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MONEY DEMAND AND FOREIGN EXCHANGE RISK IN NIGERIA: A COINTEGRATION ANALYSIS USING AN ARDL BOUNDS TEST

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ABSTRACT

The paper estimates the money demand function that incorporates a foreign exchange risk variable for Nigeria using annual time series data (1970-2006). The applied technique of cointegration analysis is the bounds test which involves autoregressive distributed lags (ARDL). Consistent with economic postulates, it is found that (a) the demand for money in the log-run is cointegrated with real income, exchange rate variability, interest rate and inflation; (b) the short-run income elasticity is less than one but greater than zero; (c) inflation is more significant than real income in the money demand function; and (d) the real money demand function is stable.

JEL Classification: C13, C22, E41, E52, F31.

Key words: Bounds test, Money demand, Foreign exchange risk, Autoregressive distributed lags (ARDL), Inflation targeting, Nigeria.

1. INTRODUCTION

In a not too recent paper, Omotor and Orubu (2003) investigated the Nigerian money demand function using annual data from 1970 to 1998. The specifications extended the model of Akhtar and Putnam (1980)[1] by introducing distributed lags and slope dummy effects of exchange rate regimes. According to the results, exchange rate variability is not a significant determinant of money demand and that exchange rate deregulation as captured by the slope dummy in the equation is important in influencing real money demand.

The empirical results of Omotor and Orubu (2003) are based on standard regression methods that totally ignore the time series properties of the variables (such as testing for unit roots and cointegration); which may lead to model mis-specification and spurious regression results (Granger and Newbold, 1974). Expectedly, the results of such statistical inference may, thus, be misleading. In more modern literature on money demand (e.g., Choi and Oxley, 2004), it has been recognized that the persistence observed in the kind of variables included in the models is likely to be brought about by unit roots, and the analysis is typically based on cointegration methods, taking the potential non-stationarity of the time series into account. As further amplified by Juselius (2000), macroeconomic variables are mostly found to be non-stationary, and as such, standard regression methods are not feasible from an econometric point of view for their analyses. Rather, the most obvious choice should be cointegration analysis.

Consequent upon the above, the general objective of this study is to re-estimate the Nigerian money demand function integrating a foreign exchange risk variable for the period 1970 to 2006. The study further applies a more robust recently-developed estimation method—the bounds test—first proposed and applied by Pesaran, Shin and Smith (2001), built on the unrestricted error-correction model (UECM). The Pesaran, Shin and Smith (2001) approach also has an added value in the estimation of cointegration analysis involving autoregressive distributed lags (ARDL). The ARDL approach, as it should be noted, equally de-emphasizes the pre-testing of orders of integration. This gives further impetus for the present study, as the model specified by Omotor and Orubu (2003) incorporates distributed lags in order to derive speed of adjustment.

The UECM, which incorporates the bounds testing approach together with the ARDL modeling approach to cointegration analysis (Pesaran and Shin, 1998), according to Mah (2000), has some major advantages over the conventional cointegration approach[2] of Engle-Granger (1987) and Johansen-Juselius (1990). The bounds test, as the literature has it, can be applied to series, irrespective of whether the explanatory variables are $I(0)$ or $I(1)$, provided the endogenous variable is $I(1)$. Secondly, the technique is found effective for small samples, (as is the case of the present study) and, thus, it avoids the uncertainty about variable exogeneity, provided that the model is sufficiently augmented and allows for estimation of both the long-run (equilibrium) and short-run (dynamic) relationships among variables (Odhiambo, 2007).

Nigeria provides an interesting venue of this study for several reasons. First, Nigeria has achieved some economic progress in the last few years. This has been associated with the various economic reform programs particularly in the financial sector. Nigeria's annual economic growth rate over the last five years is 7.4% (2003-2007) with a 2007 estimated GDP (purchasing power parity) of USD296.1 billion.[3] Second, Nigeria in recent years has experienced some reasonable improvements and growth in her external reserves. Nigeria's stock of foreign exchange reserves reached USD64.8 billion in August 2008, which could finance about 16 months' worth of imports. This phenomenal growth attributable to the nation's favorable trade balance mainly driven by oil and non-oil exports (Abubaka, 2008) is unprecedented in the last two decades. Third, the naira exchange rate has experienced peaks and troughs; it has been relatively stable since late 2007. The exchange rate stood at about N116/USD as at end of September 2008 compared to N81.25/USD in 1996 and N133.66/USD in 2005. Some reasons that have been canvassed for the recent stability are the probability of major economies of the world slumping into recession and the recent banking sector reforms since mid-2000. There is, however, likelihood that a backlash of this may spill over into the Nigerian economy, since it is a highly import-dependent one. Lastly, Nigeria liberalized its economic institutions in the mid-1980s; thus providing a relatively sufficient amount of data (given the bounds test approach used in the study) to evaluate the impact of the policy shift on the economy.

Specifically, the objectives of this paper are three-fold. In the first place, the study seeks to determine the time-series properties of some variables during the period 1970-2006, particularly that of the regressand. This is to avoid the problem of spurious regression results, although as earlier mentioned, ARDL de-emphasizes the pre-testing of orders of integration. Secondly, the study examines the existence of a long-run relationship between Nigeria's real money demand and its determinants using the bounds tests methodology. This has some implications for policy formulation. Thirdly, the study also investigates the effect of Nigeria's foreign exchange variability on its real money demand balances. Variability in foreign exchange rate may invoke volatility which is detrimental in some ways to economic policy formulation. According to Maskus (1990, 85) foreign exchange rate volatility reduces the volume of international trade since it creates uncertainty over expected profits. In addition, volatility or instability has a consequence of increasing prices of internationally traded goods given the uncertainty that surrounds its anticipated behavior. In addition to the application of bounds test methodology for cointegration, the study shall also estimate an error correction specification that allows for determining the impact of the short- and long-run exchange rate variability on money demand to be clearly distinguished.

The remainder of the paper is organized as follows. Section 2 provides the model and describes the study's methodology. Section 3 presents the data used, while Section 4 discusses the empirical findings and provides some policy implications. Section 5 concludes the study.

2. A MODEL OF THE MONEY DEMAND FUNCTION AND THE METHODOLOGY OF THE STUDY

In modeling the money demand function for Nigeria, we simply follow the lead by Omotor and Orubu (2003) which extends the Akhtar and Putnam (A-P) (1980) model. According to the A-P hypothesis, changes associated with foreign exchange risk may have direct and indirect effects on the demand for domestic money. The direct effect is how agents of transactions respond to increase in risk associated with currency values with a tendency to diversify and hold smaller amounts of domestic money, while increasing their holding of foreign monies. On the other hand, the indirect effect impacts on the volume of international transactions as uncertainty increases cost of trade. It should be noted that the exact direction of the indirect effect has been a matter of debate. As enunciated further by Akhtar and Putnam (1980, 788):

> ". . . if the increase in the cost of international transactions reduces the volume of international transactions below what it otherwise would have been, then the demand for real balances is also reduced."

The implication of the estimated A-P results is that exchange risk tends not only to reduce demand for domestic money; it is also an important explanatory variable in money demand behavior.

The A-P model thus, demonstrates the importance of including foreign exchange risk in the money demand specifications given the view that increase in the risk associated with foreign exchange tends to decrease the demand for domestic money. Two critical issues raised in the study are the choice of variable to proxy foreign exchange risk and the specification of the money demand function (Akhtar and Putnam, 1980).

The two basic versions of the money demand functions investigated by the A-P model are:

(1) $\ln(M) = a_0 + a_1 \ln(Y/P) + a_2 R + a_3 \ln(VR) + a_4 \ln(P) + u_1$

(1a) $\ln(M/P) = b_0 + b_1 \ln(Y/P) + b_2 R + b_3 \ln(VR) + u_2$

where, M is currency in hands of the public and sight deposits, Y is nominal income, R is interest rate, VR is exchange rate risk or the standard deviation of daily \$/DM spot rates, P is general rise level, and u_1 and u_2 are the error terms. The variability variable (VR) in equation (1) is the extension and contribution by Akhtar and Putnam (1980) to the core monetary theory formulation. Further extension to the A-P model by Omotor and Orubu (2003), which they label as 'a distributed lag-augmented Akhtar and Putnam (DLAP)[4] model, is specified as:

(2) $$M_{dt} = \beta_0 + \beta_1 Y_t + \beta_2 R_t + \beta_3 VR_t + \beta_4 P_t + \sum_{t=1}^{n} \beta_5 M_{dt-i} + \varepsilon_1,$$
$$i = 1,2,\ldots,n;$$

where M_{dt} is real money balances for period t, Y_t is real gross domestic product (GDP) used as a measure of real income in period t, P_t is now inflation rate for period t and ε_1 is the error term. $M_{dt\text{-}i}$ is the distributed lags of the money demand variable. The justification for the incorporation of a distributed lag scheme according to Omotor and Orubu (2003) is that it enables the determination of the speed (coefficient) at which desired levels of money demand adjust to actual levels. This has implication for monetary policy formulation and implementation.

The results of Omotor and Orubu (2003) using Nigerian data, contradicted the A-P findings (using German data) that exchange rate variability is significant in the behavior of money demand. However, Omotor and Orubu support and confirm the traditional postulate and previous studies on the Nigerian experience that real income, interest rate and inflation are significant in the money demand function. In addition, the adjustment process as captured by the distributed lags gets support. The results of Omotor and Orubu, (2003) further encapsulate that the fixed exchange regime exerts some impact on the demand for real balances in Nigeria. The summary regression results of both Akhtar and Putnam (1980) and Omotor and Orubu (2003) are presented in Appendices 1 and 2, respectively.

The present study modifies the Omotor and Orubu (2003) model specification via the application of an unrestricted error correction model (UECM) specification; *à la* autoregressive distributed lag (ARDL) methodology. The UECM methodology is briefly summarized in sub-section 2.2.

2.1 STUDIES ON VOLATILITY MEASURES IN MONEY DEMAND SPECIFICATIONS

There exist a plethora of studies that have incorporated various measures of risks in the money demand functions. These studies for estimation purpose ascribe the motives of money demand to two behavioral assumptions—the transactions and asset or portfolio balance approaches (Saatcioglu and Korap, 2005). The transactions motive specify money's role as a medium of exchange. Money by this approach is viewed essentially as an inventory held for transaction purposes. The transaction cost of switching between money and other liquid financial assets justify holding such inventories, despite that other liquid assets may offer higher yields (Judd and Scadding, 1982; cited in Saatcioglu and Korap, 2005). Earlier popular studies that apply this approach are Baumol (1952) and Tobin (1956). Succinctly put, what this approach means is that the demand for money balances increase proportionally with the volume of transactions in the economy and decreases with the increase of returns in the alternative costs of holding money.

The portfolio balance approach explains that people hold money as a store of value, and money is just one of the various assets among which people distribute their wealth. These assets when held for a longer period in relation to the transaction motives possess expected rate of return whose probable ratio of returns against each other change over time. This is the risk factor that people take into cognizance in their distribution of wealth. The basic contribution of the portfolio balance approach as Branson (1989) argues is to enter the risk considerations explicitly into the determination of the demand for money function (see Saatcioglu and Korap, 2005). Some elegant empirical studies which in earlier times emphasize the importance of the risk factor in portfolio decision for the demand for money balances are Tobin (1958) and Friedman (1959).

The money demand function incorporates the risk factor in various forms, e.g., interest rate volatility, inflation uncertainty and exchange rate volatility. Interest rate uncertainty enters the money demand theory through the financial asset motive for holding money. An increase in the volatility of interest rates increases the risk of holding fixed-term interest paying securities. To reduce this risk, firms and households may thus wish to hold larger money balances (Garner, 1986).

Some empirical literature that incorporates the risk factor in the demand for money function focuses on several aspects of how individuals respond to uncertainty about inflation. Uncertainty raises the demand for money by increasing precautionary demand (Klein, 1977; and Blejer, 1979). If savers are interested in the real returns on assets, then the proposition that money is a safe asset is invalidated when uncertainty about inflation exist (Apergis, 1999). In the theory, inflation uncertainty affects the demand for money by weakening the power of money as a store of value as well as a unit of account.

How does foreign exchange risk impact on the demand for money? According to Akhtar and Putnam (1980), riskiness of currency values has a tendency to affect people's action to hold smaller amounts of domestic money. When this happens, money no longer serves as an optimal store of value for a given level of transaction, as the previous information content concerning international transactions is eroded. Maskus (1990) highlights that volatility in exchange rate reduces the volume of international trade as it creates uncertainty over expected profits. Foreign exchange volatility may also reduce foreign direct investment (FDI) as traders for fear of unanticipated exchange rate volatility would want to add a risk premium to the prices of internationally traded goods.

Several examples of studies that have incorporated the various form of risks in the traditional money demand balances are; Tobin (1958); Akhtar and Putnam (1980); Zilberfarb (1988); Apergis (1999), Bahmani-Oskooee and Ng (2002), Omotor and Orubu (2003); Saatcioglu and Korap (2005); and Yinusa and Akinlo (2009).

2.2 THE UNRESTRICTED ERROR CORRECTION MODEL (UECM) OR BOUNDS TESTS AS APPLIED TO THE MODEL

The autoregressive distributed lag (ARDL) model adopted in this paper is aimed at examining the existence of short- and long-run relationships between money demand and foreign exchange risk. Following Pesaran, Shin and Smith (2001) as applied in Keong, Yusop and Sen (2005), we constructed a vector autoregressive (VAR) of order q, denoted as VAR(q), for the following money demand function:

$$(3) \qquad w_t = \mu + \sum_{i=1}^{q} \beta_i w_{t-1} + \varepsilon_t;$$

where w_t is the vector of both x_t and y_t, y_t is the dependent variable defined as real money demand and $x_t = [Y_t, R_t, VR_t, P_t]'$ is the vector matrix which represents the set of explanatory variables as previously defined, $\mu = [\mu_y, \mu_x]$, t is a time or trend variable, and β_i is a matrix of VAR parameters for lag i. As noted by Pesaran, Shin and Smith (2001), y_t must be $I(1)$ but the explanatory variables can be either $I(0)$ or $I(1)$. A vector error-correction model (VECM) is developed as:

$$(4) \qquad \Delta w_t = \mu + \alpha_t + \lambda \mathrm{w}_{t\text{-}1} + \sum_{i=1}^{q\text{-}1} Y_i \, \Delta \mathrm{y}_{t\text{-}1} + \sum_{i=o}^{q\text{-}1} Y_i \Delta x_{t-1} + \varepsilon_t$$

Δ is the first-difference operator. The long-run multiplier matrix λ is partitioned as:

$$\lambda = \begin{bmatrix} \lambda yy & \lambda yx \\ \lambda xy & \lambda xx \end{bmatrix}$$

The elements of the diagonal matrix, if unrestricted, implies that the selected series can be either $I(0)$ or $I(1)$.[5]

The estimated model follows the assumptions made by Pesaran, Shin and Smith (2001) in case III, that is, unrestricted intercepts and no trends.[6] The unrestricted error correction model (UECM) of the money demand-foreign exchange risk function can thus be stated following the imposition of the restrictions $\lambda xy = 0$, $\mu \neq 0$ and $\alpha = 0$ as:

$$(5) \qquad \Delta M_{dt} = \beta_o + \beta_1 Y_{t-1} + \beta_2 R_{t-1} + \beta_3 VR_{t-1} + \beta_4 P_{t-1} + \beta_5 M_{dt-1} + \sum_{t=1}^{p} \Delta\beta_6 Y_{t-1} + \sum_{t=1}^{q} \Delta\beta_7 R_{t-1} + \sum_{t=1}^{s} \Delta\beta_8 VR_{t\text{-}1} + \sum_{t\text{-}1}^{v} \Delta\beta_9 P_{t-1} + \sum_{t=1}^{w} \Delta\beta_{10} Md_{t-1} + \eta_1$$

where η_1 is a white-noise disturbance term and all other variables are as previously defined and expressed in natural logarithms. Equation (5) as an ARDL of order (p, q, s, v, w,) implies that if money demand tends to be influenced and explained by its past values, then it should involve other disturbances or shocks. Consequent upon this, a variant of equation (5) which incorporates a dummy variable (*DUM*) is re-specified in order to track and absorb some economic shocks, for example the policy shift of deregulation and reforms since 1986. The dummy variable with the value of zero before the implementation of the Structural Adjustment Program (SAP) in 1986 and the value of one then and after is included in equation (6) to measure the impact of the policy shift:

$$\begin{aligned}(6)\qquad \Delta M_{dt} = {} & \beta_o + \beta_1 Y_{t-1} + \beta_2 R_{t-1} + \beta_3 VR_{t-1} + \beta_4 P_{t-1} + \beta_5 Md_{t-1} \\ & + \sum_{t=1}^{p} \Delta\beta_6 Y_{t-1} + \sum_{t=1}^{q} \Delta\beta_7 R_{t-1} + \sum_{t=1}^{s} \Delta\beta_8 VR_{t-1} + \sum_{t=1}^{v} \Delta\beta_9 P_{t-1} \\ & + \sum_{t=1}^{w} \Delta\beta_{10} Md_{t-1} + \phi DUM_t + \eta_2\end{aligned}$$

The structural lags of equation 6 will be determined by using the Hannan-Quinn criterion. On estimation of equation (6), the Wald statistic (F-statistic) is computed for the purpose of comparison with its critical values in order to infer the long-run relationship among the variables. One way of computing the Wald test according to Keong, Yusop and Sen (2005), is by imposing restrictions on the estimated long-run coefficients of real money balances, interest rates and exchange rate risk among others. The null hypothesis H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$ (no long-run relationship) is tested against the alternative H_A: $\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq 0$ (a long-run relationship exists) by means of the F-test.

The asymptotic distribution of the F-statistic is non-standard under the null hypothesis, which means that the assumption of no cointegration can be examined whether the explanatory variables are $I(0)$ or $I(1)$, provided the regressand is $I(1)$ as noted earlier. Pesaran, Shin and Smith (2001) provide two sets of asymptotic critical values tabulated in their Table C1(iii). One set assumes that all the variables are $I(0)$ and the other assumes they are $I(1)$. For a given significance level of á for instance, if the F-statistic falls below the lower bound, the null of no cointegration cannot be rejected. If it falls above the upper bound critical value, then the null of no cointegration is rejected and we conclude that there is a long-run relationship. Finally, should the sample test statistic falls in-between these two bounds (upper and lower bound values), the result is interpreted as inconclusive. A confirmation of cointegration permits us to go into the next stage of estimating the long-run coefficients of the money demand function and the related ARDL error correction models. Other processes followed in the estimation exercise are discussed with the empirical results in Section 4.

2.3 IMPACT OF FOREIGN EXCHANGE REGIMES

Since one basic objective of this paper is to also estimate the impact of the foreign exchange regimes on the money demand function, equation (7) is estimated by the use of the foreign exchange slope dummy approach; rather than disentangling the effects of the foreign exchange rate liberalization dummy. Equation (7) is the estimable form of the slope dummy effects:

$$\Delta M_{dt} = \gamma_o + \gamma \Delta Y_t + \gamma_2 \Delta R_t + \gamma_3 \Delta EXR_t + \gamma_4 \Delta EXR_t.DUM + \eta_3 \tag{7}$$

where *EXR.DUM* is the exchange rate slope dummy, other variables as previously defined and the error term $\eta_3 \sim (0, \sigma^2)$. By this, if the attached slope dummy coefficient is found to be significant statistically, it indicates that the foreign exchange regime exerts a stronger effect on the demand for money during the period the dummy assumes the value of unity (see Orubu, 2002; Omotor and Orubu, 2003). It is worthy of note that the implementation of the Structural Adjustment Program (SAP) in 1986 deregulated the foreign exchange rate and made it market determined.

For purpose of analysis and derivation of policy implications for the study, equations (1), (5), (6) and (7) constitute the conditional models of estimation interest for the study.

3. THE DATA

Data definition adopted in this paper is as follows. *Y* is measured as real (2000 prices) expenditure on gross domestic product (GDP) and its implicit price deflator is the price variable *P*. The general price level is proxied by the consumer price index (CPI). The 90-day Treasury bill rate measures the opportunity cost of holding money, *R*. Money demand M_{dt} is M2, defined as currency outside banks plus demand deposits with commercial banks and the Central Bank and quasi money (saving and time deposits with commercial banks plus total deposit liabilities). The monthly average standard deviation of the nominal effective naira exchange rate indices for Nigeria (trade weighted; 1985 = 100) is constructed as the exchange rate risk (*VR*), which is the variability variable.

All variables are transformed to natural logarithms. Log transformation reduces the problem of heteroskedasticity because it compresses the scale in which the variables are measured. As further enunciated by Gujarati (1995), the log transformation reduces the scale variable a tenfold difference between two values to a twofold difference (cited in Keong, Yusop and Sen, 2005). The data are annual other than the foreign exchange risk variable constructed from average monthly values on annual basis and the standard deviation of CPI. The data used are obtained from the Central Bank of Nigeria, *Statistical Bulletin* (2007).

4. RESULTS AND DISCUSSIONS

The estimations were all carried out using Microfit 4.1; an econometric software. This software has appropriate templates for the expected estimation exercises, e.g., structural lags, ARDL, Wald test and other diagnostic tests.

Conceptually, the ARDL estimation procedure involves two stages. The first stage tests the model of interest for existence of long-run relationships between the variables by computing the Wald or F-statistic. The computed F-statistic tests for the significance of the lagged levels of the variables in the error correction form of the underlying ARDL model (Pesaran and Pesaran, 1997, 304). The second stage of the analysis is predicated on satisfying the first stage that the long-run relationship between the variables being estimated is not spurious. However, in this paper, we shall adopt three stages in a sequential order predicated on satisfying conditions set out in the preceding sequence.

Although the ARDL technique can be applied irrespective of whether the regressors are $I(0)$ or $I(1)$, thus avoiding the pre-testing problems associated with standard cointegration analysis, we shall proceed by first carrying out a pre-test on the regressand, M_{dt}, in order to determine whether it is $I(1)$ or $I(0)$. The reason for embarking on this first stage unlike previous ARDL studies which assumed it away; is that ARDL inherently allows for this pre-test since its application is also predicated on the condition that the regressand must be $I(1)$. On the satisfaction of this first condition, we proceed to the second stage, which ought to be the original first step—computing the Wald or F-statistic, in that order.

4.1 STATIONARITY OF THE REGRESSAND

First, the ADF unit test is applied on the regressand, M_{dt} for stationarity. The test is applied to both the original series (in log form) at level, and to the first difference. The results reported in Table 1 indicate that M_{dt} is non-stationary at level; that it is a random walk series. M_{dt} becomes stationary after employing difference operator of degree one. This means that the series is integrated of order one, $I(1)$.

4.1.1 DISCUSSIONS

Having satisfied this first stage that the regressand is an $I(1)$ series, we proceed to the second stage of testing for the existence of long-run relationship between the variables by computing the Wald or F-statistic.

The F-statistic for testing the joint null hypothesis that the coefficients of level variables are zero, i.e., there exists no long-run relationship between them, is presented in Table 2. The F-statistics are $F^* = 6.2536$ (lag 3) and 9.927 (lag 4); while the critical value bounds for this test are obtained from Pesaran, Shin and Smith (2001). The relevant critical value bounds at the 99% level are given as 3.74 and 5.06. Since $F^* = 6.2536$ and 9.927 exceeds the upper bound of the critical value bound, we can reject the null of no long-run relationship between real money balances, real income, foreign exchange risk, interest rate and the price level irrespective of the order of their integration. The test outcome varies with the choice of lag order. For $j = 1$, the computed F-statistic is inconclusive. The computed F-statistic is still inconclusive for $j = 2$, but significant at 99% for $j = 3$ and $j = 4$. These results seem to provide evidence of the existence of a long-run money demand when a higher order of lag (3 and 4) is selected.

In the third stage, the lagged levels of variables are fixed using an appropriate lag selection criterion such as the Schwarz Bayesian Criterion (SBC) and the Akaike Information Criterion (AIC). Coincidentally, both criteria report the same results for the ARDL estimates and the error correction representations for the selected ARDL model.

The long-run coefficient estimates are reported in Table 3. It should also be noted that the estimated coefficients obtained from all three model selection criteria (SBC, AIC and the Hannan-Quinn Criterion; HQC) are similar. Although the scale variable (income) is rightly signed, all the regressors are not statistically significant in Equation (1). Consequently, we proceeded to estimate Equations (5) and (6).

TABLE 1
Augmented Dickey-Fuller (ADF) Test of Stationarity of M_{dt}

Lag	Variable	Test Statistic	Variable	Lag	Test Statistic
DF	M_{dt}	-1.2514	ΔM_{dt}	DF	-3.4861
ADF(1)	M_{dt}	-1.9483	ΔM_{dt}	ADF(1)	-3.5883

Notes: Regression includes an intercept but not a trend.
The 95% critical value for the augmented Dickey-Fuller statistic = -2.9627.
Δ shows first difference.

TABLE 2
F-Statistics for Testing the Existence of a Long-Run Money Demand Equation

Order of lag	*F*-statistic
1	2.0068
2	3.1157
3	6.2536*
4	9.9270*

Notes: The relevant critical value bounds are given in Table 1.iii (with an unrestricted intercept and no trend; number of regressors = 4), Pesaran, Shin and Smith (2001). They are 2.86 and 4.01 at the 95% significance level and 3.74 and 5.06 at the 99% significance level.
*denotes that the *F*-statistic falls above the 99% upper bound.

TABLE 3
Estimated Long-Run Coefficients using the ARDL Approach
ARDL (2, 1, 0, 0, 1) selected based on Hannan-Quinn Criterion (Equation 1)

Dependent Variable is M_{dt}				
	Model without dummy variable		Model with dummy variable	
Regressor	Coefficient	*t*-ratio (Prob)	Coefficient	*t*-ratio (Prob)
Y	1.5350	1.2367 (0.228)	0.5495	0.5978 (0.555)
VR	- 0.0218	- 0.9827 (0.335)	- 0.0148	- 0.7298 (0.472)
R	0.2213	0.4593 (0.650)	0.255	0.4866 (0.631)
P	- 0.0633	- 0.3944 (0.697)	0.0976	0.6669 (0.511)
INPT	- 2.0898	- 0.5741 (0.571)	0.5339	0.1933 (0.848)
D			- 0.2790	- 1.0669 (0.2961)

TABLE 4
Error Correction Representation for the Selected ARDL Model
ARDL (2, 1, 0, 0, 1) selected based on Hannan-Quinn

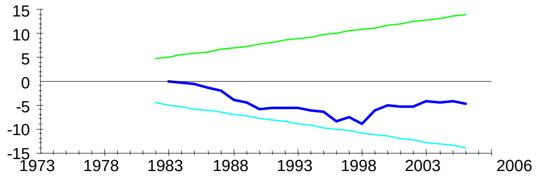
Dependent variable is ΔM_{dt}				
	Model without dummy		Model with dummy	
Regressor	Coefficient	t-ratio (Prob)	Coefficient	t-ratio (Prob)
ΔM_{dt-1}	0.2734	1.7334 (0.094)	0.3347	2.018 (0.054)
ΔY	- 0.0506	- 0.0576 (0.054)	- 0.0913	2.002 (0.06)
ΔVR	- 0.0034	- 1.3769 (0.180)	- 0.0025	- 0.938 (0.357)
ΔR	0.0345	0.4701 (0.642)	0.0424	0.481 (0.634)
ΔP	- 0.4850	- 2.6891 (0.012)	- 0.3747	- 2.087 (0.047)
INPT	- 0.3260	- 0.6420 (0.526)	0.0887	0.188 (0.853)
D			- 0.4633	- 0.998 (0.327)
ECM(-1)	- 0.1560	-2.2827 (0.031)	- 0.1661	- 2.192 (0.038)
Diagnostic statistics				
DW-statistic	2.0331		2.1585	
Adj-R^2	0.4386		0.3897	
F-Statistic	5.6311 (0.001)		4.1533 (0.003)	
AIC	49.4126		47.9919	
SBC	42.5439		41.1233	

The estimates of Equations (5) and (6), which are the error-correction representations selected by AIC and SBC (with a maximum lag order set at 3) are presented in Table 4. Some of the major findings of this paper which can augment our understanding of money demand in Nigeria are summarized below. First, it is plausible to imply that *ceteris paribus* the short-run income elasticity is significantly greater than zero in both models but less than unity, consistent with economic theory. An income elasticity of less than unity has some implications for monetary policy. As cited in Valadkhani (2008:80), Ball (2001:36) concludes that such $\beta_1 < 1$, will make the Friedman rule pseudo-optimal and therefore the supply of money should grow more sluggishly than output in order to achieve the goal of price stability. Second, inflation has an immediate and relatively larger effect on the demand for money in the short-run. The inflation variable is significant and negatively signed as expected a priori. Rising inflation, *ceteris paribus*, encourages agents to diversify their portfolios in the economy by acquiring real assets (Valadkhani, 2008), other financial assets and maybe foreign currencies as substitutes.

The foreign exchange rate variability variable which is a measure of foreign exchange risk enters insignificantly into the equation with the estimated parameter negatively signed. This may imply that foreign exchange risk is probably not an important determinant in the explanation of real money demand behavior in the case of Nigeria. This result further confirms the Omotor and Orubu (2003) study using standard regression methods which equally do not take into cognizance the time series properties of the variables. The Nigerian case on the role of exchange rate risk in money demand determination is at variance with the German experience as hypothesized by Akhtar and Putnam (1980).

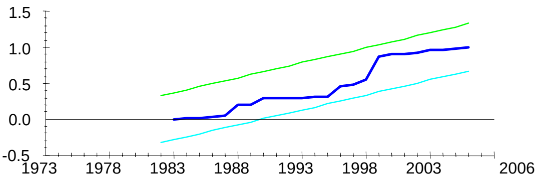
The long-run coefficients reported in Table 3 are used to generate the error correction terms. The adjusted coefficients of determination for the two models—Equations (5) and (6), respectively—at 0.44 and 0.39 are fairly high which may suggest fair fit error correction models of the data. The computed F-statistics clearly reject the null hypotheses that all the regressors have zero coefficients for all cases. Significant as well is the error correction coefficient which carried an expected negative sign and highly significant at over 95% level in both cases. This reinforces the finding of cointegration relationship in the long-run model for money demand. The larger the error correction coefficient (in absolute value) the faster is the economy's return to its equilibrium

FIGURE 1
CUSUM for the model without the SAP dummy



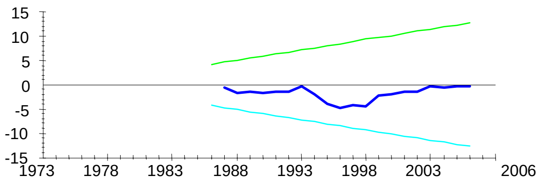
The straight lines represent critical bounds at 5% significance level

FIGURE 2
CUSUMQ for the model without the SAP dummy



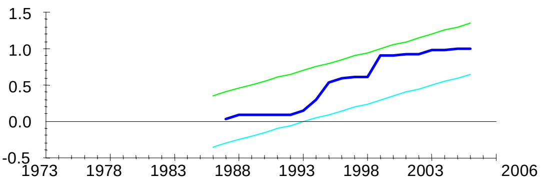
The straight lines represent critical bounds at 5% significance level

FIGURE 3
CUSUM for the model with the SAP dummy



The straight lines represent critical bounds at 5% significance level

FIGURE 4
CUSUMQ for the model with the SAP dummy



The straight lines represent critical bounds at 5% significance level once shocked, suggesting moderate speed of adjustments to equilibrium. The magnitude of the estimated coefficients for the ECM of equations (5) and (6) indicates that the lagged excess money will reduce holdings of money by over 15% and 16%, respectively, in each year. These slow magnitudes are within the neighborhood of some other studies (see Bahmani-Oskooee and Ng, 2002; and Valadkhani, 2008). The speed at which portfolio adjustments take place according to Qayyum (2005) involves two types of costs—the cost of moving to a new equilibrium and the cost of being out of equilibrium. Thornton (1998) cited in Qayyum (2005), opines that ". . . [the] higher the ratio of the cost of moving to the new equilibrium relative to the cost of being out of equilibrium, the lower the speed of adjustment". The speed of adjustment may also be related to the saving behavior of the household sector. Since savings are held as part of the broad money supply as used in this study, increased precautionary savings on long-run consideration of future income and interest rate will slow the speed of adjustment.

We further examine the structural stability of the long-run coefficients together with the short-run dynamic by applying the cumulative sum (CUSUM) and the cumulative sum of squares

TABLE 5
Estimation of Money Demand Slope-Dummy Method

Cochrane-Orcutt AR (1) converged after 3 interactions
Dependent variable is ΔLM2P

Regressor	Coefficient	*t*-ratio (prob)
INPT	015923	0.8502 (0.40)
ΔY	0.271	2.66 (0.01)
ΔR	0.647	1.58 (0.12)
ΔEXR	- 0.007	- 0.199 (0.84)
$\Delta EXRD$	0.004	0.169 (0.867)

Notes: R^2 = 0.271, DW-statistic = 1.972. Parameters of the autoregressive error specification:

$$U = 0.3748{*}U(-1) + E$$
$$(2.9362)\ [0.0048]$$

t-ratio(s) based on asymptotic standard errors in brackets

(CUSUMQ)[7] (see Brown, Durbin and Evans, 1975). The tests are applied to residuals of the two models in Table 4.

Figures 1 and 2 display the CUSUM and CUSUMQ for the model without the SAP dummy while Figures 3 and 4 display both the CUSUM and CUSUMQ for the model with the SAP dummy, respectively. Each graph displays a pair of straight lines drawn at 5% level of significance. According to Pesaran and Pesaran (1997, 117), if either of the lines is crossed, the null hypothesis that the regression equation is correctly specified must be rejected at the 5% level of significance. Since neither CUSUM nor CUSUMQ plots of the two models cross the critical bounds, these imply that there is no evidence of any significant structural instability. One policy implication of this is that monetary authorities may emphasize and maintain the broad definition of money for monetary control.

The estimated constant terms of the dynamic models return negative values. As noted by Burggeman (2000) and Choudry (1999), negative constant terms have no direct implication since they indicate both the long-run and short-run constant terms. However, this may imply decline in the unconditional growth in money demand during the period under review. This may also indicate the changing pattern of velocity of broad money in Nigeria.

4.1.2 ESTIMATE OF THE SLOPE DUMMY EXCHANGE RATE OF EQUATION (7)

The paper further estimates the impact of policy shift in foreign exchange management of Nigeria on real money demand by applying a slope dummy technique as formulated in Equation (7). The variables used in estimating Equation (7) are integrated of order one, $I(1)$. Table 5 presents results of the foreign exchange slope dummy using Cochrane-Orcutt method AR(1). This method of estimation is employed in the regression analysis because the residuals of the ordinary least squares estimation are autocorrelated and the adjusted coefficient of determination is negative.[8] Results of the Cochrane-Orcutt AR(1) converged after 3 interactions with the white noise residuals.

The attached slope dummy coefficient of 0.006 (0.2339) is statistically not significant. This may indicate that the deregulation of the foreign exchange exerted no strong effect on the real money demand. This may further signify, though with caution, the impotence of foreign exchange targeting in the formulation of monetary policy during the period under review.

5. SUMMARY AND CONCLUSION

The importance of a well-specified demand for money function to the implementation of monetary policy is a topical issue in the existing literature on monetary economics both in developed and developing countries. The specification does not matter whether the central banks' major policy variable is the money stock, interest rate or inflation. This paper among other objectives sets to re-estimate the money demand function that incorporates a foreign exchange risk variable for Nigeria using annual time series data (1970-2006). According to Maskus (1990), foreign exchange rate volatility reduces volume of international trade since it creates uncertainty over expected profits. In addition, volatility or instability has a consequence of increasing prices of internationally traded goods given the uncertainty that surrounds its anticipated behavior. Some studies that have incorporated the exchange rate risk variables are Akhtar and Putnam (1980) in the case of Germany, and Omotor and Orubu (2003) for the Nigerian case using standard regression methods.

This paper applies the bounds test techniques in the estimation of cointegration analysis which involves ARDL. According to the results, the cointegration test plausibly show that in the long-run there is a cointegrating vector, which integrates the real money demand (broad money, M2) with real income, exchange rate variability, interest rate and the rate of inflation. Consistent with economic theory and a priori expectations, the results of the dynamic error correction model that capture the short-run dynamics of money demand gets support of positively responding to increase in real income and negative to a rise in inflation rate. One implication of these findings is that the real money demand (M2) is stable. The CUSUM and CUSUMQ estimations further confirm this hypothesis. Thus, broad money supply (M2) may be a more predictable monetary aggregate than interest rate. Given the fact that the coefficients of inflation were more significant in the money demand formulation, it may not be out of place to reason that the monetary authorities in Nigeria should anchor its monetary policy on price stability.

The results of the paper further reveal that exchange rate variability is not a significant determinant of money demand in Nigeria; while a low speed of adjustment is equally reported. The low speed recorded in this paper as attested to by the estimates may be a result of the savings behavior of the household sector, which would have increased their precautionary savings possibly due to the inertia of inflation. This creates further credence and support for inflation-targeting regime, *ceteris paribus*.

ENDNOTES

1. Akhtar and Putnam (1980) posit that the optimal level of domestic money balances may vary relatively to the degree of uncertainty associated with foreign exchange value of the domestic money.
2. Examples of methods that may be applied in cointegration analysis are Johansen (1988, 1991) Johansen and Juselius (1990, 1992, and 1994), Engel and Granger (1987), Pesaran, Shin and Smith (2001), etc. The choice between Johansen (1988, 1991), Johansen and Juselius (1990, 1992, and 1994), Engel and Granger (1987) on the one hand and Pesaran, Shin and Smith (2001) on the other hand depends on the level of integration of the series. If all series are cointegrated at first difference that is $I(1)$, all mentioned methods could be applied. However, if at least one determinant is $I(0)$, other methods other than Pesaran, Shin and Smith (2001) break down.
3. See Enebeli-Uzor (2008).
4. The complete derivation of the model can be obtained from the author.
5. If $\lambda yy = 0$, then y is $I(1)$. If $\lambda yy < 0$; then y is $I(0)$.
6. The VECM procedures test for at most one cointegrating vector between the regression and a set of the regressors.
7. The CUSUM test is particularly useful for detecting systematic changes in the regression coefficients while the CUSUMQ test is useful in situations where the departure from the constancy of the regression coefficients is haphazard and sudden (Pesaran and Pesaran, 1997, 117).
8. The results are obtainable on request from the author.

REFERENCES

Abubaka, I. “Macroeconomic Environment.” *Zenith Economic Quarterly* 3 (2008): 77-80.

Akhtar, M.A., and B.H. Putnam. “Money Demand and Foreign Exchange Rise. The German Case 1972-1976.” *Journal of Finance* 35 (1980): 787-94.

Apergis, N. “Inflation Uncertainty and Money Demand: Evidence from a Monetary Regime Change and the Case of Greece.” *International Economic Journal* 13 (1999): 21-30.

Bahmani-Oskooee, M., and R.C.W. Ng. “Long-Run Demand for Money in Hong Kong: An Application of the ARDL Model.” *International Journal of Business and Economics* 1 (2002): 147-55.

Baumol, W.J. “The Transactions Demand for Cash: An Inventory Theoretic Approach.” *Quarterly Journal of Economics* 66 (1952): 545-56.

Blejer, M.I. “The Demand for Money and the Variability of the Rate of Inflation: Some Empirical Results.” *International Economic Review* June (1979): 545-49.

Branson, W.H. *Macroeconomics: Theory and Policy*. 3rd Edition. New York, NY: Harper and Row,1989.

Brown, R.L., J. Durbin, and J.M. Evans. “Techniques for Testing the Constancy of Regression Relations Over Time.” *Journal of the Royal Statistical Society*. 37 (1975): 149-92.

Bruggeman, A. “The Stability of EMU-Wide Money Demand Functions and Monetary Policy Strategy of the European Central Bank.” *The Manchester School* 68 (2000): 184-202.

Central Bank of Nigeria. *Statistical Bulletin* 17 (2000).

Choi, D., and L. Oxley. “Modelling the Demand for Money in New Zealand.” *Mathematics and Computers in Simulation* 64 (2004): 185-91.

Choudry, T. “Does Interest Rate Volatility Affect the US M1 Demand Function? Evidence from Cointegration.” *The Manchester School* 67 (1999): 621-48.

Enebeli-Uzor, S. “Nigeria-Israel Relations: Critical Roles for Agriculture.” *Zenith Economic Quarterly* 3, no. 4 (2008): 61-6.

Engle, R.F., and C.W.J. Granger. “Cointegration and Error Correction: Representation, Estimation and Testing.” *Econometrica*. 55 (1987): 251-76.

Friedman, M. “The Demand for Money: Some Theoretical and Empirical Results.” In *The Demand for Money: Some Theoretical and Empirical Results*. Cambridge, MA: National Bureau of Economic Research, Inc., 1959.

Garner, C.A. “Does Interest Rate Volatility Affect Money Demand?” *Federal Reserve Bank of Kansas City Economic Review* 71 (1986): 25-37.

Granger, C.W.J., and P. Newbold. “Spurious Regressions in Econometrics.” *Journal of Econometrics* 2 (1974): 111-20.

Gujarati, D.N. *Basic Econometrics*. 3rd Edition. New York: McGraw-Hill, 1995.

Hwang, J. "The Demand for Money in Korea: Evidence from Cointegration Test." *International Advances in Economics Research* 8 (2002): 188-95.

Johansen, S. "Statistical Analysis of Cointegration Vectors." *Journal of Economic Dynamics and Control* 12 (1988): 231-54.

———, and K. Juselius. "Maximum Likelihood Estimation and Inference on Cointegration with Applications to the Demand for Money." *Oxford Bulletin of Economics and Statistics* 52 (1990): 169-210.

Judd, J.P., and J.L. Scadding. "The Search for a Stable Money Demand Function: A Survey of the Post-1973 Literature." *Journal of Economic Literature* 20 (1982): 993-1023.

Juselius, K. "Models and Relations in Economics and Econometrics." In *Macroeconomics and the Real World. Vol. I: Econometric Techniques and Macroeconomics*, edited by R.E. Backhouse and A. Salanti, 167-97. Oxford: Oxford University Press, 2000.

Keong, C.C., Z. Yusop, and V.L.K. Sen. "Export-Led Growth Hypothesis in Malaysia: An Investigation using Bounds Test." *Sunway Academic Journal* 2 (2005): 13-22.

Klein, B. "The Demand for Quality Adjusted Cash Balances: Price Uncertainty in the U.S. Demand for Money Function." *Journal of Political Economy* 85 (1977): 691-715.

Mah, J.S. "An Empirical Examination of the Disaggregated Import Demand of Korea – the Case of Information Technology Products." *Journal of Asian Economics* 11 (2000): 237-44.

Maskus, K.E. "Exchange Rate Risk and U.S. Trade: A Sectoral Analysis." In *Financial Market Volatility and the Economy*, edited by Thomes E. Daris, 85-98. Federal Reserve Bank of Kansas City, 1990.

Mcgibany, J., and F. Nourzad. "Exchange Rate Volatility and the Demand for Money in the U.S." *International Review of Economics and Finance* 4 (1995): 411-42.

Obadan, M.I. "Foreign Administration in Nigeria." *West African Financial and Economic Review* 1 (2003): 35-58.

Odhiambo, N.M. "Supply-Leading versus Demand-Following Hypothesis: Evidence from Three SSA Countries." *African Development Review* 19 (2007): 257-80.

Omotor, D.G., and C.O. Orubu. "Money Demand and Foreign Exchange Risk: The Nigerian Case." *The Nigerian Economic and Financial Review* 8 (2003): 33-50.

Onu, E. "Money and Markets: 46 Years of Nationhood." *The Nigerian Daily Independent* (2006).

Pesaran, M.H., and Pesaran, B. *Working with Microfit 4.0: Interactive Econometric Analysis*. England: Comfit Data Limited, 1997.

Pesaran, M.H., and Y. Shin. "Generalised Impulse Response Analysis in Linear Multivariate Models." *Economics Letters* 58 (1998): 17-29.

Pesaran, M.H., Y. Shin, and R.J. Smith. "Bounds Testing Approaches to the Analysis of Long-Run Relationship." *Journal of Applied Econometrics* 16 (2001): 289-326.

Qayyum, A. "Modelling the Demand for Money in Pakistan." *The Pakistan Development Review* 44 (2005): 233-52.

Saatcioglu C., and H.L. Korap. "The Turkish Broad Money Demand." *Istanbul Ticaret Üniversitesi Sosyal Bilimler Dergisi* 4 (2005): 139-65.

Thornton, D.L. *Why Does Velocity Matter?* Federal Reserve Bank of St. Louis, 1983.

Tobin, J. "The Interest-Elasticity of Transactions Demand for Cash." *Review of Economics and Statistics* 38 (1956): 241-47.

———. "Liquidity Preference as Behavior Towards Risks." *Review of Economics,* August (1958): 65-86.

Valadkhani, A. "Long- and Short-Run Determinants of the Demand for Money in the Asian-Pacific Countries: An Empirical Panel Investigation." *Annuals of Economics and Finance* 9 (2008): 77-90.

Ventura, J.P. "Money Demand and Inflation in Peru, 1979-1991." *Federal Reserve Bank of Cleveland Economic Commentary*, December (2000).

Yinusa, D.O., and A.E. Akinlo. "Exchange Rate Volatility and the Extent of Currency Substitution. *MPRA Paper No. 16251* (2009).

Zilberfarb, B. "The Effects of Foreign Exchange Risk and Return on Demand for Domestic Balances." *European Economic Review* 32 (1988): 1359-68.

APPENDIX 1
Summary Results of the A-P Regression

	Standard Error	Adjusted R-Squared	Durbin Watson
A $\ln M = -7.91 + 1.04\ln\left(\frac{Y}{P}\right) - 0.022r - 0.020\ln V + 1.25\ln P$ (?2.59) (1.95) (?2.33) (?1.90) (8.450)	0.0368	0.95	2.27
B $\ln\left(\frac{M}{P}\right) = -6.26 + 1.72\ln\left(\frac{Y}{P}\right) - 0.024r - 0.021\ln V$ (?2.17) (4.76) (?2.50) (?1.84)	0.068	0.64	1.80
C $\ln\left(\frac{M}{P}\right) = -7.40 + 1.84\ln Y - 0.027r - 0.021\ln V$ (?2.95) (4.95) (?2.94) (?1.93)	0.0359	0.65	2.40
D $\ln\left(\frac{M}{P}\right) = -7.60 + 1.83\ln Y^{e} - 0.24r - 0.021\ln V$ (?2.76) (4.85) (?2.82) (-1.88)	0.0368	0.64	1.80
E $\ln\left(\frac{M}{P}\right) = -7.14 + 1.07\ln\left(\frac{Y}{P}\right) + 0.73\ln\left(\frac{Y}{P}\right)^{*} - 0.028r - 0.021\ln V$ (?3.10) (2.17) (1.80) (?3.04) (?2.00)	0.034	0.75	2.35

APPENDIX 2

Summary Results of the Estimated Regression Models of Omotor-Orubu Dependent Variable: Log of Broad Money Supply

A

Variable	Coefficient	Std. Error	*t*-statistic	Prob
c	-1.43	1.33	-1.07	0.27
ly	0.76	0.18	4.03	0.00
t	-0.06	0.02	-4079	0.00
lv	-0.04	0.03	-1.13	0.27
lvp	0.03	0.07	0.41	0.69
lcpi	1.52	0.11	13.52	0.00
R^2	0.98			
S.E.	0.17			
D-W	1.31			
*F**	222			

B

Variable	Coefficient	Std. Error	*t*-statistic	Prob
c	0.54	2.09	0.26	0.80
ly	0.73	0.31	2.31	0.03
r	-0.00	0.01	0.00	0.99
w	-0.04	0.05	0.68	0.50
R^2	0.13			
S.E.	0.29			
D-W	0.35			
*F**	2.06			

C

Variable	Coefficient	Std. Error	*t*-statistic	Prob
c	-1.52	1.28	-1.18	0.25
ly	- 0.76	0.18	4.13	0.00
r	- 0.06	0.01	-4.45	0.00
lgv	- 0.04	0.03	-1.19	0.25
lcpi	1.54	0.09	16.37	0.00
R^2	0.98			
S.E.	0.17			
D-W	1.42			
*F**	292			

APPENDIX 2 (continued)

Summary Results of the Estimated Regression Models of Omotor-Orubu Dependent Variable: Log of Broad Money Supply

D

Variable	Coefficient	Std. Err.	t-statistic	Prob
c	-1.83	1.48	-1.23	0.24
ly	0.51	0.20	2.48	0.02
r	-0.01	0.02	-0.45	0.65
lv	-0.02	0.02	-0.92	0.37
lvp	0.04	0.04	1.03	0.37
lcpi	0.59	0.22	-2.62	0.02
lm2t-1	0.56	0.26	2.16	0.05
lm2t-1	0.09	0.19	0.48	0.63
R^2	0.80			
S.E.	0.09			
D-W	2.21			
F*	12.13			

E

Variable	Coefficient	Std. Err.	t-statistic	Prob
c	-1.57	1.35	-1.16	0.26
lny	0.47	0.18	2.639	0.02
r	-0.00	0.01	-0.34	0.74
lv	-0.02	0.02	0.827	0.42
lgvp	0.04	0.04	1.986	0.34
lcpi	-0.63	0.20	-3.14	0.01
lm2t-1	0.68	0.10	6.534	0.00
R^2	0.916			
S.E.	0.090			
D-W	2.444			
F*	32.170			

APPENDIX 2 (continued)
Summary Results of the Estimated Regression Models of Omotor-Orubu Dependent Variable: Log of Broad Money Supply

F				
Variable	Coefficient	Std. Error	*t*-statistic	Prob
c	9.364	0.150	62.355	0.00
lexr	0.968	0.065	14.861	0.00
Fxd. lexr	5.454	1.081	5.045	0.00
R^2	0.91			
S.E.	0.369			
D-W	0.755			
*F**	157.6			

G				
Variable	Coefficient	Std. Error	*t*-statistic	Prob
c	9.110	0.459	19.81	0.00
lexr	1.209	1.141	1.059	0.298
R^2	0.83			
S.E.	0.876			
D-W	0.223			
*F**	77.20			