The Monetary Model of Exchange Rate in Nigeria: an Autoregressive Distributed Lag (ARDL) Approach

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Abstract

This study examines the monetary model of exchange rate in Nigeria, using an Autoregressive Distributed Lag (ARDL) approach over the period 1998Q1 to 2012Q2. The estimation results show that there is long run relationship among variables of the monetary model of exchange rate for Nigeria. That is, the estimated coefficients of the money supply, income and interest rate differentials support the monetary exchange rate model. As well, the stability test of CUSUM shows that there exists a significant and stable monetary model of exchange rate determination for Nigeria. Therefore, this study recommends that market participants in the foreign exchange market may monitor and forecast future exchange rate movements using the money supplies, incomes and interest rates variables.

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1. Introduction

The Bretton Woods system collapsed, to be replaced by the floating exchange rate system in 1973. Since then, volatility of exchange rates has been intractable. The character of exchange rate and its sway on the functioning of macroeconomies has continued to spawn interest among economists and policymakers. Mordi (2006) argued that the exchange rate movements have effects on inflation, price incentives, fiscal viability, competitiveness of exports, efficiency in resource allocation, international confidence and balance of payments equilibrium. To a large extent, misalignment in real exchange rate could twist productive activities, thwart exports and engender instability in an economy.

An exchange rate is the current market price for which one currency can be exchanged for another. For instance, if the Naira exchange rate for the United States Dollar stands at 155, this means that ₦155 can be exchanged for $1. For the reason that exchange rates' role in a country's competiveness level is substantial, exchange rates are among the most analysed and forecasted indicators in the world. Exchange rate is governed by the level of supply and demand on the international markets. Yet, changes in exchange rates are not amenable to prediction because the market is outsized and volatile. In fact, according to tradingeconomics.com (2013), the currency markets are the most liquid in the world with a daily turnover of close to $2 trillion.

The long run model of exchange rate determination has been the subject of intense interest for many researchers. The monetary approach has been used to understand exchange rate movements. Several models explaining exchange rate behaviour have been developed. Over the past four decades, the monetary approach to understanding exchange rates has become the prevailing model of exchange rate determination (Diamandis and Kouretas, 1996). Within the monetary approach to exchange rate determination, there are two variants: the flexible- price monetary model (Frankel 1976; Bilson, 1978) and the sticky-price monetary model (Dornbush, 1976). According to the monetary exchange rate model, a relationship exists between the nominal exchange rate and monetary fundamentals. That is, a country's exchange rate is determined by its money supply and demand through the purchasing power parity (PPP). Therefore, this model provides a long-run benchmark for the nominal exchange rate between two currencies. As well, it establishes a standard for determining whether a currency is "overvalued" or "undervalued" (Rapach and Wohar, 2002).

Prior studies on long run relationship between exchange rate and the monetary variables have their weaknesses. Their standard approach to testing the monetary exchange rate model has been through the cointegration techniques of Johansen-Juselius (1990) and Johansen (1991). Examples include Jimoh (2004), Nwafor (2006), Long and Samareth (2008) and Liew et al. (2009). By using Johansen-Juselius cointegration technique and the assumption that all variables are I(1), the studies are flawed. It is common knowledge that in order to conduct Johansen-Juselius cointegration test, all variables must be integrated of the same order. Yet, the studies failed to consider this factor in their analysis and went ahead to use variables of different orders. In order to subdue this error, this study uses ARDL approach to cointegration. The advantage of ARDL approach is that it tests the cointegrating relationship without any necessity for same order of integration for all variables.

The purpose of this paper is to fill the gap in the literature by re-examinining the validity of the monetary exchange rate model in Nigeria using an advanced econometric technique, that is to say, Autoregressive Distributed Lag (ARDL) approach. Evidence of the monetary model in Nigeria is little with the few available studies testing for Johansen-Juselius cointegration with variables of different orders. This study solves that problem by using ARDL approach which is not susceptible to such problems.

The remainder of the paper is structured as follows: section 2 provides a brief overview of the Nigerian exchange rate regime. Section 3 outlines a review of the empirical literature on the monetary exchange rate model. Section 4 presents the theoretical framework for the monetary exchange rate model. Section 5 describes the methodology and data used in the research. Section 6 presents the empirical analysis. Section 7 concludes.

2 Overview of Nigerian Exchange Rate Regime

In the beginning, Nigeria practiced a fixed exchange rate policy, where the Naira was pegged against the British pound and afterwards the American dollar. However, there was the termination of the Bretton Woods international system of fixed exchange rates in the early 1970s. Since then the international monetary system advance with copious and conspicuous developments. Many countries forsook pegged exchange rates and instead either (1) practise a monetary policy based on flexible exchange rate or (2) connect monetary policy to other countries through a monetary union or dollarization. Consequent upon these developments, Nigeria adopted a flexible exchange rate policy, allowing the Naira to float and its value relative to the American dollar controlled by market forces of demand and supply.

Various policies have been employed in Nigeria to ensure exchange rate stability. These included among others: Second-Tier Foreign Exchange Market (SFEM), Autonomous Foreign Exchange Market (AFEM), Inter-bank Foreign Exchange Market (IFEM), the Enlarged Foreign Exchange Market (FEM), and the Dutch Auction System (DAS). Generally, the hopelessness and flop of each policy to help and achieve stability in the exchange rate invariably leads to the espousal of another.

To the chagrin of all endeavors to maintain exchange rate stability by avoiding its fluctuations and misalignment, the Naira continues to depreciate against the American dollar. For example, the Naira appreciated against the American dollar in the 1970s. It depreciated throughout the 1980s. The exchange rate became relatively stable in the mid-1990s, then it depreciated further till 2004. Thereafter, it appreciated from 2005, till 2007. Summarily, from 1960 until 2013, the exchange rate averaged 119.0900 reaching an all-time high of 164.8000 in December of 2011 and a record low of 0.5300 in October of 1980.

The incessant depreciation have been attributed to the decline in the nation's foreign exchange reserves. The activities of speculators and banks are also blamable. The voracious quest for abnormal profits has compelled some banks to engage in 'round-tripping', a situation in which banks buy foreign exchange from the Central Bank of Nigeria

(CBN) and sell to parallel market operators at prices other than the official prices. These malpractices engender exchange rate fluctuations and misalignment. The exchange rate is approximately N150 against the American dollar.

3 Literature Review

The monetary approach remains one of the several important tools employed to explain the variation in exchange rates. In early 1980s, it appeared without doubt no empirical support for this approach was established. Today, with better-quality statistical tools along with a more exact specification of the model, the long-term validity of the monetary approach to exchange rate determination has been established.

Dara Long and Sovannroeun Samreth (2008) examine the validity of short-run and long-run monetary models of exchange rate for the Philippines, using Autoregressive Distributed Lag (ARDL) approach. They find robust short-run and long-run relationships between variables in the monetary exchange rate model. However, the Purchasing Power Parity (PPP) condition fails and all the monetary restrictions are rejected. Therefore, they conclude that the estimation of the monetary model of exchange rate, in which monetary restrictions are assumed to be satisfied beforehand, might suffer from a number of deficiency. That is, it is not proper to estimate the exchange rate model before the monetary restrictions are confirmed.

Hwang (2001), using Johansen's multivariate cointegration, find up to three cointegrating vectors between the exchange rate and macroeconomic fundamentals for the U.S. dollar/Canadian dollar. That is, there is a long-run relationship between the exchange rate and economic fundamentals. Based on error correction models, he finds that two monetary models outperform the random walk model at the three-, six-, and 12-month forecasting horizons. Therefore, he concludes that monetary exchange rate models are still useful in forecasting exchange rates.

Miyakoshi (2000), using Johansen-Juselius cointegration technique, examines the flexible-price monetary model in Korea. He finds the Korean Won exchange rates to be cointegrated with money supplies, incomes and interest with the US dollar, German mark and Japanese yen as numeraires.

Shylajan, Sereejesh and Suresh (2011), using the Johansen- Juselius cointegration technique, examines the link between the Indian rupee-US dollar exchange rates and the macroeconomic fundamentals using the flexible-price monetary model. The outcomes reveal the existence of long-run relationship between exchange rate and the macroeconomic variables, validating the flexible-price monetary model. Nonetheless, no short-run causal relationship was found, using the vector error-correction model.

Conversely, a strand of the literature finds little evidence in support of the monetary exchange rate model. For example, Cusham (2000) finds a cointegrating relationship for the monetary model using Canadian–US dollar exchange rate in which the estimated cointegrating coefficients are inconsistent with the monetary model predictions. Thus he concludes that the monetary model is not validated.

Nieh and Wand (2005), using both Johansen's (1988, 1990, 1994) maximum likelihood cointegration test and the ARDL Bound test by Pesaran, Shin, and Smith (2001) for Taiwan, examines Dornbusch's (1976) sticky-price monetary model to exchange rate determination. They find ambiguous results for the long-run equilibrium relationship between the NTD/USD exchange rate and macro fundamentals. With the aid of ARDL Bound test, they conclude that there is no long-run equilibrium relationship between exchange rates and macro fundamentals.

For Nigeria, Nwafor (2006), using the Johansen's multivariate cointegration technique, examines the link between the naira-dollar exchange rates. He finds at least one cointegrating vector for Nigeria, validating the existence of a long-run monetary model of exchange rate. Alao et al. (2011), using Johansen cointegration framework as well, examines the flexible price monetary model for the naira-US dollar exchange rates. The outcomes reveal one cointegrating vector for Nigeria. They conclude that the variability of the nominal naira-dollar exchange rate is consistent with flexible price model.

Adawo and Effiong (2013), using the Johansen (1991) and Johansen and Juselius (1990) cointegration technique, examines the long-run validity of the monetary exchange rate model in Nigeria for the flexible exchange rate regime. They find a unique long-run relationship between the nominal exchange rate and money supply, output and interest rate differentials. The estimated cointegrating coefficients are consistent with the monetary model and statistically significant exception of the output differential.

To study the dynamic relationship between exchange rate and macroeconomic variables, most studies have focused on the existence of a long-run relationship within the monetary model framework using the conventional Johansen's cointegration technique. Instead, the purpose of this paper is to re-examine the exchange rate determination model using ARDL (autoregressive distributed lag) Bound test by Pesaran, Shin, and Smith (2001) to investigate the long-run and short-run impacts of monetary model to exchange rates during 1986:01–2003:04. In other words, we examine the long-run equilibrium relationship between NGN/USD exchange rate and macro fundamentals of Nigeria and the US using the ARDL approach. No other study has used this approach for Nigeria.

4 Theoretical Framework

Research studies on exchange rates stem from the equilibrium theory of supply and demand (Nieh and Wand, 2005).

At equilibrium, the money supply is equal to money demand.

$$M_d = M_s \quad (1)$$

According to the Cambridge equation,

$$M_s = kPY \quad (2)$$

To keep the exchange rate stable, the nominal exchange rate, E, is defined as domestic currency value of a unit of foreign currency,

$$E = P/P^* \quad (3)$$

Therefore,

$$E = M_s k^* Y^* / M_s^* k Y \quad (4)$$

Where M_s^* and Y^* are foreign money supply and real income.

Taking the log of (4),

$$e = (m_s - m_s^*) - (y - y^*) - (\log k - \log k^*) \quad (5)$$

e, m_s, m_s^*, y, and y^* are the logarithms of E, M_s, M_s^*, Y and Y^* respectively.

Now, the cost of holding money is expressed in terms of interest rate so that the demand for real balances is:

$$m_s - p = a + by - ci \quad (6)$$

a, b, and c are constant parameters, and i is the nominal interest rate.

And for the foreign country,

$$m_s^* - p^* = a + by^* - ci^* \quad (7)$$

Taking the log of (3),

$$e = p - p^* \quad (8)$$

Putting (6) and (7) in (8),

$$e = (m_s - m_s^*) - b(y - y^*) + c(i - i^*) \quad (9)$$

According to (9), monetary theory proposes that exchange rates are a monetary phenomenon influenced by money supply, income level, and interest rates.

Three models of the monetary approach to exchange rate came up in the 1970s. The flexible-price monetary model, the sticky-price monetary model and the real-interest differential model.

In the flexible-price monetary model (Frenkel, 1976), prices are flexible; they adjust immediately in the money market. Domestic and foreign capital are perfect substitutes. The Fisher equation ($i = r + \pi$) holds in both countries. r is the real interest rate. π is the expected inflation rate.

Substitute for π for i and π^* for i^* in Equation (9),

$$e = (m_s - m_s^*) - b(y - y^*) + c(\pi - \pi^*) \quad (10)$$

Assuming different coefficients of demand for money in the two countries,

$$m_s - p = ɧ_1 + ɧ_2 y - ɧ_3 i \quad (11)$$

$$m_s^* - p^* = ȥ_1 + ȥ_2 y^* - ȥ_3 i^* \quad (12)$$

Therefore, the monetary model of exchange rate in the unrestricted form is,

$$e_t = \phi_0 + \phi_1 m_{st} + \phi_2 m_{st}^* + \phi_3 y_t + \phi_4 y_t^* + \phi_5 i_t + \phi_6 i_t^* + \xi_t \quad (13)$$

In the monetary model of exchange rate, $\phi_1 = 1$, $\phi_2 = -1$, $\phi_3 < 0$, $\phi_4 > 0$, $\phi_5 > 0$ and $\phi_6 < 0$.

5. Model Specification and Methodology

The flexible-price monetary model of exchange rate in (13) can be expressed as unrestricted error correction ARDL model,

$$\Delta e_t = \varkappa_0 + \sum \varkappa_{1i} \Delta e_{t-I} + \sum \varkappa_{2i} \Delta m_{t-i} + \sum \varkappa_{3i} \Delta m_{t-i}^* + \sum \varkappa_{4i} \Delta y_{t-i} + \sum \varkappa_{5i} \Delta y_{t-i}^* + \sum \varkappa_{6i} \Delta i_{t-I} + \sum \varkappa_{7i} \Delta i_{t-i}^*$$
$$+ \Upsilon_1 e_{t-1} + \Upsilon_2 m_{t-1} + \Upsilon_3 m_{t-1}^* + \Upsilon_4 y_{t-1} + \Upsilon_5 y_{t-1}^* + \Upsilon_6 i_{t-1} + \Upsilon_7 i_{t-1}^* + З_t \quad (14)$$

Where

Δ denotes the first difference operator,

$\varkappa_0$ is the drift component,

$З_t$ is the white noise residuals.

The left-hand side is the exchange rate. The second until seventh expressions on the right-hand side represent the short-run dynamics of the model. The remaining expressions with the summation sign correspond to the long-run relationship.

To investigate the presence of long-run relationships among the variables, bound testing procedure of Pesaran, et al. (2001) is used. After Pesaran et al. (2001), the ARDL bounds testing approach has become the state-of-the-art technique for finding the long-run and short-run relationships among time series variables. It is called the bounds testing approach because it involves testing whether the calculated F statistics are within or outside two bounds: the lower bound for I(0) and the upper bound for I(1).

The ARDL is chosen for this study because it can be applied for a small sample size as it happens in this study. It can estimate the short and long-run dynamic relationships simultaneously. ARDL precludes the need for testing the order of integration amongst the variables and of pre-testing for unit roots, because the ARDL approach is valid regardless if the underlying regressors are I(0) or I(1). With the ARDL, there is possibility that different variables have differing optimal number of lags.

The ARDL bound test is based on the Wald-test (F-statistic). The F-test is essentially a test of the hypothesis of no cointegration among the variables against the existence of cointegration among the variables, denoted as:

H_0: $\Upsilon_1 = \Upsilon_2 = \Upsilon_3 = \Upsilon_4 = \Upsilon_5 = \Upsilon_6 = \Upsilon_7 = 0$ i.e., there is no cointegration among the variables.

H_1: $\Upsilon_1 \neq \Upsilon_2 \neq \Upsilon_3 \neq \Upsilon_4 \neq \Upsilon_5 \neq \Upsilon_6 \neq \Upsilon_7 \neq 0$ i.e., there is cointegration among the variables.

Two critical values are given by Pesaran et al. (2001) for the cointegration test. The lower critical bound assumes all the variables are I(0) signifying that there is no cointegration among the variables. The upper bound assumes that all the variables are I(1) signifying that there is cointegration among the variables. When the computed F-statistic is greater than the upper bound critical value, then H_0 is rejected (the variables are cointegrated). If the F-statistic is below the lower bound critical value, H_0 is accepted (the variables are not cointegrated). If the F-statistics is between the lower and upper bounds, then the results are indeterminate.

The data are obtained from different sources, including International Financial Statistics and CIA World Factbook.

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6. Empirical Analysis of the Monetary Model

The main plus of this approach lies on the fact that ARDL methodology obviates the need to classify variables into I(1) or I(0). Compared to standard cointegration, there is no need for unit root pre-testing. The ARDL cointegration test assumes that only one long run relationship exists between the dependent variable and the independent variables (Pesaran, Shin and Smith, 2001).

In the first step, F-statistics for judging whether there is a long run relationship among variables in the system is estimated.

Table 1 Wald Test

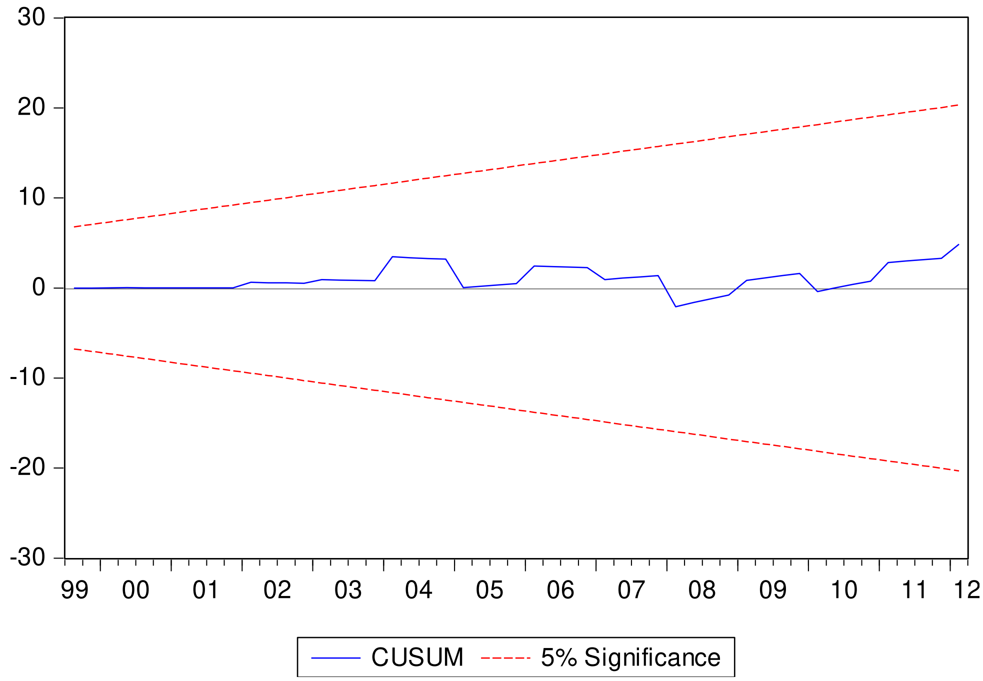
Test Statistic	Value	df	Probability
F-statistic	5.719174	(7, 39)	0.0001
Chi-square	40.03422	7	0.0000

The results of table 1 show that F-statistic is significant. The F-statistics of the model is bigger than the critical value of the case that all variables are I(1) both in 10% and 5%. This result supports the evidence of long run cointegrating relationship. It shows that the null hypothesis of no long run relationship can be strongly rejected. Therefore, it is evident that there is long run relationship among variables in the model.

From the Wald test, the calculated F-statistic 5.719174 is higher than the upper bound critical value 4.088 at the 5 percent level. Thus, the null hypothesis of no cointegration is rejected, implying long run cointegration relationships amongst the variables. The estimated coefficients of the long run relationship show that exchange rate is significantly explained by the variables included in the analysis. The adjusted R-squared shows that 95.3 percent of the variation in exchange rate is explained by the variables. The F-statistic also indicates that the model is significant. As well, the Durbin Watson statistic shows evidence of no serial correlation.

Now we use the tests of CUSUM and CUSUMQ to test the stability of the model. Figure 1 provides the graph of CUSUM test. It is categorically evident that the plot of CUSUM is within 5% of critical bands. This infers that the estimated model is stable.

Fig 1 Plot of Cumulative Sum of Recursive Residuals (CUSUM)



This gives credence to the fact that there exists long run stability of the monetary model of exchange rate in Nigeria.

7. Conclusion

This study has examined the validity of the monetary exchange rate model in Nigeria using an Autoregressive Distributed Lag (ARDL) approach over the period 1998Q1 to 2012Q2. The estimation results show that there is long run relationship among variables of the monetary model of exchange rate for Nigeria. When the stability of the estimated model is tested with CUSUM, it shows that there exists a significant and stable monetary model of exchange rate determination for Nigeria.

Therefore, the estimated coefficients of the money supply, income and interest rate differentials support the monetary exchange rate model. That is, the fluctuations in the Naira/Dollar exchange rate depend and respond to the monetary fundamentals in the monetary exchange rate model. Therefore, this study recommends that market participants in the foreign exchange market may monitor and forecast future exchange rate movements using the money supplies, incomes and interest rates variables.

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