The Monetary Model of Exchange Rate Determination: The Case of Nigeria*

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Abstract

The monetary model of exchange rate proposes a strong relationship between exchange rate and monetary fundamentals. The model infers that the price of a country's currency is determine by the interaction of demand and supply of money, hence the price level of two partner countries should not differ if expressed in the same currency. This study attempted to confirm this relationship for Nigeria using a bounds testing approach to cointegration. The result reveals that money supply differential is the most influential, followed by relative income and inflation variance. This lends support to the monetary model of exchange rate determination in Nigeria. The study, therefore, suggests that concerted effort should be made to increase the country's level of production, stabilise money supply and control inflationary spiral, so as to stabilise the value of the Naira vis-à-vis the US dollar.

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I. Introduction

The aftermath of the breakdown of Bretton-Woods system of fixed exchange rate between 1970 and 1973 saw the emergence of floating exchange rate regime, whereby the price of a country's currency is determined by a complex interaction of economic fundamentals and political dynamics. The level of production, inflation rate, money supply and interest rates, among many others, play a crucial role in determining the movement of exchange rate. Due to the complex nature of interactions it is difficult to ascertain the prominent drivers of the exchange rate dynamics.

This transition to a floating system of exchange rate coupled with the inherent challenges, prompted the search for theoretical underpinnings as well as empirical representations to explain exchange rate movements and forecast of

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its path. This led to an intensive intellectual effort at exchange rate modeling since mid-1970s.

During the early stage of exchange rate modeling, the monetary approach was most prominent. It is enshrined in the equilibrium concept of the money markets of two partnering countries, with the notion that the bilateral exchange rate is to a large extent, influenced by the supply of and demand for money in the two partnering countries. Therefore, if the assumption of purchasing power parity (PPP) holds, the model is said to be a market clearing general equilibrium model. The monetary model and many other models of exchange rate determination[13] certainly helped in explaining the perceived dynamics of exchange rate and undoubtedly contributed to the understanding of exchange rates dynamics. However, despite its wide acceptance, there is still divergence of opinions amongst academic researchers, policy analysts and market players as to the applicability of the model to emerging/developing economies.

Although, a few studies (i.e. Jimoh, 2004; Nwafor, 2006 and Alao et al, 2011) have confirmed the relevance of the model to Nigeria using the multivariate cointegration technique, none has applied the new bounds testing approach developed by Pesaran et al (2001). This study is, therefore, an attempt to contribute to this debate, by using bounds test approach to estimating a monetary model of exchange rate for Nigeria. To achieve this, the paper is divided into 5 sections. Following this introduction, section 2 presents a comprehensive review of relevant literature on monetary model of exchange rate including the essential elements of the model, as well as a few other models used in estimating the determinants of exchange rate. Section 3 explains the data used and the estimation procedure, while section 4 discusses the empirical results. Section 5 concludes the paper.

II. Review of Literature

II. 1 Models of Exchange Rate Determination

II.1.1 The Purchasing Power Parity Model

The PPP theory states that the prices of goods and services across two countries are not to be affected by the exchange rates between the countries ceteris paribus. This implies that the exchange rate between the two countries should be proportional to the inflation rate of each country (Yahya et al, 2011). Accordingly, by the PPP theorem, the exchange rate between two or more countries or currencies should equate natural and foreign currencies alike when expressed in

13. Mussa 1976, Frenkel 1976. Particularly, the flexible-price monetary model; Such as BOP approaches, other asset approaches and random walk models

a common currency (Macchiarelli, 2011). The constituent idea is that the same product should have the same price in different competitive markets. Therefore under the assumption of law of one price (LOP), the PPP theory states that for product "i":

$$P_t^i = S_t \text{ X } P_t^{*i} \qquad (1)$$

Where P_t^i is the domestic price of product "i", P_t^{*i} represents the foreign price of product "i", S_t denotes the nominal exchange rate of the domestic currency per unit of foreign currency (e.g. US Dollars). If and when this relationship is applied to all tradeables, the equation becomes:

$$S_t = \frac{P_t}{P^*} \qquad (2)$$

Where P* is the weighted average foreign price of all goods and P_t is the weighted average domestic price of all foreign goods.

Equation (2) can be re-arranged as follows:

$$S_t \times \frac{P_t^*}{P_t} = 1 \qquad (3)$$

The LHS of the equation (3) is the real exchange rate.

As a methodological approach, the PPP, however, suffers some defects which make its empirical verification difficult. Prominent among the challenges are: (i) the theory ignores trade barriers and transportation costs which exist in the real economy; (ii) it also overlooks differences in consumption baskets in different countries and trading partners which are apparent; and (iii) there exist oligopolistic competition and practices that undermine the assumptions of LOP.

II.1.2 The Uncovered Interest Parity Model

To understand and comprehend the interest rate impact on exchange rate, the interaction between the spot rate, forward rate and the expected rate of the currencies (domestic and foreign) is evaluated. Two theories are put forward in this regard; uncovered interest rate parity (UIP) and Covered Interest Rate Parity (CIRP) theory.

CIRP theory postulates that the guaranteed returns from investing in the domestic market must equal the guaranteed returns from investing in a foreign market. The UIP tries to connect the expected changes in the exchange rate to the interest rate differentials between two or more currencies (Kearns and Manners, 2006). Theoretically, UIP postulates that when the rate of return on domestic interest rate, is higher than the foreign interest rate, the domestic currency should appreciate. Thus, it defines the relationship between the interest rates and exchange rates of two currencies in equilibrium, implying that currencies that are high yielding should be expected to depreciate (Bakaert et al, 2005).

Mathematically:

$$\Delta LnS_t = \alpha + \beta(r^*_{t-1} - r_{t-1})) \qquad (4)$$

Where ΔLnS_t is the percentage change of Naira price in terms of USD from time t-1 to t, S_t denotes the price of NGN in terms of USD, r^*_{t-1} represents the USD interest rate at time t-1 and $r_{t-1}$is the NGN interest rate at time t-1. Hypothetically, if the UIP theory holds; α = 0 and β = 1. But this expectation generally does not hold. There is a vast array of literature showing that such conditions do not hold(Law, 2010)[14].

Equally challenging is the emerging puzzle regarding the application of the UIP, in situations where the high interest rates currencyis appreciating rather than depreciating. This is referred to as the UIP puzzle (Backus et al, 2010). The relationship between the interest rate and exchange rates is the fulcrum upon which international economic transaction takes place. The concept of interest rate parity posits that rate of returns of financial assets across countries is equal. Both the covered and the uncovered interest rate parity theories try to connect both domestic and foreign financial asset prices and also identify expected rates from such investments. This is premised upon the conditions of availability of sufficient funds for the transaction, cost of such transactions are negligible and free capital mobility.

II.1.3 The Extended Mundell-Fleming Model

In developing a macroeconomic framework of exchange rate movements' determination in an open economy, Mundell (1960) and Fleming (1962) independently extended the macroeconomic policy model of a closed economy to an open economy to incorporate the role of capital flows (Boughton, 2003).

This macroeconomic modelling framework is used to analyse monetary and fiscal policy issues after taking into consideration the challenges posed by capital mobility. The model suggests that in an open economy, fiscal policy is powerless in controlling aggregate demand under a flexible exchange rate, but monetary policy is quite effective (Ohyama, 2007). The model is an extension of the IS-LM model for a closed economy, by introducing capital movement and its response

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See also Engel (1996)

to interest rate and exchange rate. The model affirms that policy effects depend on the nature of the exchange rate regime.

Illustratively, for small open economy, perfect capital mobility is best summarised by equilibrium positions.

$$Y = G + A(Y, r, e) \quad (5)$$

$$D + R = L(Y, r) \quad (6)$$

$$r = r^* \quad (7)$$

Equation (5) depicts the relationship between national income (Y) and its key determinants i.e. public expenditure = G, private demand =A (which depends on national income (y), domestic interest rate (r) and exchange rate (e)). If domestic prices are assumed to be sticky in the short run, then the exchange rate (e) becomes the sole determinant of the price between domestic and foreign assets.

For econometric purposes, following, Hsing (2007) equation (5) can be re-arranged to become:

$$Y = F(Y, R - \pi^e, G, T, S, \epsilon) \quad (8)$$

$$^m/_p = L(Y, R, \varepsilon) \quad (9)$$

Where T represents real government taxes, M is money supply, L denotes demand for money, ϵ stands for real exchange rate, R is interest rate and π^e is inflation rate.

Solving for Y andϵ, equilibrium position is reached by:

$$\overline{\epsilon} = \overline{\epsilon}\ (^m/_p, G, T, S, R, \pi^e) \quad (10)$$

Fundamentally, the Mundell-Fleming monetary model allowed researchers, policy analysts and financial economist to understand the effect of government stabilisation policies either on monetary or fiscal policy under different exchange regimes. By this framework, the short run as well long run effects of stabilisation policies on monetary dynamics in an open economy is well understood in its major ramifications. This greatly simplifies a major policy problem (Boughton, 2003).

II.1.4 The Monetary Models

One of the major challenges financial economists faced after the collapse of the Bretton-Woods fixed exchange rate regime is the ability to determine and forecast the variation in exchange rates. The monetary approach to exchange rate determination has emerged as one of the dominant approaches (Neely and Sarno, 2002). The monetary approach posits exchange rate as the relative price of two currencies, and tries to model the exchange rate in terms of the relativity of the currency prices within the supply and demand paradigm.

Thus, a monetary model of exchange rate determination implies that there exist a long run equilibrium relationship between the nominal exchange rate and a country's monetary fundamentals (Vogiatzogloy et al, 2006).

Basically, the monetary model assumes an equilibria position in the monetary conditions, between domestic and foreign currencies.

$$M_t = P_t + KY_t - \lambda i_t \qquad (11)$$

$$M_t^* = P_t^* + KY_t^* - \lambda^* i_t^* \qquad (12)$$

Where M_t is the log of money supply P_t represents the log of price level, $Y_t$is the log of income and i_t denotes log of interest rate. The parameters K and λ are positive constants, the asterisk (*) denote foreign variables for the foreign country. Implicit in these equations is the assumption of perfect capital mobility, thus the real interest is exogenously determined in the long run (Neely and Sarno, 2002).

II.1.5 Dornbusch's Overshooting Model

Rationality in behavoiur of economic agents is a key assumption in economics. In 1976, Rudiger Dornbusch extended the Mundell- Fleming model of exchange rate dynamics in an open economy with perfect capital mobility to include rational expectations. The Dornbusch overshooting model posits that in a standard open economy where the economic agents have rational expectations (perfect foresight) i.e. there are no uncertainty, the nominal exchange rate can "overshoot" it's value in the long term.

To develop such a theory, the roles played by asset markets, capital mobility and rational expectations were drawn upon. Equally, the principal assumption of the formalized hypothesis is that the exchange rates and assets market adjusts faster than the goods market. This fundamentally helps the model to explain the dynamics of the exchange rate. Two relationships explain the Dornbusch overshooting model (Rogoff, 2002). The first is:

$$i_{t+1} = i^* + E_t(e_{t+1} - e_t) \quad (13)$$

Equation (13) above depicts the UIP condition, where i_{t+1} is domestic interest rate, i^* is the foreign interest rate, $E_t(e_{t+1}-e_t)$ represents the expected rate of depreciation of the exchange rate, e is the log values of the exchange rate and E_t denotes the market expectations based on information at time t.

The second equation is:

$$M_t - P_t = -\eta i_{t+1} + \theta Y_t \quad (14)$$

Equation (14) is the money demand equation, where M is the log of money supply, P is the log of domestic price level, Y is the log of domestic output, η and θ are positive parameters. They are the interest rate elasticity of money demand and income elasticity of supply of money, respectively.

If equations (13) and (14) were solved simultaneous, we have the overshooting model. It is assumed that domestic price level P does not change fast due to unanticipated monetary shocks, but reacts slowly. The overshooting model had enjoyed considerable utility by monetary economists, since it combined the Keynesian short-run analysis and the Monetarist long-run approach to macroeconomic modeling (Tu and Feng, 2009).

II.2 Empirical Literature

Many studies previously indicated that exchange rate fluctuations were largely explained by the random walk hypothesis. For instance, Meese and Rogoff (1983), Cheung, Chinn and Pascual (2003) and Qi and Wu (2003) indicated that the random walk model performed better than the monetary models in exchange rate determination. Meese and Rogoff (1983) found that a random walk model performs as well as any estimated model for the Dollar/Pound, Dollar/Mark, Dollar/Yen and trade-weighted Dollar exchange rates. Their structural models included the flexible-price (Frenkel-Bilson) and sticky-price (Dornbusch-Frankel) monetary models. Cheung, Chinn and Pascual (2003) also failed to find any particular model or specification that out-performed a random walk on a consistent basis. Qi and Wu (2003) demonstrated the inability of nonlinear models to forecast exchange rate movements and concluded that the Meese-Rogoff results cannot be overturned even with the global nonparametric neutral network models.

Barnett (2006) and Engel, Mark and West (2007), however, showed that monetary exchange rate models outperform the random walk model in their analysis. Barnett (2006) compared forecast results using mean square error, direction of change and Diebold-Mariano statistics and indicated that with Divisia monetary aggregates, the monetary fundamentals explain exchange rate movements more accurately than the random walk forecasts.

Engel, Mark and West (2007) also indicated that monetary models generally produce better forecasts than the random walk and these models do help to forecast changes in exchange rates. Cheung, Chinn and Pascual (2005) concluded that some models seem to do well at certain horizons and for certain criteria. They added that one model will do well for one exchange rate and not for another. Hsieh (2009) also indicated that monetary models were confirmed in Indonesia even though different exchange rate models have different impact on the Rupiah exchange rate.

In line with these arguments, many empirical studies have been conducted to determine the viability of the monetary approach to exchange rate determination in many countries. Hwang (2001) examine the forecasting performance of monetary exchange rate models vis-à-vis the random walk model for the US dollar/Canadian dollar exchange rate over the period January 1980 to December 1996. Using the multivariate cointegration technique, the study found a stable long-run relationship between the exchange rate and macroeconomic fundamentals (money supply, real income, short-term interest rates and expected inflation rate). The study also indicated that monetary models outperform the random walk model on the basis of the root mean squared error (RMSE) criteria. The author concluded that macroeconomic fundamentals were important in predicting the US dollar/Canadian dollar exchange rate.

Boyko (2002) modified the monetary exchange rate model to include a dollarization ratio – measured as a percentage ratio of deposits in US dollars to all deposits. Results from the modified monetary model showed that the exchange rate in Ukraine is explained largely by dollarization ratio, domestic money supply and domestic nominal deposit rate, indicating support for the monetary model. The author indicated that the stability and sustainability of the exchange rate depends on the degree of dollarization and the influencing factors. Additionally, money supply can be employed as a tool to influence the exchange rate.

Rapach and Wohar (2002) tested the long-run monetary model of exchange rate determination for 14 industrialized countries using long spans of data. Utilizing the unit root and cointegration tests, their findings indicated a considerable support for a long-run monetary model of US dollar exchange rate determination for France, Italy, the Netherlands and Spain; moderate support for Belgium, Finland and Portugal; and weak support for Switzerland. The study found some evidence of a long-run relationship between nominal exchange rates and monetary variables for the above eight countries. The authors, however, indicated that the long-run monetary model does not hold in Australia, Canada, Denmark, Norway, Sweden and the United Kingdom.

Civcir (2003) and Dara and Sovannroeun (2008) also indicated considerable support for the monetary model in Turkey and the Philippines. Civcir (2003) found evidence of a theoretically consistent long-run link between nominal exchange rates and monetary fundamentals. Dara and Sovannroeun (2008) applied the Autoregressive Distributed Lag (ARDL) approach to cointegration and quarterly data spanning the period 1981 to 2006. They indicated that there exist a significantly, both statistically as well as economically, stable monetary model of exchange rate determination for the Philippines. The authors concluded that money, income and interest rates are important determinants of the exchange rates in the Philippines.

Sim and Chang (2008) examine the effects of economic variables on the Korean Won/US dollar exchange rates relying on the monetary approach that considered the stock market using the ARDL bounds testing approach to cointegration. The study indicated that the modified monetary model produced a stable long-run cointegrating relationship and stressed that equities were important in determining exchange rates and should be included in the monetary approach to exchange rate determination.

Liew, Baharumshah and Puah (2009), who were motivated by limited number of studies using data from emerging economies to test the validity of the monetary model of exchange rate, examine the long-run validity of the flexible-price monetary model in Thailand utilizing the Baht-Yen exchange rates. Using the multivariate cointegration technique in a Vector Error Correction (VEC) framework, the study indicated the presence of long-run relationship among exchange rate and the monetary variables of domestic money supply, national output and nominal interest rates for Thailand. The authors concluded that exchange rate players in Thailand may monitor and forecast future exchange rate movements through the monetary variables of both Thailand and Japan.

Wilson (2009) also provided support for the long-term validity of the monetary model in the US using an expanded model of the monetary approach, which included 3 fiscal variables – debt, deficit and debt management. Utilizing the US dollar exchange rate against the currencies of a broad group of major US trading partners, the study also indicated that deficits and outstanding debts financed domestically or by foreign investors impact on the effective exchange rate in the long-run. Bruyn, Gupta and Stander (2011) attempted to test whether a simple form of the long-run exchange rate model for South Africa relative to the US based on the monetary fundamentals of relative money supply and relative output holds for a century of data. Their results, however, provided little support for the monetary model as long-run cointegration was found between nominal exchange rate and the output and money supply deviation even though theoretical restrictions required by the monetary model were rejected. The authors found that, in spite of its weakness, the monetary model outperform the random walk model in out-of-sample forecasts.

Shylajan, Sreejesh and Suresh (2011) examined the relevance of the FPMM in the determination of Indian Rupee-US Dollar exchange rate for the period 1996 to 2010 using monthly data on exchange rate, money supply, index of industrial production and interest rate. The study used the Johansen and Juselius cointegration analysis and a vector error correction methodology (VECM) to examine the relationships between the Rupee-Dollar exchange rate and macroeconomic fundamentals. Their test results indicated the existence of long run relationship between exchange rate and the macroeconomic variables, implying the validity of FPMM in the Indian context.

Groen (2000) and Rapach and Wohar (2004) also provided substantial support for the monetary model using panel tests. Groen (2000) failed to find an empirical support for monetary exchange rate models using pure time series data of individual countries. Results from his panel data sets involving 14 industrialized countries, however, indicated that the monetary exchange rate model has explanatory power. In addition, the change of numeraire exchange rate from US dollar to German Dutsche Mark (DM) provided more reliable results, as their parameter estimates in the sample of German DM exchange rates were closer to the theoretical values than the case of the US dollar exchange rates. Rapach and Wohar (2004) also indicated that monetary model performed poorly on a country-by-country basis during the modern float. Utilizing five residual-based panel cointegration tests and a full panel of 18 countries and 4 sub-panels, the authors found evidence for the existence of a cointegrating relationship among US dollar exchange rates, relative money supplies and relative income levels.

Jimoh (2004), Nwafor (2006) and Alao et al (2011) applied the unit root and cointegration tests to examine the monetary model of exchange rate determination using Nigerian data. Jimoh (2004) sought to determine whether Nigerian annual and monthly data between 1987 and 2001 provide any support for the monetary approach to explaining exchange rate behaviours. The study indicated that the sticky price model, irrespective of the fundamental form, is not a better representation of the Nigerian annual data than the FPMM. He added that the sticky price model was, however, slightly a better representation of the

Nigerian monthly data than the FPMM. Overall, he stated that monetary approach to exchange rate analysis provides a fairly good explanation of the behavior of the Nigerian floating rates between 1987 and 2001.

Nwafor (2006) also showed at least one cointegrating vector, suggesting a long-run equilibrium relationship between the Naira-Dollar exchange rate and the monetary fundamentals using quarterly data for the period 1986 – 2002. Alao et al (2011) also investigated the Naira/Dollar exchange rates under the FPMM using annual time series data for the period 1986 – 2008. Their cointegration tests showed at least one cointegrating vector, indicating that their model strongly supported FPMM. Ezike and Amah (2011) sought to find significant explanatory variables in the time series variation of foreign exchange rates based on Nigerian data. Using monthly data from 2004 to 2009, the authors indicated that foreign exchange demand/supply gap, money supply (narrow and broad), interest rates and exchange rate volatility were significant determinants of exchange rate in Nigeria.

III. Methodology, Data Issues and Estimation Procedure

III.1 The Model

With the assumption that PPP holds continuously, the starting point of the flexible price monetary model (FPMM) is:

$$e_t = p_t + p_t^f + \alpha \qquad (15)$$

Where e is the spot exchange rate, p is the price level in the domestic economy, p^f is the price level of foreign country, α is a constant and t is time. If α = 0, it implies absolute PPP, while α ≠ 0 entails relative PPP.

Now, if the money demand function of the partnering countries is stable, then money market equilibrium in both markets would be determined largely by real income, price level and nominal interest rate. In this case equilibrium in both markets can be represented as:

$$m_t = p_t + \beta y_t + \gamma i_t \qquad (16)$$

$$m_t^f = p_t^f + \beta^f y_t^f + \gamma^f i_t^f \qquad (17)$$

Where m which is money supply is determine exogenously by the central banks of the respective countries, p is the price level, y is the logarithms of real income and *i* is nominal interest rate. The parameters β and γ are the income elasticity of demand for money and the interest-rate semi-elasticity, respectively. Equation (17) is the assumed identical relationship for the foreign country.

Substituting equations (16) and (17) into equation (15) yields a flexible-price monetary model of the exchange-rate as follows:

$$e_t = \alpha + \beta(m - m^f)_t - \gamma(y - y^f)_t + \delta(i - i^f)_t + \mu_t \quad (18)$$

Where β, γ and δ are parameters, α is an arbitrary constant and f is the foreign component.

The nominal interest rate (i and i^f) in equation (18) consists of both real interest rate and the expected inflation rate as can be represented in equations (19) and (20) below:

$$i_t = r_t + \pi_t^e \quad (19)$$

$$i_t^f = r_t^f + \pi_t^{ef} \quad (20)$$

Where i, r and π are nominal interest rate, real interest rate and inflation rates, respectively. The subscript t is time and the superscript f denotes the foreign country.

If we equate equation (19) and (20) and assuming that r_t and r_t^f are identical in the long-run, we have:

$$i_t - i_t^f = \pi_t^e + \pi_t^{ef} \quad (21)$$

Substituting equation (21) in equation (18) yields:

$$e_t = \alpha + \beta(m - m^f)_t - \gamma(y - y^f)_t + \delta(\pi^e - \pi^{ef})_t + \mu_t \quad (22)$$

Equation (22) is the specified FPMM, where β, based on the neutrality concept of money is expected to be unity[15] and positive, while γ is expected to yield a negative sign[16] and π assumes a positive sign[17].

To set equation (22) to an unrestricted stochastic form we have:

$$e_t = \alpha + \beta m_t + \gamma m_t^f + \delta y_t + \theta y_t^f + \vartheta \pi_t + \epsilon \pi_t^f + \mu_t \quad (23)$$

Theoretically, from equation (23), β = -γ = 1, while δ and ϵ< 0; and θ and φ > 0.

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[15]This is to ensure that price changes proportionately to changes in money supply.

[16]Mundell-Fleming approach predicts a positive sign for β. Import rises, as real income increases, hence worsening the trade balance. To restore equilibrium domestic currency is expected to depreciate.

[17]Increase in the expected long-run inflation encourages portfolio adjustment, as agents resort to bonds as against domestic currency, hence decrease in the demand for domestic currency and consequently depreciation of the domestic currency and increase in exchange rate.

We adopted the unrestricted autoregressive distributed lag developed by Pesaran et al. (2001) to estimate equation (23) so as to test the existence of a long-run relationship among the variables. The choice of ARDL methodology is based on several considerations, prominent among which is that it can be applied irrespective of the order of integration of the variablesIn other words, ARDL is applicable irrespective of whether the underlying properties are purely I(0), I(1)or mutually cointegrated.The ARDL model takes the following format:

$$\Delta Le_t = \alpha + \sum_{i=1}^{p} \omega \Delta Le_{t-i} + \sum_{i=0}^{p} \beta \Delta Lm_{t-i} + \sum_{i=0}^{p} \gamma \Delta Lm^f_{t-i} + \sum_{i=0}^{p} \delta \Delta Ly_{t-i} + \sum_{i=0}^{p} \theta \Delta Ly^f_{t-i} + \sum_{i=0}^{p} \vartheta \Delta \pi_{t-i} + \sum_{i=0}^{p} \epsilon \Delta \pi^f_{t-i} + \delta_1 Le_{t-1} + \delta_2 Lm_{t-1} + \delta_3 Lm^f_{t-1} + \delta_4 Ly_{t-1} + \delta_5 Ly^f_{t-1} + \delta_6 \pi_{t-1} + \delta_7 \pi^f_{t-1} + \mu_t \quad (24)$$

Where Δ is a difference operator, L is logarithm, t is time, t -1 is lag one (previous quarter), α is an intercept term, ω, β, γ, δ, θ, φ and ϵas well as δ_1 to δ_7 are the coefficients of their respective variables and p's are the lag lengths. Other variables are as defined earlier under equations 15, 16 and 17.

Now, if $(m - m^f)_t$ is represented as md, $(y - y^f)_t$ is given as yd and $(\pi e_t - \pi e^f_t)t$ is denoted as πd, then we can also consider the restricted version of equation (22) as follows:

$$e_t = \alpha + \beta md_t + \gamma yd_t + \delta \pi d_t + \mu_t \quad (25)$$

Equation (25) offers the long-run effects of the variables on the exchange rate and the restricted ARDL format can be given as:

$$\Delta Le_t = \alpha + \sum_{i=1}^{p} \omega \Delta Le_{t-i} + \sum_{i=0}^{p} \beta \Delta Lmd_{t-i} + \sum_{i=0}^{p} \gamma \Delta Lyd_{t-i} + \sum_{i=0}^{p} \vartheta \Delta \pi d_{t-i} \sum \quad + \delta_1 Le_{t-1} + \delta_2 Lmd_{t-1} + \delta_3 Lyd_{t-1} + \delta_4 \pi d_{t-1} + \mu_t \quad (26)$$

Where md, yd and πd are the differences in money supply, income and inflation of home and foreign country, respectively.

The short-run dynamic equation (26) can be presented as follows:

$$\Delta Le_t = \alpha + \sum_{i=1}^{p} \omega \Delta Le_{t-i} + \sum_{i=0}^{p} \beta \Delta Lmd_{t-i} + \sum_{i=0}^{p} \gamma \Delta Lyd_{t-i} + \sum_{i=0}^{p} \vartheta \Delta \pi d_{t-i} + EC_{t-1} \quad (27)$$

Where EC is the error correction representation of equation (26)

III.2 Data Issues and Estimation Procedure

Quarterly data spanning from the period 2002:Q1 to 2012:Q2 were used for the study. The data is obtained from the Statistical Bulletin of the Central Bank of Nigeria (CBN).

To examine the existence of long-run relationship following Pesaran et al (2001), we first test, based on Wald test (F-statistics), the null and alternative hypothesis of the existence of the long run relationship among the variables as:

$$H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0 \text{ and } H_1: \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq 0$$

The asymptotic critical values are tabulated in Pesaran et al (2001) with one set assuming all variables are I(1) and the other I(0). If the calculated F-statistics exceeds the upper level of the band, the null hypothesis is rejected, implying that there is co-integration, if it is below the lower level of the band; the null cannot be rejected, indicating lack of co-integration. If the F-statistics falls between the two bands, the result is inconclusive. Furthermore, the error correction model represented as equation (27) is also estimated to determine the speed of adjustment towards equilibrium in case of distortions in the economy[18].

IV. Discussion of Result

Before examining the long-run relationship between exchange rate and monetary fundamentals, time series properties of the variables are first investigated using Augmented Dickey Fuller (ADF) and Phillips Perron (PP) tests. The ADF test was based on Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and Hannan Quinn Information Criterion (HQ).

The result of the unit root test as presented in table 1, shows that, while ADF test based on AIC reports exchange rate (e), foreign money supply (mf) and both Nigeria (if) and foreign inflation (iff) rate as I(1) series, SIC and HQ both show that all the variables are I(1) series except Nigeria and foreign GDP. Phillips Perron (PP) on the other hand reports all the variables as I(1) series significant at 1.0 per cent except foreign inflation which was significant at 5.0 per cent. In a nutshell, therefore, while some of the variables are I(0) series some are I(1), except in case of PP. This, therefore, lend support to the use of bounds testing approach to cointegration.

[18]The equivalent of equation (27) which applies to equation (26) is also tested in equation (24).

Table 1: Unit Root Test (Augmented Dickey-Fuller and Phillip-Perron)

Variable	Augmented Dickey – Fuller						Phillip-Perron Statistic	
	AIC		SBC		HQ			
	Level	First Diff.	Level	First Diff.	Level	First Diff.	Level	First Diff.
e	-1.2731	-4.9562*	-1.0233	-4.9562*	-1.2731	-4.9562*	-1.2242	-4.9562*
m	-2.8195	-4.0771	-2.2528	-5.7821*	-2.2528	-5.7821*	-2.4163	-5.7495*
m^f	-0.0863	-4.5056*	0.4786	-4.5056*	-0.0863	-4.5056*	0.0261	-4.4919*
y	-1.7373	-3.2128	-1.7373	-3.2128	-1.7373	-3.2128	-3.5001	-11.319*
y^f	-2.0505	-3.3282	-2.0505	-3.3282	-2.0505	-3.3282	-1.6651	-3.3282**
if	-1.6020	-6.8553*	-3.1674	-6.8553*	-1.6020	-6.8553*	-3.1569	-11.5360*
if^f	-1.8680	-6.1534*	-3.2058	-6.1535*	-1.8680	-6.1534*	-3.2899	-6.8936*

Note: *, ** and * represents significance at 1%, 5% and 10% respectively**

Table 3 presents the result of the estimated long-run equation. The result is consistent with the theory and conforms to the *apriori* expectation, as all the coefficients yielded the anticipated signs and were statistically significant. Money supply and inflation differentials related positively with the dependent variable while income differential established an inverse relationship. The calculated F-statistics (F-statistics = 34.69419) is higher than the upper bound critical value of 5.61 as tabulated in Pesaran et al (2001) indicating that the null of no co-integration can be rejected at 1.0 per cent level. In other words, there exists a long-run relationship among the studied variables.

Table 2: Statistics for Selecting Optimal Lag Length of the Model

ρ	1	2	3	4	5	6	7
AIC	5.6929	5.7608	5.8432	5.6880	5.46665*	5.5795	5.7609
SIC	5.8897	6.1185	6.3651	6.3774	6.32677*	6.6138	6.9729
HQC	5.7669	5.8948	6.0377	5.9437	5.78384*	5.9586	6.2022

*Note: ρ is the lag order of the model. * is optimal lag AIC denotes Akaike Information Criterion, SIC is Schwarz Information Criterion and HQC is Hannan Quinn Criterion*

Table 3, reveals that the long run overall model is well fitted as the independent variables explains about 94.0 per cent ($\bar{R}^2$) movements in the dependent variable. The coefficients show that money supply and inflation differentials are positively related to NGN/USD exchange rate. This implies that as money supply differential widens exchange rate depreciates and the same is true for inflation. Conversely, relative income negatively influences exchange rate, implying that as income differential increases NGN/USD exchange rate appreciates. This result is consistent with the standard monetary model of exchange rate. According to conventional Mundell-Fleming model an expansionary monetary policy are in most cases accompanied by capital account surplus which in-turn leads to depreciation in exchange rate.

Table 3: Estimated Long-Run Coefficients, ARDL (1, 1, 1, 1)

Dependent Variable: **Le**

Variables	Coefficient	t-stats	Prob. Values
C	5.4530	3.7892	0.0005
Le(-1)	0.8134	14.9969	0.0000
Lmd	0.0356	4.5970	0.0000
Lyd	-0.5283	-3.2767	0.0022
πd	0.0227	3.0722	0.0039
R^2 = 0.94	*F-Stat = (5, 3) =34.69419 [0.0000]*		
Adj.- R^2 = 0.94	*AIC = -4.47294, SIC = -4.26815, HQ = -4.39742*		

The relevant critical value for unrestricted intercept and no trend under 3 variables for 0.01 is 4.29 - 5.61. It is obtained from Pesaran et al. (2001) Table CI(iii) Case III.

The positive and statistically significant coefficient of inflation differential is an indication that an increase in the rate of domestic inflation vis-à-vis the US inflation rate brings about depreciation in the value of the naira vis-à-vis the US dollar. This confirms the critical influence of inflation on exchange rate movement. The result also indicates the possibility of inflationary spiral to drive the economy into a state of disequilibrium, if not properly checked.

The negative and statistically significant coefficient of output differential shows the relative importance of growth in determining the movement in exchange rate. High economic growth is likely to be a result of high rate of investment which in-turn could lead to increased export. Rising exports lead to current account surplus, which without deliberate intervention of the monetary authorities, leads to an appreciation of the exchange rate. There seems to be a consensus among economists on the critical role of growth on the strength of a country's currency. Strong growth strengthens the country's currency and the reverse is also true. Although, there are few exceptions[19]but this hypothesis tends to hold for Nigeria. This, therefore, lend support to the submission that robust growth leads to currency appreciation and if accompanied by structural changes, improvement in the standard of living whereasweak growthcauses sharp depreciation in the value of the currency and hence deteriorates the standard of living.

Table 4 presents the result of the error correction model (ECM). The coefficient of the ECM in the ARDL model is negative and statistically significant, providing additional support to the co-integrating relationships among the variables in the model (Sung-Hoon and Byoung-Ky 2008). The ECM shows that about 6.3 per cent disequilibrium is restored on quarterly basis, in case of distortion in the economy.

The short-run model, however, revealed that, unlike in the long-run, money supply differential is negatively related to exchange rate and not statistically significant. The relative income and inflation maintains their signs as in the long-run. Relative income is statistically significant at all lags except at the fourth lag while is significant at lag one. The implication is that the level of productivity and inflation determines the movement of exchange rate leaving rarely no critical role for money supply. This is an indication that the strength of distortionary tendencies of inflation is not only in the long-run.

Table 4: Error Correction Estimate of the ARDL Model

Dependent Variable: **ΔLe**				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-0.0194	0.0115	-1.6819	0.1037
ΔLe(-1)	8.3568	2.0401	4.0962	0.0003
ΔLe(-2)	-2.0577	0.5012	-4.1054	0.0003
ΔLe(-4)	-0.2027	0.1115	-1.8183	0.0797
ΔLmd(-1)	-0.0583	0.0414	-1.4080	0.1701
ΔLyd(-1)	-0.8729	0.3020	-2.8900	0.0074
ΔLyd(-2)	-0.8796	0.3419	-2.5725	0.0157
ΔLyd(-3)	-0.7992	0.3182	-2.5117	0.0181
ΔLyd(-4)	-0.5726	0.3671	-1.5599	0.1300
Δπd(-1)	0.0095	0.0075	1.2581	0.2187
EC(-1)	-0.0625	0.0153	-4.0814	0.0003

[19]GDP is said to be rarely the most influential factor as the foreign exchange market is very complex. Some other economic and political factors can also exert some degree of influence.

$R^2 = 0.65$	Adjusted $R^2 = 0.53$

To test the stability of the equation and of the estimated parameters, the techniques of cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests were adopted. The equation parameters are said to be stable, if the whole sum of recursive errors lies within the two critical lines. Both Figure 1 and 2 show that the parameters of the analysed equation are stable, since the recursive errors lie within the two critical lines of CUSUM and CUSUMSQ tests.

Figure 1: Cumulative Sum of RecursiveResidual Test

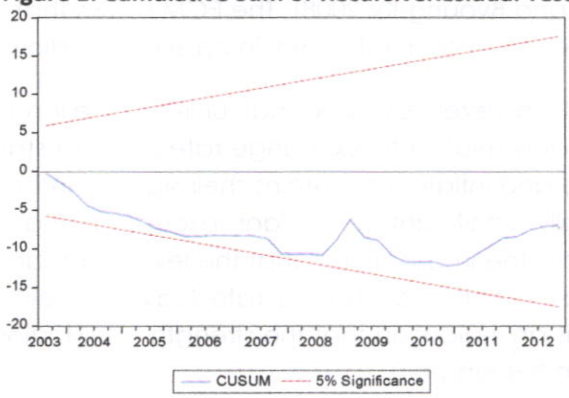
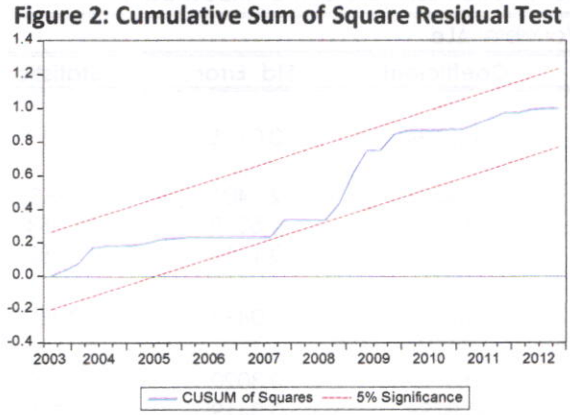


Figure 2: Cumulative Sum of Square Residual Test



V. Conclusion

In this paper, we estimate the long-run relationship between exchange rate and some macro- fundamentals by relying heavily on the principles of the monetary model of exchange rate determination. The study used ARDL technique to determine the relationship. Overall, the results suggest that the monetary model of exchange rate holds for Nigeria, with money supply differential been the most influential in the long-run, followed by relative income and inflation variance.

The result suggest that a concerted effort should be made to increase the country's level of production, particularly of non-oil sector so as to facilitate more exports of non-oil products to enhance inflow of foreign exchange and consequently stabilise the value of the NGN vis-à-vis the USD. There is also the need to stabilise money supply. Since money supply has a strong positive relationship with exchange rate, it follows that stability in the growth of money supply will likely stabilise the exchange rate in the long-run. Most importantly, effort to curb inflation needs to be intensified. The positive statistical relationship between inflation and exchange rate in both short and long-run models reveals the destabilising tendencies of inflation. High inflation could lead to distortions in the economy and disequilibrium in the foreign exchange market.

It is, however, important to note that besides the identified monetary and economic variables, exchange rate can be influenced by many other factors. It is agreed that the value of a country's currency is sensitive to mere expectations in changes in various other variables, which makes it prone to short-term volatility and misalignments. Sometimes deliberate government policy determines exchange rate movement. The government, if Marshall-Lerner condition holds, may decide to deliberately keep the value of the country's currency low to boost exports. On the other hand, countries producing beyond the need of the domestic economy could over-value or appreciates their currency so as to make exports cheaper. Therefore, besides market forces, some fundamentals determine the movement of exchange rate.

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