International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: 6.614
Available Online at www.journalijcar.org
Volume 9; Issue 04 (B); April 2020; Page No. 21891-21899
DOI: http://dx.doi.org/10.24327/ijcar.2020. 21899.4310

Research Article

MONEY DEMAND FUNCTION IN NIGERIA: AN ARDL APPROACH

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A R T I C L E I N F O

Article History:
Received 06th January, 2020
Received in revised form 14th February, 2020
Accepted 23rd March, 2020
Published online 28th April, 2020

Key words:

Autoregressive distributed-lag, Co-integration, Money demand function, Stability, World Bank.

A B S T R A C T

This paper employed the cointegration-based autoregressive distributed-lag (ARDL) modelling technique to examine the money demand function (MDF) and its stability in Nigeria from 1986 to 2018 using quarterly time series data sourced from the publications of the Central Bank of Nigeria (CBN) and the World Bank. An empirical model was formulated, estimated, and validated. First, the results indicate that a stable money demand function (MDF) can be established in Nigeria when crude oil price, exchange rate, interest rate, and income variables are included in the money demand model. Second, the money demand function in Nigeria is highly expectations-driven. Thirdly, whereas crude oil price, exchange rate, interest rate, and income have significant relationships with the short-term movements in money demand, foreign reserves and inflation do not have significant relationships with short-term movements in money demand in Nigeria. Furthermore, changes in expected money demand have negative t short and long-term effects on current money demand; income has negative short and long-term effects on current money demand; crude oil prices have positive short and long-term effects on current money demand; exchange rates have negative and positive short-term effects on current money demand; and interest rates have negative and significant short-term effects on current money demand. Based on the findings, it is recommended that the monetary authority should ensure a clear-cut distinction between short run and long run objectives. Thus, the monetary authority can use the previous crude oil prices and previous exchange rates to improve on the level of money demand in the short run; the expected money balances, the current exchange rate, the current interest rate, the current income, and expected income to reduce the level of money demand in the short run; the expected money balances and expected income to reduce the money demand in the long run; and the expected crude oil prices to increase the money demand in the long run.

INTRODUCTION

One of the key requirements for a successful targeting of monetary aggregates is the stability of money demand (Anoruo, 2002; Khan & Ali, 1997). The demand for money represents the desire of households and businesses to hold assets in a form that can be easily exchanged for goods and services. A sustained increase in money demand mostly indicates a country's improved economic situation, as opposed to the falling demand which is normally a sign of deteriorating economic climate (Maravic & Palic, 2010). The stability of the money demand function is necessary for understanding how the formulation and implementation of an effective monetary policy is crucial in offsetting the fluctuations that may arise from the real sector of the economy, and it enables a policy-driven change in monetary aggregates so that the desired values of targeted macroeconomic variables are ensured (Busari, 2009; Essien, Onwioduokit, & Osho, 1996; Owoye & Onafowora, 2007; Sober, 2013).

The formulation of appropriate demand for money model which is the basis for the execution of appropriate and sound monetary policies continues to remain a subject of disagreement amongst scholars (Maravic & Palic, 2010). Therefore, every fresh attempt at studying the demand for money in Nigeria must be vigorously justified. A sound monetary policy formulation presupposes theoretically coherent and empirically robust model of money demand. Some of the policy-related developments that motivated the rigorous investigation of demand for money in Nigeria have not changed substantially. Amongst other things, the success of such a policy stance would depend, to a large extent, on the nature and stability of the MDF in Nigeria (Busari, 2009). The Central Bank of Nigeria (CBN) in 1974 adopted monetary targeting as the framework for the implementation of monetary policy. Till date, the Central Bank of Nigeria (CBN) is increasingly relying on the use of monetary targeting as the framework for the implementation of monetary policy. It thus

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appears that the tremendous efforts at understanding, applying, and implementing a stable money demand function in Nigeria has not yielded the expected result. One major reason adduced for Nigeria not meeting major policy targets has been the relatively weak scientific efforts at explaining the policy dynamics in Nigeria (Adenikinju, Busari, & Olofin, 2009) and as a result, policy decisions are not anchored on scientific models that track major macroeconomic indices (Adenikinju, Busari, & Olofin, 2009). Against this background, this study empirically developed a scientific model to examine the money demand function (MDF) in Nigeria. This study attempted to do this by applying the autoregressive distributed-lag (ARDL) approach suggested by Pesaran, Shin, and Smith (2001). The ARDL approach can be used to simultaneously estimate short-term and long-term relationships between variables (Ghatak & Siddiki, 2001).

Literature Review

Conceptually, money is an asset with a particular set of characteristics, most notably its liquidity (Carpenter & Lange, 2002). Like other financial assets, demand for money is part of a portfolio allocation decision, in which an agent's wealth is distributed among competing assets based on each asset's relative benefits (Tobin, 1969). To a certain extent, agents are willing to give up the higher return of alternative assets in order to receive the benefit of liquidity that money provides. Thus, according to Carpenter and Lange (2002), standard money demand equations include an interest rate or interest rate spread to measure the opportunity cost of holding non-interest earning money. This is true in the sense that since opportunity cost is the cost of alternative foregone, a higher return on alternative assets depletes liquidity (cash holding).

A stable money demand allows for better predictions of the effects of monetary policy on interest rates, output, and inflation, and therefore reduces the possibility of an inflation bias (Cziraky & Gillman, 2006). Stable money demand is a precondition for an effective monetary policy, especially for countries pursuing a monetary targeting framework. Since the SAP in 1986, the Nigerian economy has undergone a number of important structural and institutional changes which included (a) the liberalization of the external trade and payment systems, (b) substantial degree of financial deepening and innovations in the banking sector, (c) the adoption of a managed float exchange rate system, (d) the dismantling of price and interest rate controls, (e) changes in monetary policy, and (f) the reliance on market determined indirect instruments of monetary policy (Owoye & Onafowora, 2007). These developments may have altered the relationship between money, income, prices and other key economic variables, and may have caused the money demand function to become structurally unstable.

Monetary policy is the process by which the central bank or monetary authority of a country controls the supply of money, availability of money, and cost of money or rate of interest to attain a set of objectives oriented towards the growth and stability of the economy (Nelson, 2008). It is the specific actions taken by the monetary authorities to regulate the value, supply and cost of money in the economy with a view to achieving government's macroeconomic objectives. Monetary policy focuses on the relationship between the rates of interest in an economy, that is the price at which money can be borrowed, and the total supply of money. Monetary policy uses a variety of instruments to control one or both of these, to influence outcomes like economic growth, inflation, exchange rates with other currencies and unemployment. Where currency is under a monopoly of issuance, or where there is a regulated system of issuing currency through banks which are tied to a Central Bank, the monetary authority has the ability to alter the money supply and thus influence the interest rate to achieve policy goals.

Theoretical Review

The literature on the demand for money, also referred to as the demand for real balances, is quite vast. At the theoretical level, the motives for holding money are clearly distinguished into transactions, speculative, and precautionary motives (Keynes, 1936). Keynes (1936) argues that economic agents hold a certain proportion of money for the sake of medium of exchange function, that is, to effect transactions. This motive is viewed as dependent on income. The relationship between the transactions demand for money and income is postulated to be stable. Cash balances are also held to bridge receipts and payments since people are sometimes unsure as to when they will have needs to make payments. This motive, which Keynes refers to as precautionary, also depends on the level of income. The third motive for holding money in the Keynesian theory of demand for money is speculative purposes. He argues that individuals hold cash balances in order to speculate or invest. The speculative demand for money is hypothesized to depend on expectations about future (or expected) rates of interest. Post-Keynesians, in particular, Baumol (1952) and Tobin (1956) indicate that this motive for holding money is also income elastic, in addition to providing greater insights about the role of interest rate in the demand for money. The Baumol-Tobin model explains money holding in terms of transactions demand. Hence, when income increases, the transaction demand for money increases less proportionally. This leads to rise in income velocity of money. Post-Keynesian theories of demand for money include the inventory-theoretic approach and the buffer-stock/portfolio models (Sriram, 2001). From the forgoing, the demand for real balances increases with the level of income and decreases with interest rate. Zecher (1974) expressed this symbolically as:

$$\frac{Md}{P} = Y^{k} I^{-h} \qquad \textbf{(1)}$$

$\frac{Md}{P}$ is demand for real money balances, Y is income, and I is interest rate, k and $-h$ are elasticities with respect to income and interest rate, respectively.

Earlier, the classical school of the quantity theory had made significant imprints on the field of monetary economics. The postulations of the classical thought are represented by the Fisher's equation of exchange and the Cambridge approach.
The Fisher's equation of exchange is symbolically presented as:

$$MV = PT \qquad \textbf{(2)}$$

where M is the quantity of money, V is the velocity of circulation, P is the price level, and T is transactions volume. MV, which is total spending, equals PT (what is purchased) simply implies that money is demanded for transactions sake

only. This strict position was later modified in the Cambridge approach also known as the cash-balance approach. In this formulation, money is held as part of an individual's wealth and has an opportunity cost. The store of value function of money is emphasised. It nevertheless admits income as a key determinant of the demand for money in addition to the opportunity cost variable and the rate of interest (Laidler, 1993).

Empirical Review

The discourse on the demand for money in Nigeria has remained active after many years of concerted research and debates on the subject. As argued by Sriram (2001), there is a growing literature on the stability of the MDF in developing countries like Nigeria, due, largely to the move towards a flexible exchange rate system, globalization of capital markets, financial liberation, innovation in domestic financial markets, and the country-specific events on the demand for money. The decade of the 1970s witnessed pioneering works on the subject by Ajayi (1974), Odama (1974), Ojo (1974), Teriba (1974), Tomori (1974), Iyoha (1976), and Fakiyesi (1980). These scholars examined the determinants, their relative importance, and the stability of the demand for money in Nigeria. Since the economic reform measures started, several studies have been carried out on the MDF in Nigeria though not all made explicit attempts at investigating the stability of the MDF. Asogu and Mordi (1987) examined the monetary sector in general to uncover some of the main determinants of the money demand function. Adejugbe (1989) examined some aspects of the stability of the MDF for Nigeria and observed that the function was stable. Essien, Onwioduokit, and Osho (1996) observed that indebtedness could signal to private economic agents the direction of government fiscal and monetary policies which in turn influenced the demand for money in the domestic economy. As lively as the debate was then, the issue remained unresolved since these studies essentially focused on definition of money, income as a key variable, and a bit of stability issues (Yamden, 2011).

Studies that are more recent have leveraged on the tremendous progress in economic research methodologies and econometrics to shift the debate to a higher level. Some of these studies include Akinlo (2006), Kumar, Webber, and Fargher (2010), Omanukwue (2010), Yamden (2011), Bassey, Bessong, and Effiong (2012), Aiyedogbon, Ibeh, Edafe, and Ohwofasa (2013), Iyoboyi and Pedro (2013), Nduka, Chukwu, and Nwakaire (2013), Imimole and Uniamikogbo (2014), Apere and Karimo (2014), Bassey, Solomon, and Okon (2017), Nwude, Offor, and Udeh (2018), and Tule, Okpanachi, Ogiji, and Usman (2018).

The table below shows a summary of the empirical studies on the demand for money in Nigeria.

Table 1 Summary of empirical literature on money demand in Nigeria

Author	Study Period	Method	Key Finding (s)
Aiyedogbon, J.O., Ibeh, S.E., Edafe, M., & Ohwofasa, B.O. (2013).	1986-2010	VECM	Stable money demand function; long run interest rate and inflation rate had negative impact on real money demand while exchange was positive; in the short run, lagged money demand, interest rate and exchange rate had negative relationship with current money demand while inflation was positive.
Akinlo, A.E. (2006).	1970-2002	ARDL	M2 was cointegrated with exchange rate, income, and interest rate.
Anoruo, E. (2002).	1986-2000	ECM/OLS	Stable demand for money; income, M2, real discount rate were co-integrated.
Apere, T.O., & Karimo, T.M. (2014).	1971-2012	Partial Adjustment Model (PAM)	Stable money demand function was stable, indicating the absence of structural breaks in the demand for real money balances in Nigeria. Furthermore, the study showed that the transaction and precautionary motives for holding money, and the speculative motive are all important determinants of real money demand in Nigeria in the short run.
Bassey, E.B., Bessong, P.K., & Effiong, C. (2012).		OLS	They showed negative impacts of interest rate, exchange rate, and expected inflation on money demand in Nigeria
Bassey, N.E., Solomon, U.U., & Okon, U.E. (2017).	1986-2013	ECM	The result revealed that while income enhances the desire to hold money, interest rate and expected inflation rate impacted negatively on money demand indicating that during inflationary expectation and periods of lower interest rates, asset holders switch out of money assets into real assets.
Imimole, B., & Uniamikogbo, S.O. (2014).	1986-2010	ARDL	The short and long run parameters of the real broad money demand function exhibited remarkable stability.
Iyoboyi, M., & L. M. Pedro (2013).	1970-2010	ARDL	M2 was cointegrated with real income, short term interest rate, expected exchange rate, and expected inflation rate.
Kumar, S., Webber, D.J., & Fargher, S. (2010),	1960-2008	ECM	Stable money demand; the study also identified 1992 and 1996 as the endogenous structural break points.
Nduka, E.K., Chukwu, J.O., & Nwakaire, O.N. (2013).	1986-2011	Engle-Granger two-stage test	The results showed a stable and long-run relationship between demand for real broad money and its determinants (income, domestic real interest rate, expected rate of inflation, expected

			foreign exchange depreciation, and foreign interest rates). Further results showed that income elasticity and foreign interest rate coefficients to be positive while interest rate, inflation rate, and exchange rate coefficients were negative, respectively.
Nwude, E.C., Offor, K.O., & Udeh, S.N. (2018).	1991-2014	OLS	The results indicated that a long-run relationship existed between the real broad money aggregate and real income, domestic interest rate, inflation rate, exchange rate, and foreign interest rate. Real income and exchange rate were directly related to the real broad money balances while domestic interest rate, inflation rate, and foreign interest rate were inversely related to the demand for broad money.
Omanukwue, P.N. (2010).	1990-2008	Engle-Granger two-stage test	A long-run relationship between money, prices, output, interest rate, and money demand in Nigeria.
Owoye, O., & Onafowora, O.A. (2007).	1986-2001	OLS/ECM	Stable demand for money; income, M2, real discount rate were cointegrated
Tule, M.K., Okpanachi, U.S., Ogiji, P., & Usman, N. (2018).	1998-2016	ARDL	Stable long-run relationship existed between M2 and its determinants including GDP, stock prices, foreign interest rates and real exchange rate.
Yamden, B. P. (2011).	1985-2007	OLS	Stable money demand; income, inflation, and exchange rate were significant determinants; income was the most significant determinant of demand for money.

Source: Researchers' survey (2019).

The general observation in the empirical literature in Nigeria is that the empirical studies differ by time periods of study, explanatory variables, data frequencies, and model specifications. Some of these studies have serious methodological setbacks ranging from micronumerousity to wrongly applied techniques of analyses. Some used data points pertaining to annual time series that are too small which of course, going by the central limit theorem is too short to generate meaningful estimates. Some employed the Engle-Granger approach in the presence of more than two variables without ascertain that there exist a single cointegrating vector. The issue with this is that if there is more than one cointegrating vectors governing the long run relationship between the variables the Engle-Granger approach breaks down and the Johansen's technique becomes more useful. All these would lead to spurious results. Therefore, there are gaps in the body of knowledge concerning the money demand function in Nigerian. This study attempted to fill these gaps by extending the data set from 1986 to 2018 using quarterly data and applying the autoregressive distributed-lag (ARDL) approach suggested by Pesaran, Shin, and Smith (2001). The ARDL approach is used in regression primarily because it can be applied irrespective of the order of integration of the series, it overcomes the unit-root pitfalls in regression, and it solves the often present problem of serial correlation in economic time series (Banerjee, Dolado, & Mestre, 1998; Ghatak & Siddiki, 2001). The ARDL approach can be used to simultaneously estimate the short-term and long-term relationships in a model (Ghatak & Siddiki, 2001).

METHODOLOGY

Data, Sources, and Description

This study employed quarterly time-series data from 1986 to 2018. The data were sourced from the Central Bank of Nigeria Statistics and World Bank database. The variables include broad money supply, crude oil price, exchange rate, foreign reserves, inflation, interest rate, and real gross domestic product. Broad Money (M2) is defined as the sum of currency in the hands of the public plus all of the public's deposits in commercial banks. Crude oil price is a product of crude oil production and the prevailing international price of crude oil. Exchange rate is the price of one nation's currency in terms of another nation's currency. It is calculated as a quarterly average based on monthly averages (local currency units relative to the U.S. dollar). Foreign exchange reserves (or reserve assets in the balance of payments) are those external assets that are readily available to and controlled by a country's monetary authorities. They comprise foreign currencies, other assets denominated in foreign currencies, gold reserves, special drawing rights (SDRs), and IMF reserve positions. Inflation is measured by the consumer price index (CPI). It is the composite consumer price index of the rural and urban price indexes. Interest rate is the percent increase in purchasing power (that is, in real goods and services) that borrowers pay back to lenders. This equals nominal rate of interest minus the expected rate of inflation. Real gross domestic product (RGDP) is an inflation-adjusted measure that reflects the value of all goods and services produced by an economy in a given year, expressed in base-year prices.

The ARDL Specification

The money demand model was first introduced by Baumol (1952) and Tobin (1956). In constructing money demand function (MDF), the main issue to be addressed is the choice of variables to be included in the function. A common practice in the empirical literature is to assume that the desired level of money demand depends on the price level, a transaction (or scaling) variable and a vector of opportunity costs (Baharumshah, Mohd, & Yol, 2009; Goldfield & Sichel, 1990) as follows:

$$\left(\frac{M*}{p}\right) = f(Y, R_1, R_2 \ldots) \qquad \textbf{(3)}$$

where $M*$ is desired nominal money demand, p is the price level, Y is real income (as a proxy for the transaction variable), and R_i are the elements of the vector of opportunity costs which usually includes a measure of (expected) inflation.

In terms of empirical implementation, a common specification is the partial adjustment model (PAM). Goldfield and Sichel (1990) demonstrate that a desired level of money holding, $MR*$ as:

$$MR_t^* = \left(\frac{M_t^**}{P_t}\right) = \phi_0 + \phi_1 Y_t + \phi_2 R_t + \phi_3 \pi_t, \quad \textbf{(4)}$$

where R represents one or more interest rates and $\pi_t = \ln(P_t / P_{t-1})$ is the inflation rate.

Taking into account the special characteristics of the Nigerian economy and by considering recent empirical studies in the context of money demand function, an empirical multivariate functional relationship between the selected monetary variables and money demand is constructed which emphasises the effect of crude oil price, exchange rate, real gross domestic product growth rate, inflation, and interest rate, on broad money supply. That is:

$$M2 = f(CRUDEOILP, EXCRT, FORESERVE, INFRT, INTRT, RGDP) \quad \textbf{(5)}$$

Where *M*2 is real money stock, *CRUDEOILP* is crude oil price, *EXCRT* is exchange rate, *FORESERVE* is foreign reserves, *INFRT* is inflation rate, *INTRT* is interest rate, and *RGDP* is real gross domestic product. Equation (5) is re-written in semi-log form as shown in (6).

$$\ln M2_t = \alpha_0 + \alpha_1 CRUDEOILP_t + \alpha_2 EXCRT + \alpha_3 FORESERVE + \alpha_4 INFRT_t + \alpha_5 INTRT_t + \alpha_6 \ln RGDP_t + \varepsilon_t \quad \textbf{(6)}$$

The parameters in equation (6) capture the response of money demand to changes in its determinants. The crude oil price elasticity and the income elasticity of money demand are expected to be positive. Exchange rate, inflation rate, and interest rate are expected to have negative or positive elasticities depending on the strengths of the income and substitution effect on money balances.

The autoregressive representation of the model can be stated as:

$$\ln(M2)_t = \alpha_0 + \alpha_1 \ln(M2)_{t-1} + \alpha_2 CRUDEOILP_t + \alpha_3 EXCRT + \alpha_4 FORESERVE + \alpha_5 INFRT_t + \alpha_6 INTRT_t + \alpha_7 RGDP_t + \varepsilon_t \quad \textbf{(7)}$$

In order to develop a model that captures the short-term and long-term dynamics of money demand, the study adopts the econometric technique of the autoregressive distributed-lag (ARDL) model. The model was introduced by Pesaran, Shin, and Smith (2001). The autoregressive distributed lag (ARDL) approach is a regression technique for determining long-run and short-run relationships among variables under study simultaneously.

Following Pesaran, Shin, and Smith (2001), the autoregressive distributed lag (ARDL) representation of the model (Equation 7) is specified as follows:

$$\Delta(M2)_t = \alpha_0 + \sum_{i=i}^{n} \alpha_{1i} \Delta M2_{t-i} + \sum_{i=i}^{n} \alpha_{2i} \Delta CRUDEOILP_{t-i} + \sum_{i=i}^{n} \alpha_{3i} \Delta EXCRT_{t-i} + \sum_{i=i}^{n} \alpha_{4i} \Delta FORESERVE_{t-i} + \sum_{i=i}^{n} \alpha_{5i} \Delta INFRT_{t-i} + \sum_{i=i}^{n} \alpha_{6i} \Delta INTRT_{t-i} + \sum_{i=i}^{n} \alpha_{7i} \Delta RGDP_{t-i} + \beta_1 M2_{t-1} + \beta_2 CRUDEOILP_{t-1} + \beta_3 EXCRT_{t-1} + \beta_4 FORESERVE + \beta_5 INFRT_t + \beta_6 INTRT_{t-1} + \beta_7 RGDP_{t-1} + \varepsilon_t \quad \textbf{(8)}$$

Where Δ denotes the first difference, α_0 is the drift component, and ε_t is the white noise residual. The left-hand side is the money demand (M2). The first until seventh expressions $(\alpha_1 - \alpha_7)$ on the right-hand side correspond to the short-run dynamics of the model. The remaining expressions with the $(\beta_1 - \beta_7)$ represent the long-run dynamics of the model.

Estimation Procedure

The analyses were carried out in four phases. The first phase dealt with some pre-tests to ascertain the stationarity of the variables used for the study. The second phase was the estimation of the ARDL model. The third was the post-estimation analyses (diagnostic testing) of the model. The fourth phase assessed the forecasting performance of the model using forecasting measures such as root mean square error (RMSE) and mean absolute error (MAE).

Presentation of Results

Graphical Analysis

The first step in modelling a series is to ascertain the stationarity of the series. Figure 1 below shows the line graphs of the historical performance of the variables used in this study.

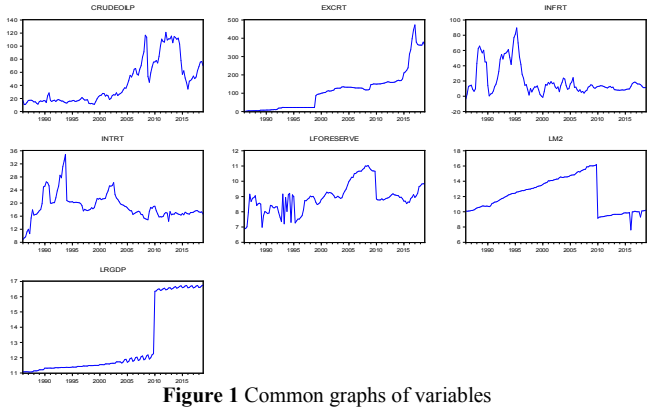

Figure 1 Common graphs of variables

Source: Researchers' calculation by EViews (2019).

The graphs show that there is little evidence to suspect the presence of structural breaks in the seven variables. However, the graphs reveal that the series are not stationary. The graphical analyses show that the variables have some variations and using them in the models will require identifying their stationary properties.

Unit Root Tests for the Variables

Though ARDL models do not impose pre-testing of variables for unit root problems, however, unit root tests are conducted in this study to find out if there are mixtures in the order of integration of the variables. The order of integration of the time series was investigated by the Augmented Dickey-Fuller (1979) test. The unit root test results for the time series variables are presented in Table 2 below.

Table 2 The Augmented Dickey-Fuller (ADF) unit root test results

Variable	ADF Test Statistic at Level	ADF Test Statistic at 1st Difference	95% Critical ADF Value	Order of Integration	Remark
CRUDEOILP	-1.399566	-9.230481*	-2.883930	*I* (1)	Stationary
EXCRT	-0.017134	-8.639378*	-2.883753	*I* (1)	Stationary
FORESERVE	-1.768890	-11.54247	-2.883753	*I* (1)	Stationary
INFRT	-3.297928*		-2.883753	*I* (0)	Stationary
INTRT	-3.170753**		-2.883579	*I* (0)	Stationary
M2	-2.422432	-12.45141*	-2.883753	*I* (1)	Stationary
RGDP	-0.052997	-11.38276*	-2.883753	*I* (1)	Stationary

Note: * = 1 percent significance; ** = 5 percent significance.

Source: Researchers' calculation by EViews (2019).

The ADF tests in Table 2 show that inflation rate (INFRT) and interest rate (INTRT) were stationary at level while crude oil price (CRUDEOILP), exchange rate (EXCRT), foreign reserves (FORESEVE), money supply (M2), and real gross domestic product (RGDP) were stationary at first difference. Thus co-integration tests can be applied for all variables.

Co-Integration Test

The Engel and Granger (1987) co-integration test is used for single equation models. The co-integration test result for the research model is presented in Table 3 below.

Table 3 Engel and Granger residual-based co-integration test result

Series	Adf	5% critical value	Order of integration	Remark
Residual	-3.9	-2.88	I (0)	Co-integrated

Source: Researchers' calculation by EViews (2019).

The results in Table 3 show that there is co-integration among crude oil price (CRUDEOILP), exchange rate (EXCRT), foreign reserves (FORESEVE), inflation rate (INFNRT), interest rate (INTRT), money supply (M2), and real gross domestic product (RGDP) variables since the ADF test value for the residual is greater (absolute values) than the critical value. This means that a long-run stable relationship exists among the variables used in this study implying that any short-run deviation in their relationships would return to equilibrium in the long-run.

Correlation Matrix

A correlation matrix is a table showing correlation coefficients between variables. Correlation measures both the strength and direction of the linear relationship between two variables. The Pearson correlation coefficient (correlation matrix) and the results are presented in Table 4.

Table 4 Pearson correlation matrix

Variable	Crudeoilp	Excrt	Foreserve	Infrt	Intrt	M2	Rgdp
Crudeoilp	1	0.544	0.416	-0.390	-0.386	0.247	0.684
Excrt	0.544	1	0.210	-0.351	-0.233	0.061	0.771
Foreserve	0.416	0.210	1	-0.263	-0.233	0.909	-0.140
Infrt	-0.390	-0.351	-0.263	1	0.367	-0.207	-0.261
Intrt	-0.387	-0.233	-0.233	0.367	1	-0.113	-0.322
M2	0.247	0.061	0.909	-0.207	-0.113	1	-0.316
Rgdp	0.684	0.771	-0.140	-0.261	-0.322	-0.316	1

Source: Researchers' calculation by EViews (2019).

The correlation coefficients show that whereas crude oil price (0.247) and exchange rate (0.061) have weak positive relationship with broad money (M2), foreign reserve (0.909) has a strong positive relationship with broad money (M2). On the other hand, inflation rate (-0.207), interest rate (-0.113), and real gross domestic product (-0.316) have weak and negative relationship with broad money (M2). This means that increases in inflation rate, interest rate, and real gross domestic product are associated with decrease in broad money demand (supply) in Nigeria. The correlation among the explanatory variables shows that there is no evidence of the presence of multicolinearity in the specified model.

Model Estimation and Diagnostics and Interpretation

The autoregressive distributed-lag (ARDL) is a technique used to estimate the short-run and long-run coefficients of a model to simultaneously. The estimated parsimonious auto-regressive distributed lag **(ARDL)** model is presented in Table 5.

Table 5 Parsimonious ARDL (4, 4, 2, 1, 4) model estimates
Dependent Variable: DLM2 Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.840866	1.659397	1.711987	0.0905
Independent Variables				
Short-Run Results				
DLM2(-1)	-0.878629	0.096142	-9.138903	0.0000
DLM2(-2)	-0.946199	0.121759	-7.771060	0.0000
DLM2(-3)	-0.877646	0.133019	-6.597886	0.0000
DLM2(-4)	-0.597576	0.121487	-4.918857	0.0000
DCRUDEOILP(-4)	0.005830	0.003422	1.703759	0.0921
DEXCRT	-0.008765	0.002412	-3.634185	0.0005
DEXCRT(-1)	0.003859	0.001818	2.122835	0.0367
DEXCRT(-2)	0.005791	0.001839	3.149652	0.0023
DINTRT(-1)	-0.030900	0.015537	-1.988771	0.0499
DLRGDP	-1.655948	0.069810	-23.72076	0.0000
DLRGDP(-1)	-1.353784	0.174206	-7.771156	0.0000
DLRGDP(-2)	-1.502771	0.211279	-7.112728	0.0000
DLRGDP(-3)	-1.435523	0.228962	-6.269704	0.0000
DLRGDP(-4)	-0.935942	0.214545	-4.362441	0.0000
Long-Run Results				
LM2(-1)	-0.065246	0.036772	-1.774314	0.0796
CRUDEOILP(-1)	0.006736	0.003272	2.058759	0.0426
LRGDP(-1)	-0.198194	0.082823	-2.392967	0.0189
R-squared	0.922039			
Adjusted R-squared	0.884434			
F-statistic	24.51921			
Prob(F-statistic)	0.000000			
Durbin-Watson stat	2.090013			

Source: Researchers' calculation by EViews (2019).

After estimating the empirical **ARDL** model, a variety of diagnostic tests were carried out to enhance the credibility of the model. The serial correlation (Breusch-Godfrey serial correlation LM) test, the efficiency (Heteroskedasticity) test, the forecasting performance (RMSE and MAE) test, and the stability (cumulative sum of squares) test were conducted. The results of the respective tests are presented in Table 6 and Figure 2.

Table 6 ARDL model diagnostic tests

test	*f-statistic* (*prob*)	*value*
Serial Correlation: Breusch-Godfrey serial correlation LM test	1.19 (0.31)	
Heteroskedasticity Test: ARCH	0.18 (0.95)	
Root Mean Square Error (RMSE)		0.20
Mean Absolute Error (MAE)		0.12

Source: Researchers' calculation by EViews (2019).

The diagnostics indicate that the residuals were serially uncorrelated and efficient based on Breusch-Godfrey serial correlation LM test and heteroskedasticity test respectively. The results also show that the model is relevant for forecasting economic growth in Nigeria. The stability properties of the ARDL model were examined by the cumulative sum (CUSUM) **of** recursive residuals plot test which Brown, Durbin, and Evans (1975) developed. According to Bahmani-Oskooee and Wing NG (2002), if the plot of these statistics remains within the critical bound of the 5% significance level, the null hypothesis (that is, all coefficients in the model are stable) cannot be rejected. A graphical presentation of this test for our ARDL model is provided in Figure 2 below.

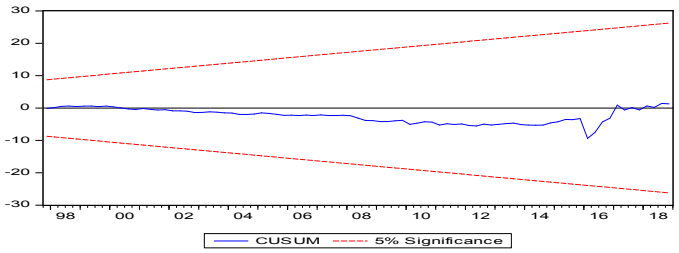

Figure 2 Cumulative sum (CUSUM) of recursive residuals plot.

Source: Researchers' calculation by EViews (2019).

Since the plot of the cumulative sum of recursive residuals statistic for money demand function does not cross the critical value lines as Figure 2 indicates, it is therefore safe to conclude that ARDL money demand function is stable and money demand can be used as a target variable.

DISCUSSION OF FINDINGS

The study examined the relationship between crude oil price, exchange rate, foreign reserves, inflation, interest rate, output, and real money balances using quarterly time series data from 1986 to 2018. The data were sourced from the publications of the Central Bank of Nigeria (CBN) and the World Bank. A model was formulated, estimated, and validated (using standard statistical and econometric techniques). The results of the model show that the ARDL model can be applied in explaining the dynamics of money demand in Nigeria. The empirical model extracted from the regression results (Table 5) is stated in Equation 9 below.

$$\begin{aligned}\Delta LM2_t &= 2.84 - 0.88\Delta LM2_{t-1} - 0.95\Delta LM2_{t-2} - 0.88\Delta LM2_{t-3} - 0.60\Delta LM2_{t-4} - 0.01\Delta CRUDEOILP_{t-4} - 0.01\Delta EXCRT_t \\ &\quad (1.71)\ (-9.14)\ (-7.77)\ (-6.60)\ (-4.92)\ (1.70)\ (-3.63) \\ &\quad \{0.09\}\ \{0.00\}\ \{0.00\}\ \{0.00\}\ \{0.00\}\ \{0.09\}\ \{0.00\} \\ &\quad +0.003\Delta EXCRT_{t-1} + 0.006\Delta EXCRT_{t-2} - 0.03\Delta INTRT_{t-1} - 1.66\Delta LRGDP_t - 1.35\Delta LRGDP_{t-1} \\ &\quad (2.12)\ (3.156)\ (-1.99)\ (-23.72)\ (-7.77) \\ &\quad \{0.04\}\ \{0.002\}\ \{0.05\}\ \{0.00\}\ \{0.00\} \\ &\quad -1.50\Delta LRGDP_{t-2} - 1.44\Delta LRGDP_{t-3} - 0.93\Delta LRGDP_{t-4} - 0.07LM2_{t-1} - 0.007CRUDEOILP_{t-1} \\ &\quad (-7.11)\ (-6.27)\ (-4.36)\ (1.35)\ (-0.30) \\ &\quad \{0.00\}\ \{0.00\}\ \{0.00\}\ \{0.08\}\ \{0.04\} \\ &\quad -0.20LRGDP_{t-1} + \varepsilon_t \\ &\quad (-0.65) \\ &\quad \{0.02\} \end{aligned} \quad (9)$$

R-squared = 0.92
F-statistic = 24.5 (0.00)
D-Watson = 2.1
Note:
*t-values are in brackets.
**probability values are in braces.

From the results, the coefficient of determination $(R^2 = 0.92)$ shows that about 92% of the changes in money demand in Nigeria is jointly accounted for by crude oil price, exchange rate, foreign reserves, inflation rate, interest rate, and output. The *F*-test shows that the overall regression is statistically significant at 1% level. This implies that the ARDL model has a satisfactory goodness-of-fit. The results show that whereas expected money demand, crude oil price, exchange rate, interest rate, and output have a significant predictable impact on the quantity of money demand in Nigeria, foreign reserves and inflation do not have significant relationships with real money balances in Nigeria.

The study reveals that previous values of money balances have negative and significant impacts on the changes in the current money balances in Nigeria during the sample period in both the short run and the long run. Since the results showed that past values of money balances influence the current value of money balances in the long run, it means that money demand dynamics largely find explanation in the adaptive-expectations theory in Nigeria. There is a positive and statistically significant effect of crude oil prices on real broad money demand in Nigeria. This means that an increase in crude oil prices would lead to increases in money balances in Nigeria. This is consistent with the theoretical expectation.

There is a positive and statistically significant effect of exchange (the first-period and second-period lags) on broad money demand in Nigeria. This is consistent with theory that predicts that an increase in exchange rate can be perceived as an increase in wealth, leading to a rise in the demand for domestic money. Depreciation of the exchange rate increases the external value of the domestic currency in foreign assets. The positive coefficient of exchange rate in Nigeria is in conformity with the findings of Imimole and Uniamikogbo (2014). There is also a negative and statistically significant effect of current exchange rate on real broad money demand in Nigeria. Therefore, any increase in exchange rate will be perceived as a decline in wealth, hence, facilitating a fall in the demand for domestic currency because people would prefer to opt for foreign currency with higher value. This is in conformity with the findings of Onafowara and Owoye (2004), and Nduka, Chukwu, and Nwakaire (2013), in Nigeria as they attributed the negative coefficient of the exchange rate depreciation to the existence of currency substitution in Nigeria. So also, for exchange rate depreciation, the elasticity is quite low and significant for broad money. This demonstrates that excessive speculation in the foreign exchange market is quite low amongst the general populace.

The results show that the interest rate coefficient carries a negative sign and is statistically significant in the short run. By implication, an increase in the interest rate may give rise to a fall in the demand for the local currency (Naira). The negative coefficient of interest rate follows the Friedman quantity theory of money and is consistent with the contributions of Nduka, Chukwu, and Nwakaire (2013) Bassey, Bessong, and Effiong (2012), and Iyoboyi and Pedro (2013). Beyond this, the Keynesian theory which stipulates that interest rate acts indirectly in regulating monetary equilibrium is justified here. This result is in contrast to Imimole and Uniamikogbo (2014), Owoye and Onafowora (2007).

The coefficients for real income are negative and significant in both the short run and long run. The plausible justification for this is that any increase in either the previous or current income of asset holders would invariably reduce their desire to hold money presumably to meet up daily transaction. Hence money is considered as a luxury goog. This is not consistent with the findings of Iyoboyi and Pedro (2013) and Nduka, Chukwu, and Nwakaire (2013) in Nigeria.

CONCLUSIONS, POLICY DIMENSIONS, AND RECOMMENDATIONS

The study analysed the money demand function (MDF) for Nigeria from 1986 to 2018. Five major conclusions can be drawn from the study. Firstly, the demand for money in Nigeria is highly expectations-driven. Secondly, existence of a stable money demand function (MDF) in Nigeria can only be firmly established when crude oil price, exchange rate, interest rate, and income are included in the money demand model. Thirdly, the study provides no evidence that inflation rates and foreign reserves have significant influence on the short run and long run money demand function in Nigeria during the study period. Fourthly, changes in expected money demand have

negative significant short and long-term effects on current money demand; income has negative significant short and long-term effects on current money demand; crude oil prices have positive significant short and long-term effects on current money demand; exchange rates have negative and positive short-term effects on current money demand; interest rates have negative short-term effects on current money demand. Lastly, income is the most significant determinant of the demand for money followed by money demand expectations.

The policy dimensions to the above results are clear. First, the adoption of aggregate targeting by the monetary authority for the control and implementation of monetary policy will largely depend on the behavior of short term crude oil prices, exchange rates, interest rates, and income because of the established stability of the broad money demand with respect to these aggregates (crude oil price, exchange rates, interest rates, and income). Second, given that the money demand function in Nigeria follows the adaptive-expectations theory, the conduct of monetary policy in Nigeria should ensure transparency in monetary policy eformulation, presentation, and implementation. Thirdly, the empirical finding with respect to the interest rate, calls for policies aimed at developing the financial system, increasing its depth and reaches within the economy, and reducing money banks interest rate. Finally, given that exchange rate has a negative and positive significant impacts on current money demand in Nigeria, the government should develop economic structure that can compete favourably with international community's which will be characterized by high investment inflows into the country thereby improving the real foreign exchange rate in Nigeria for better economic development and growth.

Based on the findings and policy dimensions, it is recommended that the monetary authority should ensure a clear-cut distinction between short run and long run objectives. Thus, the monetary authority can use the previous crude oil prices and previous exchange rates to increase the level of money demand in the short run. The monetary authority can also use the expected money balances, the current exchange rate, the current interest rate, the current income, and expected income to reduce the level of money demand in the short run. Whereas the monetary authority can use the expected money balances and expected income to reduce the money demand function in the long run, it can also use the expected crude oil prices to increase the money demand function in the long run.

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How to cite this article:

Ibrahim Shaibu and Chinwuba Okafor (2020) ' Money Demand Function in Nigeria: an Ardl Approach', *International Journal of Current Advanced Research,* 09(04), pp. 21891-21899. DOI: http://dx.doi.org/10.24327/ijcar.2020. 21899.4310

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