An Evaluation of Foreign Exchange Intervention and Monetary Aggregates in Nigeria (1986- 2003)

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A Study of Foreign Exchange Intervention and Monetary Aggregates in the Nigerian Financial Sector (1986- 2003)

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Abstract

The paper investigates the impact of foreign exchange intervention in the Nigerian foreign exchange market using an *Autoregressive Distributed Lag (ARDL) modeling approach. Quarterly time series data spanning 1986:1 to 2003:4 are used and a number of statistical tools are employed to verify this hypothesis. The study examines stochastic characteristics of each time series by testing their stationarity using Phillip Perron (PP) test. This is followed by performing cointegration test using Johansen technique. The existence of co-integration motivates us to estimate the error correction model for broad money, M_2.*

The overall finding from all the techniques employed is that foreign exchange intervention in Nigeria is sterilized because the cumulative aid, which constitute part of foreign exchange inflows, and net foreign assets variables, which are proxies for intervention, are not significant. Thus, paper concludes by recommending, among others, that the use of stock of external reserves to support the exchange rate through increased funding of the foreign exchange market should be encouraged.

Key Words*:* Foreign Exchange Intervention, Nigeria, Co-integration and Auto-regressive Distributed Lag

Introduction

Foreign exchange intervention occurs when the monetary authority of a country buys or sells foreign exchange in the foreign exchange market in order to affect the exchange rate. Since 1986 when the exchange rate was floated in Nigeria, the Central Bank of Nigeria (CBN) has periodically intervened in the foreign exchange market. As part of the International Monetary Fund (IMF) conditions under the structural adjustment package, the CBN has also intervened in the form of foreign exchange purchases in order to accumulate foreign reserves for the government.

The issue of whether these interventions affect the exchange rate and how this happens has important implications for policy and has been a subject of much debate in the literature (Simatele, 2003). Distinguishing between sterilized and non-sterilized intervention is very important. On the one hand, there is general agreement that non-sterilized intervention can affect the exchange rate through its effect on money supply. On the other hand, the effectiveness of sterilized intervention is still controversial (see Danker et al., 1996; Lewis, 1988b; Humpage, 1989; Baillie and Humpage, 1994; and

Dominguez, 1998). Our interest in the paper is to determine whether foreign exchange intervention has an effect on exchange rates in Nigeria (the exchange rate in the study is defined as the number of naira per unit of foreign exchange). We would like to determine whether or not intervention in Nigeria is indeed sterilized. This is of importance because stabilization policy in Nigeria is based on the control of money supply with M_2 as an intermediate target and base money as the policy instrument. Policy implementation is conducted by minimizing deviations of M_2 from target. If intervention is not sterilized, then interventions are likely to affect money supply growth and this becomes a part of monetary policy issues.

The question on the effect of interventions on the exchange rate in Nigeria has both research and policy interest. Research interest because very few such studies, if any, have been done on Africa and only one such study (conducted by Simatele, 2003) is known to the author. It is of policy interest because, if sterilized intervention has an effect on the exchange rate in Nigeria, this offers the monetary authority an additional policy tool independent from general monetary policy.

In an open economy, once the exchange rate is floated, it becomes an important component in the transmission mechanism. The more open the economy, the greater the importance of the exchange rate in the policy process and the more important this variable becomes as an optional policy conduit. For instance, when exchange rate is depreciated, inflation rate is increased and vice versa. For this reason, the stability of the exchange rate is very important for price stabilization. To ensure this, most central banks intervene in foreign exchange markets to smooth out short run fluctuations of the exchange rate. However, the effects of central bank intervention in the foreign exchange market are not straightforward. The efficiency of the foreign exchange market matters coupled with the nature and credibility of the interventions. The effect of such interventions, therefore, is an empirical question, which this paper attempts to address.

Thus, the objective of this study is to determine whether or not intervention by the Central Bank of Nigeria (CBN) in the Nigerian foreign exchange market is sterilized. That is to find out whether or not the CBN intervention in the Nigerian foreign exchange has effect on the growth of monetary aggregates, M_2. The rest of the paper is structure as follow. Section 2 provides the literature review and the theoretical background, while foreign exchange intervention in Nigeria is discussed in Section 3. Section 4 highlights methodology and data sources, while section 5 addresses empirical analysis. The conclusions and recommendations are contained in the last Section.

2 Theoretical Background and Literature Review

2.1 Theory of Intervention

In the literature, distinction is made between sterilized and non-sterilized intervention. Sterilized intervention occurs when the monetary authority offsets its foreign exchange market intervention, usually with an equal change in the net domestic credit either simultaneously or with a very short lag. On the other hand, intervention is non-sterilized when it occurs without any offsetting changes. The relationship between exchange rates and monetary control stems from the central bank's balance sheet.

From the liabilities side, we have the base money (Mb) made up of reserves and currency and the central bank's net worth. On the assets side, we have net foreign assets (NFA) and net domestic assets (NDA). Intervention in the foreign exchange markets will alter NFA. If net worth is negligible, balance sheet becomes Mb equals NFA plus NDA. Sterilization requires offsetting action on the part of the central bank such as open market operation sales or purchases of securities. This will result in an equal change in domestic assets. Without sterilization, the monetary base must also change i.e. change in Mb equals change in NFA. The extent of sterilization depends on how much simultaneous change takes place in NDA as NFA changes. There is full sterilization when changes in NFA are totally offset by changes in NDA (i.e. change in NFA equals change in NDA and change in monetary base equals zero) so that there is no impact on the monetary base.

Non-sterilized interventions on the other hand will induce changes in the monetary base. These changes will in turn translate into changes in broader money aggregates and interest rates. This will affect expectations, capital flows and ultimately the exchange rate. Because of this, studies of intervention have generally focused on the effect of sterilized intervention.

2.2 Sterilized Intervention

A useful taxonomy of how sterilized intervention affects the exchange rate is broadly divided into two. These are often referred to as the portfolio balance channel and the signaling channel.

The Portfolio Balance Channel

The basic idea behind this channel is that investors balance their portfolios between domestic and foreign assets on the basis of their expected returns and the risk associated with those returns. The key distinguishing feature in the approach is the assumption of different risks associated with local and foreign assets. The channel operates by changing the relative supplies of these assets and thereby the relative riskiness. Sterilized foreign exchange interventions will have little or no effect on interest rates since, by definition, it will not affect the money supply. However, it will change the relative supplies of these assets.

The exchange rate will then shift to affect the domestic value of foreign assets and the expected return for holding them as investors try to re-balance their portfolios in the asset market. It is important for the portfolio balance channel that foreign and domestic assets have different returns and risk levels. Without this assumption, domestic and foreign assets become perfect substitutes and investors will be indifferent between them with no need to re-balance their portfolios after an intervention.

Studies testing the portfolio balance channel have used two main approaches. The first is a direct test of the model by estimating a reduced form solution of the portfolio balance model called the demand approach. The second approach focuses on an indirect method by solving the portfolio balance model for the risk premium and testing for perfect substitutability of bonds denominated in different currencies. Most traditional approaches have not provided strong evidence for this channel despite many attempts to overcome the perceived econometric problems encountered in estimating these models (Rogoff, 1984; Danker et al., 1996; Lewis, 1988b; Gosh, 1992).

An approach pioneered by Frankel (1992), extends the traditional approach by incorporating mean variance optimization. This approach links expected rates of return with bond supplies by requiring that the coefficients of an inverted asset demand function be closely related to the variance-covariance matrix. This approach and the extensions made to this approach failed to yield support for the channel (Engle and Frankel, 1984; Lewis, 1988a; Engle and Rodriguez, 1989). The study by Dominguez and Frankel (1993) finds that intervention is statistically significant in a regression for the risk premium providing strong support for the portfolio balance. This study attempted to overcome some of the major problems encountered in previous studies. Actual intervention data was used and survey data was used instead of invoking expectations.

Signaling Channel

This channel contends that even when there is perfect substitutability between domestic and foreign assets, intervention can still affect the exchange rate through expectations (Mussa, 1981). The basic idea is that agents see exchange rate intervention as an indicator of future monetary policy. When there is intervention, agents change their exchange rate expectations because they expect a change in future monetary policy due to the intervention.

Investigation of the signaling hypothesis has taken two main strands. The first strand studies the impact of intervention on the exchange rate expectations in the context of portfolio balance models, while the second strand focuses on whether or not intervention actually signals monetary policy. The early studies by Humpage (1989) and Dominguez (1990), generally find mixed results. In their 1993 study, Dominguez and Frankel (1993) test both the signalling and portfolio balance hypotheses. They find significance of both channels. More recent studies include those of Kaminsky and Lewis (1996), Bonser-Neal and Tanner (1996) and Dominguez (1998). Kaminsky and Lewis (1996) examine the signalling story by checking whether or not central bank intervention signals future monetary policy. They find that indeed intervention provides significant information about future monetary policy but the signal is in a direction opposite to that predicted by the signalling hypothesis.

The two latter studies focus on the impact of intervention on the volatility of exchange rates. Bonser-Neal and Tanner (1996) test the hypothesis that central bank intervention is stabilizing. Generally they find that intervention affects exchange rate volatility but in a destabilizing way. Apart from one sub-period, all the coefficients on intervention in a volatility equation were positive. Dominguez (1998) finds similar results.

The general formulation of the exchange rate follows Dominguez (1998) and models exchange rates as a forward-looking process conditional on public information.
Given $S_t = \Sigma\Delta E_t(Z_t + k/R_t$, where St is the nominal spot exchange rate in logs, Δ is the discount factor, E_t is the expectations; Zt a vector of exogenous variables; Rt is the public information set at time t. In the case of the portfolio balance approach, foreign exchange interventions lead people to re-balance their portfolio due to changes in their relative portfolio compositions so that the effect of intervention can enter as an exogenous variable in the vector Z. Under signalling on the other hand, intervention provides additional information to the market so that $R < R + I_t$ where It is foreign exchange

intervention. This new information will change market agents' expectations translating ultimately into changes in the spot rate, St.

Inherent in the equation above is the assumption that exchange rates are efficient aggregators of information and market expectations are rational so that any hypothesis test based on this equation involves a joint hypothesis that the foreign exchange market is economically efficient (Dominguez, 1998). Implicit also in the signalling interpretation above is the hypothesis that intervention signals are credible and unambiguous. In both cases, reality may be otherwise. In Nigeria, actions of the monetary policy authority may be conflicting. For example, it is not clear to a market agent when the CBN buys foreign exchange whether this is signalling future monetary policy or foreign reserves accumulation. In this case a market purchase of the dollar is an ambiguous signal.

Empirical work on the effect of exchange rates has used a number of different approaches. Simatele (2003) regressed the spot exchange rate on intervention variables. He uses different approaches to test the impact of exchange rates on the volatility of exchange rates, particularly; he uses the contemporaneous value and one lag of the intervention variable. This approach may be relevant to Nigeria. For instance, Nigeria financial asset markets are underdeveloped and investment is often associated with political risk. With this is in mind, exchange rate movements are more likely to be important for local exporters and importers of goods and services. In this case, volatility in exchange rates is likely to result from speculative band wagons and changes in expectations about future market fundamentals.

2.3 Brief History of the Nigerian Foreign Exchange Market

Nigeria has practised both fixed and flexible exchange rates. Between 1960 and 2000, exchange rate policy in Nigeria has fluctuated from a fixed exchange rate system (1960-1986) to a flexible exchange rate system (1986-1993). However, there was regulation in 1994 with the pegging of official exchange rate and the reversal of policy in 1995, which has been tagged ‘guided deregulation’ of the exchange market. With this exchange rate was liberalized and a dual exchange rate mechanism was instituted in 1997 and 1998. This policy thrust was retained except that all official transactions, other than those approved by the President were undertaken at the Autonomous Foreign Exchange Market (AFEM). As a result, transactions at the pegged official exchange rate were relatively minimal.

However, due to market imperfections and continuous instability in the exchange rate of the naira, the AFEM was replaced with an Inter-bank Foreign Exchange Market, (IFEM) in October 1999, after short period of co-existence. Under the IFEM system, oil companies were allowed to place their foreign exchange resources in banks of their choice, as against the AFEM conditions where they were mandated to place such funds with the Central Bank of Nigeria (CBN). There has been a continuous fine-tuning of IFEM by the CBN to make it more effective and efficient to the financial market. As part of this process, international dealing agency was permitted to transact foreign exchange business on travelers’ cheques in Nigeria with the aim of deepening the market and reduce undesirable impact of the parallel market.

By July 2002, the Dutch Auction System (DAS) of foreign exchange management was introduced to replace IFEM. The main objective of IFEM was to devalue the naira,

moderate imports, and consequently strengthen the balance of payment while at the same time reduce the parallel market premium. Since the introduction of DAS, the naira has lost value significantly, the parallel market premium, narrowed, but it has not limit the appetite of Nigerian's for foreign goods and persistent demand for foreign exchange.

Parallel market in Nigeria is dated back to 1970s when the use of British pound sterling was stopped and subsequent adoption of naira as a national currency. There are two schools of taught to the origin of parallel market in Nigeria. Some believed that it started from Lagos Island (around Ereko Street) while others were of the opinion that it started in Kano (Wafa area). While the currency that was believed to be used in the Lagos black market then was French franc, the currency that was used in Kano was the Saudi Riyah. The reason for the differences in currencies in these locations was that customers at the two locations were businessmen and women from Benin Republic, and pilgrims going to or coming from Saudi Arabia in the case of Kano.

During this period, however, the market had no impact on the economy until after the deregulation of 1986 which marked a radical departure from the previous era. During this period of deregulation, the naira was let loose to the whimsical vagaries of market forces. This, however, brought about insatiable demand for hard currencies which made its supply grossly inadequate compared with the demand, thereby creating a yawning gap between demand and supply of foreign exchange. As a result of this gap, the parallel market flourished. It plummeted the naira and made it weak, compared to other foreign currencies. Before the deregulation of the foreign exchange market in 1986, there existed parallel market but its activities were not so pronounced nor did it have any significant impact on the stability of the naira exchange rate. One can say, therefore, that there were no serious balance of payments problems in the country until the late 70s and early 80s.

However, when government deregulated the economy as a result of serious economic predicaments, the foreign exchange market was equally deregulated to allow market forces determine the appropriates exchange rate for the naira. Hence, some were of the opinion that the naira was seriously overvalued. It was in this era that the activity of parallel market flourished, because government through CBN could not adequately provide enough foreign exchange to meet the increasing demand in the market and coupled with the procedures that were involved and the guidelines especially as these related to the sectoral allocation of the foreign exchange. A lot of foreign exchange users then resorted to patronizing the parallel market in which the rate was usually higher than the FEM rate. In spite of the risk associated with transacting business in the black market, which includes buying fake currency, people still continue to patronize the market since the official market was not able to provide enough foreign exchange to the market.

In order to ensure a stability of naira, CBN licensed more Bureau de Change in 2006 and empowered them to sell foreign exchange to interested importers. Also, CBN was able to ease out the problem of scarcity of foreign exchange faced by genuine importers by designating CBN branches to sell directly to customers. With this, CBN was able to stabilize naira against other currencies.

3 Methodological Framework and Sources of Data

3.1 Data Sources

The study relies on historical quantitative data, which are available in secondary form. The study employs quarterly time series data spanning between 1986:1 and 2003:4. The variables used, which include cumulative net foreign assets, cumulative aid, broad money supply and gross domestic product, are obtained from International Financial Statistics (IFS), the publication of International Monetary Fund and it is supplemented with CBN Statistical Bulletin, the publication of Central Bank of Nigeria. Further explanations on these variables are necessary.

Intervention is measured as open market dealings in the foreign exchange market by the CBN. These interventions are done purposely to smoothing exchange rate movements. Official statistics distinguish between such foreign exchange intervention and interventions meant for other purposes, such as accumulation of reserves and debt servicing. It is known that central banks are reluctant to release high frequency intervention data and when released it is usually with a lag (Gosh 2002, Dominguez (1998). With the high level of secrecy in intervention operations, it is probable that the statistics may not accurately distinguish between the various types of interventions in which the central bank is involved. We are unable to obtain on both announced and secret interventions. Thus, the study uses net foreign assets as a proxy for interventions in line with other studies (see Kearney and Macdonald, 1985; Von Hegen, 1989 and Sarno and Taylor, 2001).

Aid is measured as donor inflows as shown in Central Bank of Nigeria (CBN) official statistics. The net foreign assets and aid data are shown in millions of naira. Cumulative series for these variables are used in preference to net foreign assets and aid series because it allows us to capture cumulated effects of these variables over time (Simatele, 2003). Broad money is measured as the sum of currency plus demand deposit plus time and savings deposits. The quarterly output series is obtained by interpolating using Sandee, 2003 (quoted form Turker, 2004). To reflect the structural breaks in the economy over time, a dummy variable was introduced in the model.

3.2 Model Specification

To determine whether or not foreign exchange intervention is sterilized, the paper checks if it has an effect on the growth of monetary aggregate (broad money, M_2). In the estimation, the paper considers the outliers identified in the data. A dummy for outliers in both the cumulative net foreign assets and aid series are created. For the aid and cumulative net foreign asset variables, the paper calls this "dummy" which takes the value of one for the 1993 to 1995 (when there was intervention in the Nigerian foreign exchange market) and zero for the rest of the estimation period. The paper then regresses the growth of the broad money (M_2) on cumulative aid (cAID), cumulative net foreign assets (cNFA), output (GDP), and the dummy (Dum). E is the error term.

$$M_2 = a_0 + a_1 cNFA + a_2 cAID + a_3 GDP + a_4 dum + E \quad \ldots\ldots (1)$$

Equation 1 is estimated using vector autoregressive technique. The equation is a standard way of checking for sterilization with a measure for the income gap (Kearney and Macdonald, 1985; Von Hagen, 1989; Sarno and Taylor, 2001). Most of the early studies that investigated issues of sterilization used net foreign assets as a measure of intervention in the absence of actual intervention data (see Kearney and Macdonald, 1985; Von Hegen, 1989 and Sarno and Taylor, 2001). This paper follows this approach since information on actual intervention data is absence in Nigeria.

The paper specifies unrestricted over-parameterized equations with an inclusion of one-lag error correction term. From the over-parameterized model, which usually deals with problems of mis-specifications, the paper derives a parsimonious model through stepwise reduction of relatively insignificant parameters until parsimony is obtained. The co-integrated Equation 1 is re-specified as an ECM using Engel-Granger two-step method (lagged residual as error correction term). The economic model (Eq. 1) is transformed into an econometric model under ECM framework in Equation 2.

$$\Delta (M_2)_t = h_0 + \sum_{i=0}^{p} h_{1i}\, \Delta cNFA_{t-i} + \sum_{i=0}^{p} h_{2i}\, \Delta M_{2t-i} + \sum_{i=0}^{p} h_{3i}\, \Delta cAID_{t-i} + \sum_{i=0}^{p} h_{4i}\, \Delta GDP_{t-i} + \sum_{i=0}^{p} h_{5i}\, \Delta dum_{t-i}$$

$$+ h_6 NFA_{t-1} + h_7 M_{2\,t-1} + h_8 cAID_{t-1} + h_9 GDP_{t-1} + h_{10} dum_{t-1} + h_{11} ECM_{t-1} + E_t \ldots\ldots\ldots\ldots (2)$$

Where ECM is the error correction term (lagged residual of static regression) and 'Δ' stands for first difference. All the variables in the equation are stationary and therefore OLS method gives consistent and valid estimates (Enders, 1995). The model is estimated by OLS method and the residual is tested for autocorrelation error. The model makes use of quarterly time series data and has lagged dependent variable as explanatory variable. Stability and residual tests are conducted to evaluate the predictive accuracy of the model.

3.3 Econometric Framework

There are several methods available for conducting the cointegration test. The most widely used methods include the residual based Engle-Granger (1987) test, and maximum likelihood based Johansen (1991) and Johansen-Juselius (1990) tests. The Engle-Granger cointegration test consists of a two-step procedure. In the first step, the residual error is tested for stationarity. Variables A and B might individually be non-stationary but if the estimate of their residual error is stationary, A and B are said to be cointegrated. It implies that A and B form a long run relationship and the regression is not spurious. Engle and Granger (1987) have shown that any cointegrated series has an error correction representation. Therefore, if the residual error of the estimation in the first step is stationary, the error correction model can be estimated. In the second step, the error correction model is estimated, which represents the short run dynamics of the

model. Thus, this two-step procedure covers both long run equilibrium and the short run adjustment process.

The residual-based cointegration tests are inefficient and can lead to contradictory results, especially when there are more than two I(1) variables under consideration (Pesaran and Pesaran1997, p.291). Therefore, Johansen (1991) and Johansen and Juselius (1990) tests are used in multivariate case. These tests are based on the maximum likelihood procedure and provide a unified framework for testing of cointegrating relations in the context of vector auto regressive (VAR) error correction models.

Johansen proposes two tests to determine the number of cointegrating vectors. The first is the likelihood ratio test based on the maximal eigenvalue and the second is the likelihood ratio test based on the trace test. The power of the trace test is lower than the power of the maximal eigenvalue test (Johansen and Juselius 1990). If the null hypothesis of no cointegrating vector can be rejected, it indicates that there is a long run relationship among the variables in the model. As a result, the error correction mechanism can be presented. The above methods require that the variables in the system be of equal order of integration. These methods do not include the information on structural break in time series data and also suffer from low power. Due to these problems associated with the standard test methods, the OLS based autoregressive distributed lag (ARDL) approach to cointegration has become popular in recent years.

3.3.1 ARDL Modelling Approach

The ARDL modelling approach[1] popularised by Pesaran and Pesaran (1997), Pesaran and Smith (1998), Pesaran and Shin (1999), and Pesaran *et al.* (2001) has numerous advantages. The main advantage of this approach lies in the fact that it can be applied irrespective of whether the variables are I(0) or I(1) (Pesaran and Pesaran 1997, pp.302-303). Another advantage of this approach is that the model takes sufficient numbers of lags to capture the data generating process in a general-to-specific modelling framework (Laurenceson and Chai 2003, p.28). Moreover, a dynamic error correction model (ECM) can be derived from ARDL through a simple linear transformation (Banerjee *et al.* 1993, p.51). The ECM integrates the short-run dynamics with the long-run equilibrium without losing long-run information. It is also argued that using the ARDL approach avoids problems resulting from non-stationary time series data (Laurenceson and Chai 2003, p.28).

This paper illustrates the ARDL modelling approach by considering Equation 1:

$$M_{2t} = a_0 + a_1 cNFA_t + a_2 cAID_t + a_3 GDP_t + a_4 dum_t + E_t \quad \ldots\ldots (1)$$

where M_2, cNFA, cAID, GDP_t and dum are five different time series; E_t is a vector of stochastic error terms; and a_0, a_1, a_2, a_3 and a_4 are the parameters. For the above equation, the error correction version of the ARDL model, as given in Equation 2 is:

$$\Delta (M_2)_t = h_0 + \sum_{i=0}^{p} h_{1i} \Delta cNFA_{t-i} + \sum_{i=0}^{p} h_{2i} \Delta M_{2t-i} + \sum_{i=0}^{p} h_{3i} \Delta cAID_{t-i} + \sum_{i=0}^{p} h_{4i} \Delta GDP_{t-i} + \sum_{i=0}^{p} h_{5i} \Delta dum_{t-i}$$

$$+ h_6 NFA_{t-1} + h_7 M_{2\,t-1} + h_8 cAID_{t-1} + h_9 GDP_{t-1} + h_{10} dum_{t-1} + h_{11} ECM_{t-1} + E_t \ldots\ldots\ldots\ldots (2)$$

The first part of equation (2) with h_1, h_2, h_3, h_4, and h_5 represents the short run dynamics of the model whereas the second part with h_6, h_7, h_8, h_9 and h_{10} represents the long run relationship. The null hypothesis in the equation is $h_6 = h_7 = h_8 = h_9 = h_{10} = 0$, which means the non-existence of the long run relationship.

3.3.2 ARDL Model Testing Procedure

The ARDL model testing procedure starts with conducting the bound test for the null hypothesis of no cointegration. The calculated F-statistic is compared with the critical value tabulated by Pesaran and Pesaran (1997) or Pesaran *et al*. (2001). If the test statistic exceeds the upper critical value, the null hypothesis of no long-run relationship can be rejected regardless of whether the underlying orders of integration of the variables are zero or one. Similarly, if the test statistic falls below a lower critical value, the null hypothesis is not rejected. However, if the sample test statistic falls between these two bounds, the result is inconclusive. When the order of integration of the variables is known and all the variables are I(1), the decision is made based on the upper bound. Similarly, if all the variables are I(0), then the decision is made based on the lower bound.

The ARDL method estimates $(p+1)^k$ number of regressions in order to obtain optimal lag length for each variable, where p is the maximum number of lag to be used and k is the number of variables in the equation. The model can be selected using the model selection criteria like Schwartz-Bayesian Criteria (SBC) and Akaike's Information Criteria (AIC). SBC is known as the parsimonious model: selecting the smallest possible lag length, whereas AIC is known for selecting the maximum relevant lag length.

In the second step, the long run relationship is estimated using the selected ARDL model. When there is a long run relationship between variables, there exists an error correction representation. Therefore, in the third step, the error correction model is estimated. The error correction model result indicates the speed of adjustment back to the long run equilibrium after a short run shock.

To ascertain the goodness of fit of the ARDL model, the diagnostic test and the stability test are conducted. The diagnostic test examines the serial correlation, functional form, normality and heteroscedasticity associated with the model. The structural stability test is conducted by employing the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ). Examining the prediction error of the model is another way of ascertaining the reliability of the ARDL model. If the error or the difference between the real observation and the forecast is infinitesimal, then the model can be regarded as best fitting.

4.0 Empirical Analysis

The paper examines the characteristics of the variables used to establish whether or not the variables are stationary at level; and if not whether or not stationarity can be induced by differencing the variables once or twice.

4.1 Unit Root Tests

Table 1 shows the unit root tests using the Phillip-Perron (1988) method. The series includes the broad money, cumulative net foreign assets, gross domestic product, and cumulative aid. All variables are expressed in natural logs. From the casual inspection of the series, three of the series exhibit some non-stationarity. The unit root test suggests that three of the variables are integrated of order one and they are stationary at first differences. Cumulative aid is stationary at second difference.

Table 1: Phillip Perron Unit Root Tests

Variable	Levels	1st difference	Integration order
M_2	-1.45	-6.26*	I(1)
cNFAn	.1.05	-10.91*	I(1)
cAID	-2.10	-2.08	I(2)
GDP	-0.29	-16.12*	I(1)

Source: Own Computation

Note: M_2 is the growth of the broad money; cAID stands for cumulative aid; cNFA represents cumulative net foreign assets; GDP is the gross domestic product (GDP), dum is the dummy variable.

*Significant at 1% level of significance

Table 2 reports the estimates of Johansen procedure and standard statistics. In determining the number of cointegrating vectors we used degrees of freedom adjusted version of the maximum eigenvalue and trace statistics. These test statistics strongly rejects the null hypothesis of no cointegration in favor of one cointegration relationship for maximum eigenvalues and two co-integration relationships for trace statistic.

Table 2: Johansen Co-integration Tests

Eigenvalues	0.472967	0.253907	0.128817	0.034571
Hypothesis	R = 0	r ≤ 1	r ≤ 2	r ≤ 3
λmax	43.55349*	19.91753	9.377448	2.392422
95% critical Values	27.58434	21.13162	14.26460	3.841466
λtrace	75.24089*	31.68740*	11.76987	2.392422
95% critical. Values	47.85613	29.79707	15.49471	3.841466

Notes: VAR includes four lags on each variable and a constant term. The estimation period is 1986:1-2003:4. None of the deterministic variable is restricted to the co-integration space; the λ_{max} and λ_{trace} are maximum eigenvalue and trace test statistics, adjusted for degrees of freedom. The critical values are taken from Osterwald-Lenum (1992). The * indicates rejection of likelihood ratio tests at 5%significance level.

To examine the existence of structural breaks, the paper presents the line graphs of the variables in logs form and first differences in Figures 1 and 2 respectively. From Figure

2, we identify some outliers especially in the cumulative aid and cumulative net foreign assets.

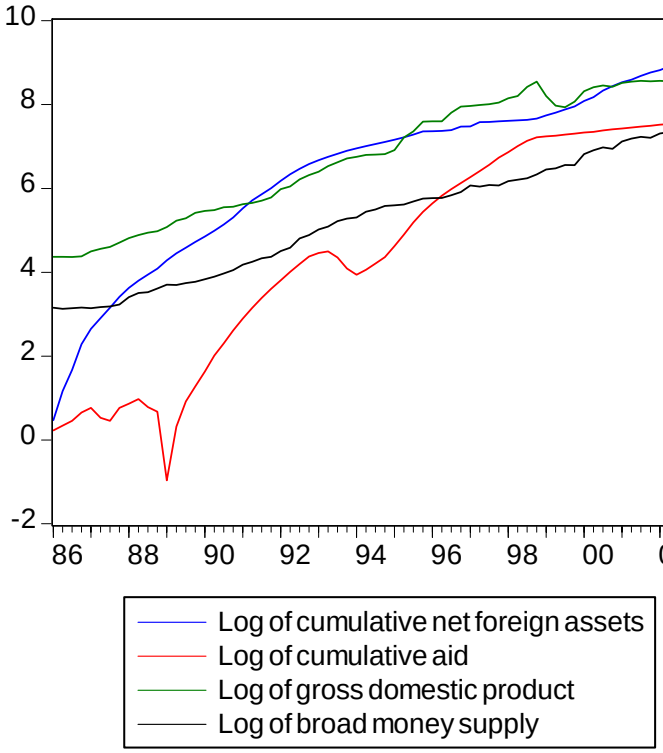
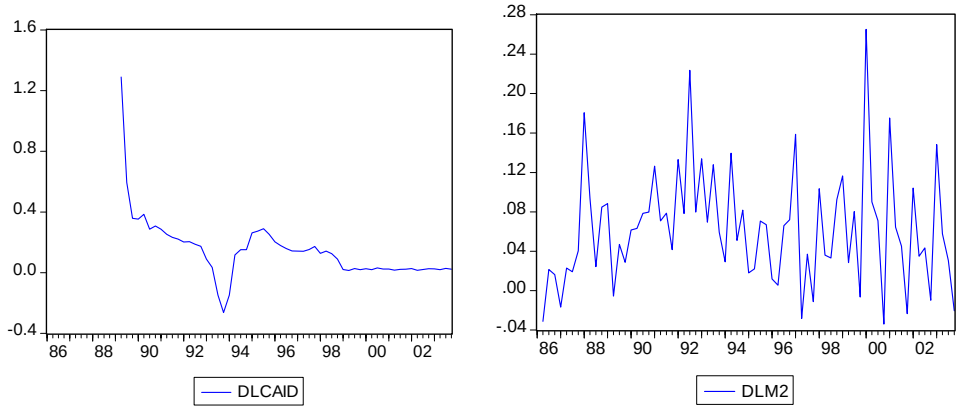


Figure 1: Quarterly series of cumulative net foreign assets (CNFA), cumulative aid (CAID), broad money supply (M_2) and gross domestic product (GDP) in Logs.

For the aid series, this occurs in third quarter of 1993 (see Figure 2). The paper also observes unusually high values for growth in cumulative net foreign assets reflecting periods of high levels of intervention in the foreign exchange market. This is observed between 1996 and 1997 (see Figure 2). To take care of these structural breaks, the paper includes dummy variable in the model.



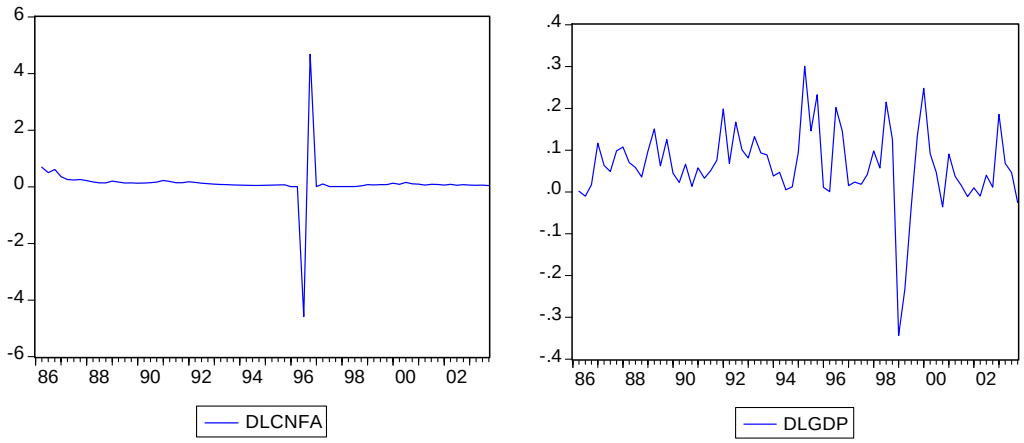


Figure 2: First Difference of the growth of M_2, GDP, Cumulative AID and Cumulative Net Foreign Assets on Quarterly Series

4.2 Pair-wise Granger Causality Test

Pair-wise Granger causality test on growth of broad money supply (M_2), GDP, cumulative aid, and cumulative net foreign assets are presented in Table 3.

Table 3: Pairwise Granger Causality Tests

Sample: 1986:1 2003:4
Lags: 2

Direction of causality	F-Value	Decision
GDP -→ LM_2	1.28058	Do not reject
M_2 -→GDP	3.55710	Reject
cNFA -→M_2	2.02798	Do not reject
M_2 -→ cNFA	1.00949	Do not reject
cAID-→ M_2	0.27310	Do not reject
M_2-→ cAID	4.96383	Reject
CNFA -→ GDP	0.39979	Do not reject
GDP -→ cNFA	0.99630	Do not reject
CAID-→ GDP	0.39404	Do not reject
GDP-→ cAID	2.83886	Do not reject
cAID-→ cNFA	4.37913	Reject
cNFA -→ CAID	1.28611	Do not reject

Source: Own Computations
Note: Variables are as defined in Table 1

The null hypothesis in each case is that variable under consideration does not 'Granger-cause' the other variable. The Pairwise Granger causality tests were inconclusive at 5 per cent level of significance. The results alternated between bi-directional, no causality and uni-directional, depending on the lag length allowed. The outcome in respect of two-lag length is presented in Table 3.

The results suggest that the direction of causality is from money growth to GDP growth; from money growth to cumulative aid growth; and from cumulative aid growth to cumulative net foreign assets growth since the estimated F is significant at the 5 percent level. However, there is no 'reverse causation' from cumulative aid to money growth since the estimated F is insignificant. Also, there is no discernable relationship between growth of money and cumulative net foreign assets growth. This shows that broad money is not determined by net foreign assets and cumulative aid. This confirms that foreign exchange market in Nigeria is sterilized.

4.3 Long Run Static Regression on Broad Money Supply

The Table 4 presents the results from estimation of the equation in static form.

Table 3: Long Run Static Regression of Broad Money Supply LM_2), 1986:1- 2003:4

Dependent Variable: LM_2
Method: Least Squares
Sample(adjusted): 1989:1 2003:4
Included observations: 60 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DUMMY	0.016381	0.074440	0.220059	0.8266
LCAID	-0.018638	0.052597	-0.354359	0.7244
LCNFA	0.202164	0.041579	4.862118	0.0000
LGDP	0.803393	0.093976	8.548931	0.0000
C	-1.452003	0.429390	-3.381553	0.0013
Adjusted R-squared	0.967014			
Akaike info criterion	-0.121328			
Schwarz criterion	0.053201			
Durbin-Watson stat	0.793210			

Source: Own Computations
Note: Variables are as defined in Table 1

The adjusted coefficient of determinations (R^2), t-statistic and the Durbin-Watson statistics are shown in the Table. It is observe from the Table 4 that while the while cumulative net foreign assets (cNFA) is significant in broad money supply (LM_2) equation, cumulative aid (cAID) is statistically insignificant. Thus, the paper does not totally support the hypothesis that foreign exchange market intervention by the Central Bank Nigeria in sterilized.

To further verify the effect of foreign exchange intervention on monetary aggregates, M_2, the paper estimates the error correction model in Equation 2.

4.4 Error-Correction Model (ECM) of Broad Money Supply, M_2

In order to capture the short-run deviations that might have occurred in estimating the long-run co-integrating equation, a dynamic error-correction model is estimated in Table 4.

Table 4: Over-parameterized Error Correction Model on Broad Money Supply

Dependent Variable: D(LM2,1)
Method: Least Squares
Sample (adjusted): 1986Q3 2003Q4
Included observations: 70 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LM2(-1),1)	-0.067668	0.127456	-0.530909	0.5975
D(DUMMY,1)	0.064943	0.040706	1.595402	0.1160
D(DUMMY(-1),1)	0.030356	0.041248	0.735950	0.4647
D(LCAID,1)	-0.031500	0.023616	-1.333837	0.1874
D(LCAID(-1),1)	0.007942	0.024162	0.328706	0.7435
D(LCNFA,1)	0.007941	0.010151	0.782347	0.4371
D(LCNFA(-1),1)	0.012011	0.009833	1.221500	0.2268
D(LGDP,1)	0.143391	0.086080	1.665785	0.1011
D(LGDP(-1),1)	0.051825	0.089403	0.579674	0.5643
ECM(-1)	-0.058822	0.033315	-1.765633	0.0826
C	0.055024	0.012700	4.332606	0.0001

Source: Own computations

Note: Variables are as defined in Table 1

Since the paper is not focusing on the coefficients of all the explanatory variables of M_2, the paper placed emphasis on the coefficients of cumulative aid (cAid), GDP, cumulative net foreign assets (cNFA) and error correction term. The paper finds that neither the coefficients of current and previous net foreign assets nor the aid variables are significant at 5 per cent. The proxy for the income gap, GDP is also insignificant. The coefficient of ECM_{t-1} is found to be small in magnitude and is statistically significant at 10 per cent level. It confirms a long run relationship between the variables. The coefficient of ECM term is -0.059, which suggests a slow adjustment process. Nearly 6 per cent of the disequilibria of the previous quarter's shock adjust back to the long run equilibrium in the current quarter.

Since the cumulative net foreign assets and aid variables are insignificant, we concluded that there is sterilization of foreign exchange intervention in Nigeria. That is, foreign exchange intervention has no effect on the growth of broad money in Nigeria.

4.5 Diagnostics Tests

To confirm the robustness of the model, the paper performs the following diagnostic tests.

4.5.1 Key Regression Statistics:

R-squared	0.194010	Mean dependent var	0.063854
Adjusted R-squared	0.057402	S.D. dependent var	0.058066
S.E. of regression	0.056375	Akaike info criterion	-2.770249
Sum squared resid	0.187511	Schwarz criterion	-2.416914
Log likelihood	107.9587	F-statistic	1.420194
Durbin-Watson stat	1.919105	Prob(F-statistic)	0.194078

Source: Own Computations

The low value of R^2 shows that the overall goodness of fit of the models is not satisfactory. The Akaike information criteria and Schwarz criterion show that the model is correctly specified. F-statistics measuring the joint significance of all regressors in the model is statistically insignificant at the 1 per cent level. Similarly, the Durbin-Watson statistics is almost 2.

4.5.2 Diagnostic Test Statistics:

Serial Correlation F(2, 57) = 0.4653 (0.399)
Normality (JB) $\chi 2$ (2) = 9.0805 (0.0106)
Heteroscedasticity F(20,49) = 1.3397 (0.1945)
ARCH Test F(1, 67) = 0.1957 (0.6596)

Application of Jarque-Bera (JB) is about 9.081, and the probability of obtaining such a statistic under the normality assumption is about 1 percent. Therefore we do reject the hypothesis that the error terms are normally distributed. The result indicates that there is no serial correlation and heteroscedasticity in the model since F statistic is statistically insignificant at 5 percent. The ARDL model has been shown to be robust against residual autocorrelation. Since the time series in the equation are of the same order of integration, i.e., and I(1), it is natural not to detect heteroscedasticity.

4.5.3 Plot of CUSUM and CUSUMSQ (Stability Test)

The plots of the stability test results (CUSUM and CUSUMSQ) of the ARDL model are given in Figure 4 (a) and 4 (b). The CUSUM and CUSUMSQ plotted against the critical bound of the 5 per cent significance level show that the model is stable over time.

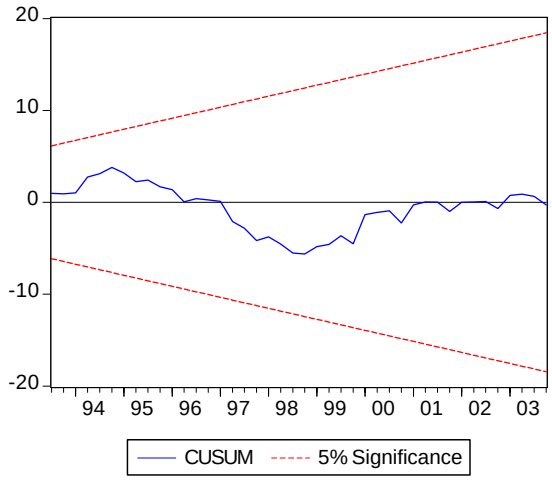


Fig. 4(a): Plot of Cumulative Sum of Recursive Residuals

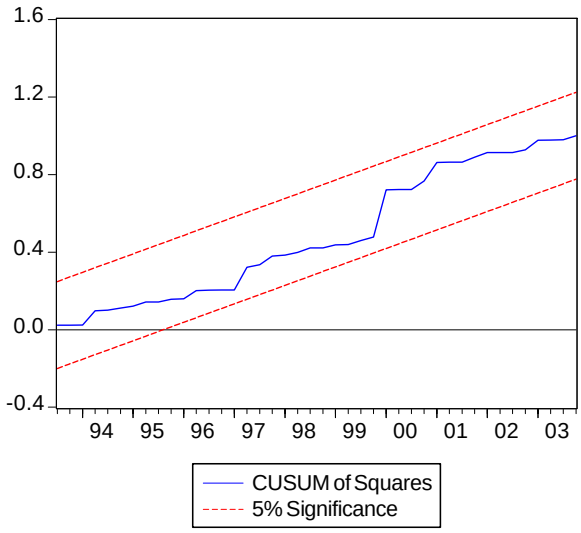


Figure 3(b): Plot of Cumulative Sum of Squares of Recursive Residuals

5 Summary, Conclusion and Recommendations

This paper investigates the impact of Central Bank of Nigeria's intervention in the Nigerian foreign exchange market to see if intervention, in Nigeria, is sterilized or not. The paper carries out different techniques to verify this hypothesis. The results indicated that, indeed, there is sterilization as the net foreign assets variable is not significant. Since aid forms a significant foreign exchange inflows, we also included this variable in the model estimated and found that this variable also has no effect on broad money.

In the analysis, we have concentrated on the short run effects of intervention on the monetary aggregate, M_2. Some observers have argued that although full sterilization can be achieved in the short run, there may not be full sterilization in the long run (Simatele, 2003). Inability to achieve full long run sterilization may have thrown more weight to exchange rate considerations. In a study of sterilization in Germany, for example, Von

Hagen (1989) found that the Bundesbank sterilizes in the short run but not in the long run. This is even more likely in the case for Nigeria since political interference in preference for stable exchange rates over achieving monetary goals is sometimes very significant. The focus on short-term sterilization in this study is sufficient for analyzing the effect of intervention on the short-term fluctuations in the exchange rate.

On this basis the paper proffers the following recommendations. First, the use of stock of external reserves to support the exchange rate through increased funding of the foreign exchange market should be encouraged. This is feasible, as an interim measure, with the current stock of external reserves estimated at over US$ 43 billion. The sterilization of the resulting naira revenue will be helpful to control inflation.

Second, the deregulation of the foreign exchange market must be properly guided. The major lesson from the market-determined exchange rate experience is that the exchange rate cannot be left to market forces alone. We should not assign to those forces in our economy a role, which is very much beyond them. Therefore, the market has to be properly guided, through strategic interventions, to ensure orderliness and proper and equitable allocation of foreign exchange resources.

Third, there should be discipline and harmony between fiscal and monetary policy. Expansionary monetary and fiscal policies in the past worsen exchange rate depreciation. It is, thus, important that monetary and fiscal policies are properly coordinated and harmonized in order to achieve macroeconomic stability. The situation should be avoided whereby monetary policy adjusts passively to the expansionary fiscal operations of the government. As government spending has a direct relationship with the exchange rate, it is necessary to rationalize and restructure government expenditure towards productive activities and reduce the fiscal deficits significantly (Obadan, 2002).

Fourth, government should include in its policy objectives the pursuance of ‘weak’ exchange rate targeting. Fixing exchange rate at all costs should be discouraged. This is because a policy of fixing exchange rate without any regard for inflation is misguided. Also, a policy of raising interest rates to control inflation without any regard to what is happening to the exchange rate should not be tolerated. Some flexibility in the exchange rate should be welcomed since it enables a country to cope with macroeconomic shocks arising from policy changes. It also helps in preventing ‘speculative bubbles' in the foreign exchange market, which might otherwise cause destabilizing movements in the exchange rate (Wren-Lewis (1997).

Lastly, government should eschew unhealthy speculation in the foreign exchange, as well as rent-seeking behavior, and adopt positive attitudes that are geared towards ensuring stable naira exchange rate.

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