand for the probability values*

The result suggests that as oil price increases, the value of the Naira appreciates as well. The result conforms to apriori expectation. A 100% rise in the oil price leads to a 10% real appreciation of the Naira. M2 coefficient was relatively small, but was significant at the 5% level - an M2 growth leads to the depreciation of the real Naira exchange rate via other transmission mechanism. Real interest rate rise also undermine real Naira rate viz-a-viz the US Dollar.

Figures 5a and 5b indicate the trend of foreign reserves, real interest rate and oil price. The graphical representation depicts a stronger tie between foreign reserve and oil price in Nigeria. The correlation coefficient was a positive 78%.

Our results are in line with cited literatures (Zalduendo, 2006; Koranchelian, 2005 and Tariffi, 2008). It shows that oil price, M2 and real interest rate differentials are real random determinants of Nigeria's real Naira exchange rate. Hence, policy measure must take cognizance of these factors in a bid to adjust the economy to attained desired objective. However, since price of oil and interest rate differentials are exogenously determined, it follows that Nigeria is indeed not the architect of her own fortune. Obadan (1983) observed that oil has come to dominate the whole economy, such that anything happening in the international oil industry reverberates through all sectors of the Nigerian Economy. At the height of the oil price crash of 2007, external reserves dwindled and hence the apex bank allowed that Naira to depreciate markedly from an average of N118/US$ to about N140/US$.

Figure 7a: Foreign Reserves And Real Interest Rate Differentials



Source: Authors' Computation

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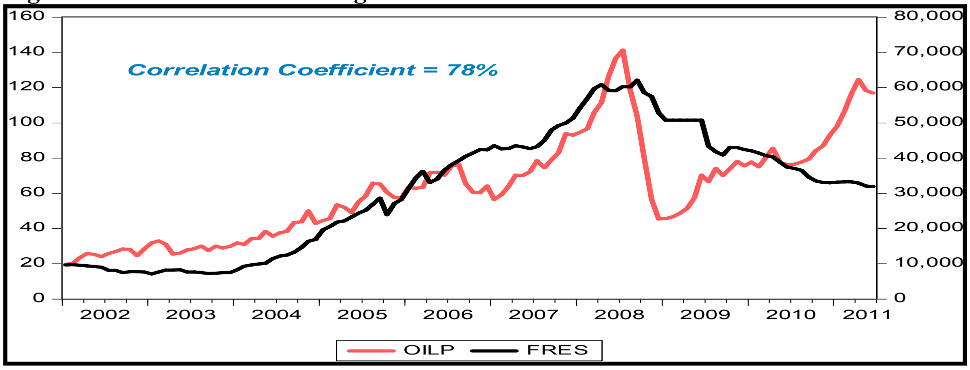
Figure 7b: Oil Price And Foreign Reserves



Source: Authors' Computation

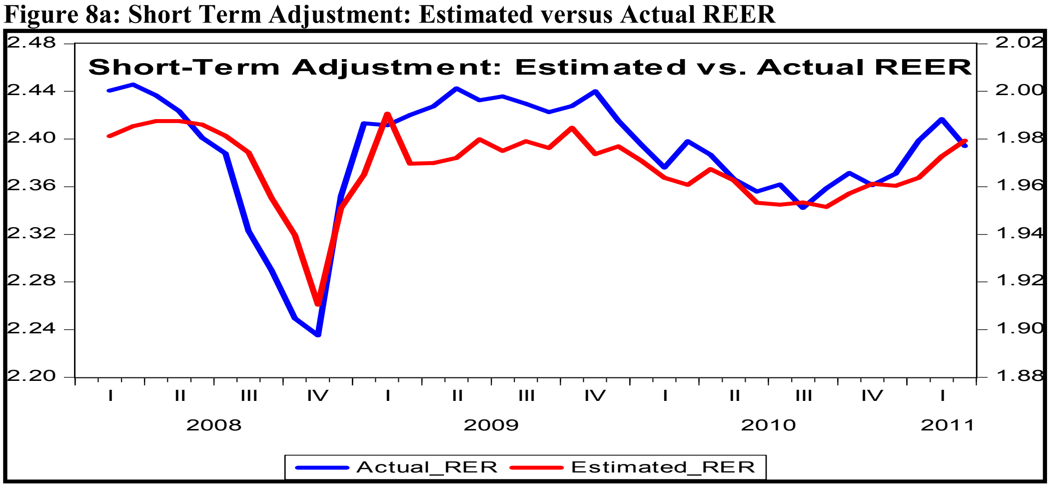
4.3 Review of Rate Misalignments

The equilibrium real exchange rate is derived by transforming the vector error correction model to data in levels. Exchange rate misalignment, whether overvaluation and under valuation, was then obtained by calculating the percentage difference between actual RER and estimated RER (see appendix IV). VEC model technique was adopted for analysis, using data obtained from the CBN covering our interested period of study. From empirical findings, this paper suggests that the Naira exchange rate was relatively overvalued during the period under consideration.

The graph of estimated RER and actual RER trended in same direction in the presence of induced short term adjustment. A noticeable feature in the geometry was a precipitous decline in both variables following the impact of the 2008 global financial crisis. This culminated in a sharp fall in real exchange rate but picked up at the start of 2009 fiscal year when the CBN adopted a managed float exchange rate strategy. As at late 2010, the Naira was again under severe speculative attack, as demand continued to be in excess of supply. With this the CBN revised its currency benchmark from N150 ± 3% to N155 ± 3% to safeguard the nation's external reserves, and by implication the value of the Naira.

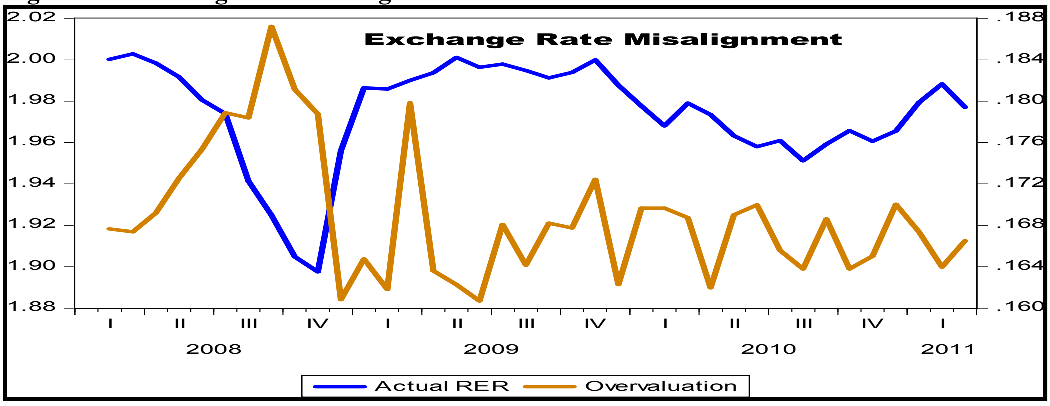
As computed in appendix IV, the Naira remained overvalued in the period under investigation, returning -0.165, -0.169, -0.167 and -0.176 as at end-2008, 2009, 2010 and the 3rd quarter of 2011, respectively.

Figure 8a: Short Term Adjustment: Estimated versus Actual REER



Source: Authors' Computation

Figure 8b: Exchange Rate Misalignment



Source: Authors' Computation

5.0 Conclusion

This paper developed a Vector Error Correction (VEC) methodology to estimate the determinants of Naira's real exchange rate, using high frequency data which include Bonny Light crude oil prices, real interest rate differentials, broad money and foreign reserves time series data. Empirical findings suggest that increases in the oil price lead to an appreciation of the REER; money supply changes also have an increasing effect on the dependent variable (REER) while real interest rate differentials leads to a negative change in the REER. This was in line with conclusions arrived at by Zalduendo (2006), Koranchelian (2005) and Tariffi (2008). Changes in the level of foreign reserves also explain some variation in the REER.

The equilibrium (estimated) real exchange rate was found to trend in line with the actual REER (see figure 6), showing the strength of the explanatory variables in the adopted vector error correction model. The Naira has weakened in real terms against the US Dollar as opposed to its pre-financial crisis overvaluation. This may be due to policy inconsistencies in exchange rate strategy and other structural misalignment in the economy. RER rose during the start of the financial crisis until the third quarter of 2009. As at end-2010 fiscal year, the actual RER and estimated equilibrium level were relatively stable. This continued into 2011 as the Naira was effectively managed via depletion in accretion to the external reserves and stringent foreign exchange policies. In recent times, there has been a reduced variation in the nominal Naira exchange rate.

In concluding this study, it is quite obvious that the composition of Nigerian export sector exhibits a disturbing structural weakness. The dominance of crude oil as the main source of foreign exchange earner has titled economic structure in Nigeria in favour of a highly inelastic commodity which continues to make the Nigerian economy extremely tied to the developments in the oil sector (and by extension the external sector). It is in this regard that the diversification of the Nigerian economy becomes vital.

References

Balvers and Bergstrand. 2002. Government Expenditure and Equilibrium Real Exchange Rates, Journal of International Money and Finance 21 (2002) 667–692.

Bems, R. and Irineu de Carvalho Filho, 2009. Exchange Rate Assessments: Methodologies for Oil Exporting Countries. IMF Working Papers 09/281 Washington: International Monetary Fund Dec. 2009.

Coudert V. and Couharde, C. 2007. Currency Misalignments and Exchange Rate Regimes in Emerging and Developing Countries, CEPII, No 2008 – 07 (April)

Edwards, S. 1994. Real and Monetary Determinants of Real Exchange Rate Behaviour: "Theory and Evidence from Developing Countries", in John Williamson (ed.) Estimating Equilibrium Exchange Rates, Institute for International Economics, pp. 61-92.

Edward Sebastian, 1988, The determinant of equilibrium real exchange rate, UCLA Working Paper No. 508, September 1988; in T. Leonardo (ed.) Euro-dollar real exchange rate misalignments: Is the euro overvalued? University of Barcelona, 2008

Engle, R. Granger C. W. J, 1987. Co-integration and Error Correction Representation, Estimation and Testing, Econometrica, 55(2), March 1987, pp. 251-276

Froot, Kenneth and Rogoff, 1994. Perspectives on ppp and long-run real exchange rates, National Bureau of Economic Research, Working Paper No. 4952, December 1994.

Johansen, S. and K. Juselius, 1992. Testing Structural Hypothesis in a Multivariate Cointegration Analysis of the PPP and the UIP for UK, journal of Econometrics 53: 211-244.

Koranchelian, T. 2005. The Equilibrium Real Exchange Rate in a Commodity Exporting Country: Algeria's Experience. IMF Working Papers 05/135, Washington: International Monetary Fund.

Leonardo Tariffi, 2008. Euro-dollar real exchange rate misalignments: Is the euro overvalued? University of Barcelona, 2008

Meese, Richard and Rogoff Kenneth, 1988; Was it Real? The Exchange Rate-Interest Rate Differential Relation Over the Modern Floating rate Period, The Journal of Finance, 43(4), September 1988, pp. 933-946, in T. Leonardo (ed.) Euro-dollar real exchange rate misalignments: Is the euro overvalued? University of Barcelona, 2008

Mordi, C.N.O. 2006. Challenges of Exchange Rate Volatility in Economic Management in Nigeria, Central Bank of Nigeria Bullion, Vol. 30, No.3 (July - Sept)

Mundell, R. A. 1964. Exchange Rate Margins and Economic Policy, Money in the International Order, ed. C Murphy, Southern Methodist University Press, 1964.

Obadan, M.I. 1995. Determinants of Real Exchange Rates in Nigeria: Some Preliminary Empirical Evidence. Journal of Economic Management. Vol. 2, No. 2 (October).

Appendix I: Co-integration LR Test Based on Trace of the Stochastic Matrix

120 observations from 2002M01 to 2011M07. Order of VAR = 1

List of variables included in the co-integration vector:

REER FRES OILP M2 IRATE Trend

List of eigenvalues in descending order:

0.8783 0.4924 0.2993 0.1739

****

Null	Alternative	Trace	95% Critical Value	Prob****
r=0	r>=1***	93.2854	47.8561	0.0000
r<=1	r>=2***	34.3017	29.797	0.0142
r<=2	r>=3**	15.3127	15.4947	0.0532
r<=3	r>=4**	5.3504	3.8414	0.0207

****

*, ** and *** denote rejection of the null hypothesis at 90%, 95% and 99% confidence levels;
****Mackinnon-Haug-Michelis (1999) p-values

Appendix II: Estimates of the real exchange rate modeling

Estimates of the real exchnage rate modeling	
REER (in logs; log(reer))	1
Oilp prices (bonny light; in logs -log(oilp))	0.1054**
	[0.0583]
M2 (in logs; log(m2))	0.0285**
	[0.0407]
Real interest rate differentials(irate)	-0.0012**
	[0.0003]
***	
Error correction diagnostic statistics	
***	
R-squared	0.7268
Adj. R-squared	0.6227
Sum sq. resids	0.0101
S.E. equation	0.0224
F-statistic	6.9836
Log likelihood	76.7185
No. of observations	120
***	

Appendix III: Exchange Rate Misalignment

Real Exchange Rate Misalingment (Naira-US Dollar)

Date	Actual_RER	D(REER)	Estimated_REER	Overvaluation
2008M01	1.997604787	0.402435023	2.4	-0.167664672
2008M02	2.000217093	0.404697726	2.402302514	-0.167375016
2008M03	2.002900069	0.410604944	2.410822037	-0.169204513
2008M04	1.998346537	0.412179697	2.415079766	-0.172554644
2008M05	1.991669007	0.416847572	2.41519411	-0.175358618
2008M06	1.980639567	0.420393174	2.412062181	-0.178860486
2008M07	1.97391257	0.421888012	2.402527579	-0.178401702
2008M08	1.941461739	0.414781184	2.388693755	-0.187228695
2008M09	1.924899264	0.40921418	2.35067592	-0.181129458
2008M10	1.904769626	0.394429951	2.319329215	-0.178741158
2008M11	1.897572114	0.356415892	2.261185518	-0.160806533
2008M12	1.956072337	0.44430264	2.341874753	-0.164740841
2009M01	1.986547813	0.41396885	2.370041187	-0.161808738
2009M02	1.985875357	0.434761901	2.421309714	-0.179834225
2009M03	1.990027899	0.393419793	2.37929515	-0.163606122
2009M04	1.993700695	0.389909281	2.37993718	-0.162288521
2009M05	2.001214325	0.390618428	2.384319122	-0.160676813
2009M06	1.996336518	0.398487285	2.39970161	-0.168089687
2009M07	1.997866726	0.393887985	2.390224503	-0.164151014
2009M08	1.994712985	0.400176093	2.39804282	-0.168191256
2009M09	1.991270389	0.397878223	2.392591209	-0.167734805
2009M10	1.993876915	0.418128018	2.409398407	-0.172458607
2009M11	2	0.393524294	2.387401209	-0.162269001
2009M12	1.987621582	0.393770141	2.393770141	-0.169668989
2010M01	1.977586438	0.394038274	2.381659856	-0.169660423
2010M02	1.967968963	0.389809352	2.36739579	-0.168719919
2010M03	1.979001748	0.393475352	2.361444314	-0.16195282
2010M04	1.973451144	0.395819343	2.374821091	-0.169010604
2010M05	1.963268252	0.391854324	2.365305468	-0.169972641
2010M06	1.957990178	0.383307059	2.34657531	-0.165596702
2010M07	1.960946196	0.387031638	2.345021817	-0.163783389
2010M08	1.95114316	0.385916437	2.346862633	-0.168616376
2010M09	1.959327646	0.391928967	2.343072127	-0.163778348
2010M10	1.965765964	0.394937042	2.354264688	-0.165019136
2010M11	1.960661007	0.396562383	2.362328348	-0.170030276
2010M12	1.965530944	0.399978021	2.360639028	-0.167373359
2011M01	1.979366242	0.40201991	2.367550854	-0.163960411
2011M02	1.988291342	0.406133959	2.385500202	-0.166509674
2011M03	1.97708312	0.410326011	2.398617353	-0.175740508

Appendix IV: Mathematical Derivation of Underlying Assumptions of the Production Function

(a) Constant Returns to Scale:

$$Y_i = A_i\ f(K_{i,}\ L_i) \qquad \text{(i)}$$

Let equation (1) be increased by ϕ;

$$\phi Y_i = A_i\ f(\phi K_{i,}\ \phi L_i) \qquad \text{(ii)}$$

$$\phi Y_i = \ \phi\, A_i\ f(K_{i,} L_i) \qquad \text{(iii)}$$

Equation (iii) posits the constant returns to scale of production function. It follows that output rises by that specific increase ϕ.

(b) Positive and Diminishing Returns to Private Capital/Labour Input:

$$Y_i = A_i\ f(K_{pi,}\ L_{pi})$$

$$\frac{dY_i}{dK_{pi}} = A_i\ f\,'(K_{pi,}\ L_{pi})\ = 0;$$

$$\frac{d^2 Y_i}{dK_{pi}^2} = A_i\ f_{kk}^{'}(K_{pi,}\ L_{pi}) \frac{<}{>} 0$$

The second order derivative measures the slope of the marginal productivities of inputs, thus, the positive (greater than zero) expressions matches the positive returns on the private inputs while the negative (less than zero) equation presents the shape of the diminishing returns of private factor inputs.

(c) Inada Condition:

$$\lim_{k \to 0} f\,'(k) = \infty\ ; \lim_{l \to 0} f(l) = \infty$$

$$\lim_{k \to \infty} f\,'(k) = 0\ ; \lim_{l \to \infty} f(l) = 0$$

As size of inputs increases so will marginal productivity tends towards zero, thus, when capital stock is small, marginal product is infinitely large.