

RESEARCH ARTICLE

## A Nonlinear Approach to the Analysis of the Financial Innovation-Money Demand Nexus in Nigeria

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Received: 20 November, 2023, Accepted: 07 December, 2023, Published: 08 December, 2023

### Abstract

This study examines the asymmetric roles of financial innovation in the money demand function in Nigeria using annual data over the period 1981-2020. This is with a view to providing insight into how changes in financial innovation have contributed to the level and stability of the money demand function. The study questions the fundamental assumption of the existing literature that growing trends in financial innovation have symmetric or linear effects on the country's money demand. Hence, it adopts the nonlinear autoregressive distributed lag (NARDL) with bounds testing procedure together with the cumulative sum of recursive as well as the cumulative sum of squares of recursive residuals tests. Results show that the link between financial innovation and money demand is asymmetric and that of the two partial sum variables, only positive changes in financial innovation have significant effects with the sign being positive in both the short run and long run. This shows that assumptions of linearity and no asymmetric structure reported in extant studies for financial innovation are somewhat misleading. Findings also confirm the stability of demand for money in Nigeria on account of the introduction of asymmetric effects of financial innovation. The study concludes that the financial innovation-money demand nexus is asymmetric and that there is stability in the country's money demand function once asymmetry or nonlinearity is captured in the nexus. Therefore, it recommends the need for monetary authorities to pay attention to positive changes in financial innovation when policies on money demand are formulated for the purpose of enhancing the effectiveness and reliability of monetary policy as a tool for stabilising the economy.

**Keywords:** Demand for money; Financial innovation; Monetary policy; NARDL; Nigeria; Stability

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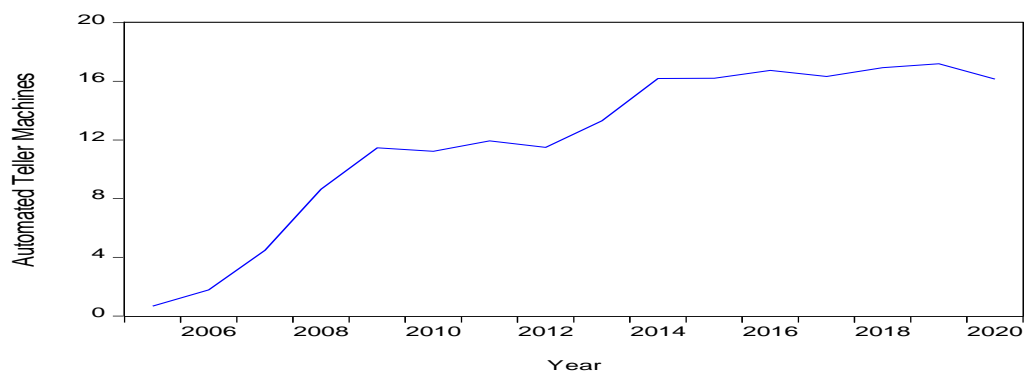
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## Introduction

Empirical studies abound on the issues surrounding the factors that determine money demand and its stability (Bahmani-Oskooee & Nayeri, 2020a). Despite this plethora of studies, the literature is still evolving because of how sensitive and important a stable money demand function is to the effectual conduct and implementation of monetary policy in any economy. For instance, a stable money demand has been described as a condition that is necessary if monetary policy is to serve as a reliable and effective tool for stabilising the economy (Asongu *et al.*, 2019; Bahmani-Oskooee & Nayeri, 2018; Foresti & Napolitano, 2014). This is consistent with the position of Serletis (2007) that maintaining stability in the money demand function is one of the critical components that must be considered in formulating an effective monetary policy. Besides, for a monetary policy to stimulate real sector output growth, the existence of a highly predictable and stable money demand function is a prerequisite. Hence, when there is instability in money demand, the conduct of effective monetary policy becomes difficult (Ivanovski & Churchill, 2019). In such an environment, undesirable and unpredictable fluctuations are triggered which render monetary policy ineffectual while its forecasting power is reduced (Pradhan & Subramanian, 2003).

In their attempts to test how stable money demand is, scholars have incorporated several variables or factors into the function. Some of the factors that are commonly used include real income, exchange rate, interest rate, rate of inflation, economic policy uncertainty and financial innovation (see, for example, Adil *et al.*, 2020; Akinlo, 2006; Ala' Bashayreh *et al.*, 2019; Bahmani-Oskooee, Bahmani, Kones & Kutan, 2015; Bahmani-Oskooee & Nayeri, 2018; Bahmani-Oskooee & Nayeri, 2020a; Chimobi & Igwe, 2010; Gan *et al.*, 2015; Gbadebo, 2010; Hye, 2009; Ivanovski & Churchill, 2019; Malik & Aslam, 2010; Mumtaz & Smith, 2020; Odularu & Okunrinboye, 2009).

Among all these factors, the role of financial innovation has not been adequately explored, particularly in the context of Nigeria. Financial innovation captures technological advances (such as the cashless policy, Automated Teller Machines (ATMs), credit cards, money transfer cards, mobile money, etc.), institutional and structural changes, financial sector development, as well as banking sector reforms which occur as a result of diverse liberalisation policies (Adil *et al.*, 2020; Qamruzzaman & Wei, 2019; Dunne & Kasekende, 2018; Gbadebo, 2010). The Nigerian financial sector has undergone significant changes particularly in the area of financial innovation in the last one and half decades (see Figure 1, for example).



**Figure 1:** ATMs (per 100,000 adults) in Nigeria, 2005-2020

**Source:** Authors' Compilation (2022) Using World Development Indicators, 2021

It has been emphasised that these evidences of financial innovation tend to influence changes in the entire financial system as well as the money demand function, and subsequently the conduct of monetary policy. It has also been stressed that if financial innovation is unaccounted for in a money demand function, it may give rise to the problem of misspecification (Motsewakgosi, 2019). This problem has the tendency of producing spurious estimates and

false stability or instability of money demand function (Dunne & Kasekende, 2018), which may cause ineffectual monetary policy. Another group of scholars have posited that financial innovation tends to alter stability of demand for money (Arize, 1990; Folarin & Asongu, 2019). All these arguments make financial innovation an important input of money demand function, particularly in a country like Nigeria which has experienced some significant development in her financial system.

The few studies that have examined the role of financial innovation as a component of money demand function in the context of Nigeria (Chimobi & Igwe, 2010; Gbadebo, 2010; Odularu & Okunrinboye, 2009; Ujunwa *et al.*, 2022) arrived at mixed and inconclusive results. Aside from the inconclusiveness, all the previously published works assume symmetry in the nexus between financial innovation and money demand. Although there is a plethora of studies which examined money demand function within a framework of asymmetric and nonlinear approaches (Bahmani-Oskooee *et al.*, 2020; Bahmani-Oskooee & Nayeri, 2020a & b; Ivanovski & Churchill, 2019; Ongan & Gocer, 2021), none has tested the asymmetric and nonlinear effects of financial innovation on demand for money. The extant studies, which incorporated financial innovation as a driver of money demand function, were restricted to the framework of linearity and symmetric structure. Hence, the studies failed to distinguish the effects of positive unanticipated shocks (increases) in financial innovation from those of negative unanticipated shocks (declines). Such an approach does not accord well with reality (Hatemi-J & El-Khatib, 2020; Olaniyi, 2019 & 2020; Olaniyi & Olayeni, 2020; Tiwari *et al.*, 2020), as there could be potential asymmetric and nonlinear structures in the ways financial innovation influences money demand function. After all, the rate at which people reduce their holding of money during the period of positive changes in financial innovation may not be the same as the rate at which they increase it during the period of negative changes. For example, they may not reduce their money holding during the period of positive changes in financial innovation at the same rate that they increase it during negative changes if they always expect the return of negative changes. It has also been argued that financial innovation often creates shocks which have both positive and negative consequences (Tule & Oduh, 2017).

Hence, this study complements the existing ones as it focuses on potential asymmetric and nonlinear effects of financial innovation on money demand and its stability in Nigeria. Specifically, it unravels nonlinear and asymmetric effects of financial innovation on money demand and its stability in Nigeria within the framework of the nonlinear autoregressive distributed lag (NARDL) model. The choice of Nigeria is appropriate for two main reasons, the first of which is that the country has undergone series of financial innovation (Okafor, 2019). Various reforms such as financial sector reforms, liberalisation of interest as well as exchange rates, cashless policy, adoption of ATM, Point of Sale (POS) terminals, mobile banking, Remita, WEB payment, and internet banking have taken place in the country's financial system. These are evidences of financial innovation which could influence, alter and cause changes in the amount of cash holding in the economy as well as the stability of money demand function. Second, Nigeria is one of the countries which practise monetary aggregates targeting which is susceptible to asymmetric structure in financial innovation. Thus, accounting for both positive and negative shocks created by financial innovation in money demand function is necessary for an effectual conduct of monetary policy in the country.

The remainder of the paper is organised as follows: Following this introductory section, section 2 focuses on a brief review of the empirical literature. The methodology that is adopted for the purpose of achieving the objective of the research is presented in section 3. Section 4 is dedicated to the presentation and discussion of the findings of the paper. The conclusion of the study as well as policy implication are highlighted in the last section.

## Literature Review

Studies are not scarce on the variables or factors that determine the money demand function and its stability. However, the results that have emanated from these studies remain inconclusive which leaves the issues open for further investigation. Early scholars in Nigeria who examined these issues (Ajayi, 1974; Odama, 1974; Ojo, 1974; Teriba, 1974; Tomori, 1972) were fixated on which factors to include in the money demand function as well as the correct measurements of variables. Their analyses yielded conflicting results in terms of the variables that account for changes in Nigeria's money demand and its stability in the long and short runs. Meanwhile, as fascinating as the contributions of these scholars are, they failed to capture the importance of financial innovation as a factor in money demand.

More recent studies have also attempted to contribute to the debate with a view to providing further insight into the issues of concern. Those that have focused on Nigeria include Akinlo (2006), Aniekan and Moses (2018), Apere and Karimo (2014), Doguwa *et al.* (2014), Edet *et al.* (2017), as well as El-Rasheed *et al.* (2017). Others are Folarin and Asongu (2019), Imimole and Uniamikogbo (2014), Kumar *et al.* (2013), Nakorji and Asuzu (2019), Nduka (2014), Nwude *et al.* (2018), Ogunsakin and Awe (2014), Okonkwo *et al.* (2014), Onakoya and Yakubu (2016), Tule *et al.* (2018). These studies examined money demand function using different techniques such as the ordinary least squares (OLS), cointegration techniques (ARDL, Gregory-Hansen, Engle-Granger), error correction model (ECM), etc. The stability of the function has been explored based largely on the cumulative sum (CUSUM) and cumulative sum square (CUSUMSQ) tests. Out of this plethora of studies, those that captured the role of financial innovation in their analyses are Chimobi and Igwe (2010), Gbadebo (2010), Matthew *et al.* (2010), Nakorji and Asuzu (2019), Odularu and Okunrinboye (2009), Ogunsakin (2019), Tule and Oduh (2017), as well as Ujunwa *et al.* (2022). All these studies were conducted within the framework of linearity and symmetry in the relationship. The obvious lacuna in these studies is that their analysis is based on the assumption that financial innovation has symmetric or linear effects on the country's money demand.

This current study deviates from extant studies by relaxing the assumption of linearity and symmetry structure. It is, therefore, conducted to address the gap in the literature by examining asymmetric and nonlinear effects of financial innovation on money demand function and its stability in Nigeria within the framework of the NARDL cointegration approach developed by Shin *et al.* (2014).

## Methodology

This section presents the methodology that is adopted for the purpose of achieving the objective of the research. It comprises the model specification as well as data description and measurement.

## Model Specification

The model to be used for analysis is an extension of the money demand specification by Bahmani-Oskooee *et al.* (2020). Specifically, the specification by Bahmani-Oskooee *et al.* (2020) is augmented with financial innovation. This is based on the assumption that, in addition to income, inflation rate and the exchange rate, financial innovation is another factor that determines money demand. The extended model is specified as follows;

$$\ln RMB_t = a + b \ln INC_t + c INF_t + d \ln EXR_t + e FIV_t + \varepsilon_t \quad (1)$$

where  $\ln$  is natural logarithm,  $RMB$  is real money balances defined as money stock deflated by GDP deflator,  $INC$  is real income,  $INF$  is inflation rate,  $EXR$  is nominal exchange rate,  $FIV$  is financial innovation, and  $\varepsilon$  is the error term.

The parameters of the model in equation (1) provide information on the response of demand for money to changes in the explanatory variables. The elasticity of money demand with respect to income, measured by  $b$ , is expected to be positive. This is because the variable enters the model as a scale variable to capture the transactions demand for money. The coefficient on inflation rate ( $c$ ) is expected to be negative since it represents a measure of opportunity cost. Exchange rate is used for capturing the substitution between domestic currency and foreign currencies. Hence, its estimated coefficient, denoted as  $d$ , may be positive (depicting wealth effect) or negative (depicting expectation or currency substitution effect). The effect of financial innovation on money demand depends on the measure of financial innovation used (Ajide, 2016). For example, the effect of the ratio of broad money ( $M2$ ) to narrow money ( $M1$ ), as a measure of financial innovation, is expected to be negative. This is so because as the ratio increases, people tend to move away from  $M1$  which reflects more liquid assets, to  $M2$  which captures less liquid assets (Dunne & Kasekende, 2018). In the same vein, the effects of ATMs/debit cards as well as quasi-money are also expected to be negative. This is because of their role in improving the efficiency of intermediation and lowering transaction costs. Hence, people are motivated to hold less money in liquid form. Since equation (1) captures only the long run, Bahmani-Oskooee and Nayeri (2020a) emphasised the need to capture the process of adjustment in the short run by turning equation (1) into an error-correction model. In view of this, equation (1) is transformed into an error-correction form based on Pesaran *et al.*'s (2001) ARDL approach which allows for the separation of the short-run effects from those of the long-run. Thus, equation (1) is re-specified as follows:

$$\Delta \ln RMB_t = \alpha + \sum_{i=1}^{n_1} \beta_i \Delta \ln RMB_{t-i} + \sum_{i=0}^{n_2} \sigma_i \Delta \ln INC_{t-i} + \sum_{i=0}^{n_3} \psi_i INF_{t-i} + \sum_{i=0}^{n_4} \vartheta_i \Delta \ln EXR_{t-i} + \sum_{i=0}^{n_5} \theta_i \Delta FIV_{t-i} + \delta_0 \ln RMB_{t-1} + \delta_1 \ln INC_{t-1} + \delta_2 INF_{t-1} + \delta_3 \ln EXR_{t-1} + \delta_4 FIV_{t-1} + \mu_t \quad (2)$$

where  $\mu_t$  is the linear combination of the lagged level variables as proposed by Pesaran *et al.* (2001). The omission of the lagged level variables in equation (2) will reduce the equation to a standard vector autoregressive (VAR) model. Evidence of cointegration is based on the establishment of the joint significance of the lagged level variables. In this regard, Pesaran *et al.* (2001) developed the F-test based on a table of new critical values. Provided cointegration exists, long-run effects are generated in the form of estimates of  $\delta_1$ ,  $\delta_2$ ,  $\delta_3$  and  $\delta_4$ , normalised on  $\delta_0$ . On the other hand, short-run effects are captured by the size as well as significance of the coefficients on the variables in first difference.

The linear ARDL model of Pesaran *et al.* (2001) was extended by Shin *et al.* (2014) in developing the NARDL model to accord well with the reality of asymmetric structure. Thus, the linear model in equation (2) is transformed into a partial asymmetric one. Following extant studies, this is done by decomposing variations in the financial innovation variable into positive and negative changes using a partial sum process as follows;

$$FIV_t = FIV_0 + FIV_t^+ + FIV_t^-$$

where  $FIV_t^+$  and  $FIV_t^-$  are the partial sums of the positive change (an increase in financial innovation) as well as the negative change (a decrease in financial innovation) in  $FIV_t$ , respectively. Specifically,  $FIV_t^+$  and  $FIV_t^-$  are obtained as follows:

$$FIV_t^+ = \sum_{j=1}^t \Delta FIV_j^+ = \sum_{j=1}^t \max(\Delta FIV_j, 0) \tag{3}$$

$$FIV_t^- = \sum_{j=1}^t \Delta FIV_j^- = \sum_{j=1}^t \min(\Delta FIV_j, 0) \tag{4}$$

Substituting the two partial sums of changes in  $FIV_t$  into equation (2) yields the NARDL model as follows:

$$\begin{aligned} \Delta \ln RMB_t = & \chi + \sum_{i=1}^{n_1} \eta_i \Delta \ln RMB_{t-i} + \sum_{i=0}^{n_2} \varpi_i \Delta \ln INC_{t-i} + \sum_{i=0}^{n_3} \varsigma_i \Delta INF_{t-i} + \sum_{i=0}^{n_4} \tau_i \Delta \ln EXR_{t-i} + \sum_{i=0}^{n_5} \gamma_i \Delta FIV_{t-i}^+ \\ & + \sum_{i=0}^{n_6} \lambda_i \Delta FIV_{t-i}^- + \phi_0 \ln RMB_{t-1} + \phi_1 \ln INC_{t-1} + \phi_2 \ln INF_{t-1} + \phi_3 \ln EXR_{t-1} + \phi_4 FIV_{t-1}^+ + \phi_5 FIV_{t-1}^- + \xi_t \end{aligned} \tag{5}$$

where  $n_1, n_2, n_3, n_4, n_5$  and  $n_6$  stand for the lag lengths of the variables in the distributed lag part.

Using the model above, Wald  $F$  test is adopted in confirming the existence of cointegration based on a null of no cointegration and an alternative hypothesis of the existence of cointegration. A rejection of the null hypothesis allows for testing some asymmetric assumptions in the spirit of extant studies such as Bahmani-Oskooee *et al.* (2020). One, the study will test whether money demand reacts at different speeds to increase and decrease in financial innovation, a phenomenon that is referred to as short-run adjustment asymmetry. The phenomenon is confirmed if the lag orders of the two partial sum variables ( $FIV_t^+$  and  $FIV_t^-$ ) turn out to be different, i.e.,  $n_5 \neq n_6$ . In addition, the study will verify the assumption of short-run asymmetric effects which involves

evaluating the null hypothesis of the existence of symmetries, i.e.,  $H_0 : \sum_{i=0}^{n_5} \gamma_i = \sum_{i=0}^{n_6} \lambda_i$ . This will be tested against

the alternative hypothesis of the existence of asymmetries, i.e.,  $H_1 : \sum_{i=0}^{n_5} \gamma_i \neq \sum_{i=0}^{n_6} \lambda_i$  using the Wald test. The

presence of short-run asymmetric effects of financial innovation on money demand is confirmed by the rejection of the null hypothesis. Finally, the study will test long-run asymmetric effects of financial innovation on demand for money also using the Wald test by evaluating the null hypothesis of the existence of long-run symmetries, i.e.,

$H_0 : \frac{\phi_4}{-\phi_0} = \frac{\phi_5}{-\phi_0}$ . This is tested against the alternative hypothesis of the existence of long-run asymmetries, i.e.,

$H_1 : \frac{\phi_4}{-\phi_0} \neq \frac{\phi_5}{-\phi_0}$ . The overall predictive power of the model is adjudged on the basis of four diagnostic tests,

namely, Jarque-Bera normality test, functional form test also known as Ramsey's Regression Specification Error (RESET) test, Breusch-Pagan-Godfrey test for heteroscedasticity, as well as Breusch-Godfrey Lagrange Multiplier (LM) test for serial correlation. In line with the extant literature, the investigation of the stability of the money demand function is carried out by using the CUSUM and CUSUMSQ tests.

## Data Description and Measurement

This study utilises annual time series data on Nigeria over the period 1981-2020. The first task inherent in estimating demand for money functions is how to choose an explicit measure of money. This study adopts  $M2$  in line with the argument by Matthew *et al.* (2010) as well as Odularu and Okunrinboye (2009) that it is more consistent with official monetary conduct in Nigeria than  $M1$ . Data on the chosen measure is obtained as broad money (current local currency unit) from the World Development Indicators (WDI). However, the nominal money stock obtained is deflated using GDP deflator. The essence of the deflation is to arrive at a measure of real money balances which will yield more feasible and meaningful estimates (Kotsoni, 2011). Data on the GDP deflator are also obtained from the WDI.

In addition, real income is measured by GDP at 2010 Constant Market Prices and data are obtained from the Statistical Bulletin of the Central Bank of Nigeria (CBN). This measure of real income is expressed in per capita terms by dividing it with total population obtained from WDI. Change in consumer prices (annual %) is used in measuring inflation rate and data are also obtained from the WDI. Exchange rate is measured by Nigerian currency (naira) per U.S. dollar and data are sourced from the International Financial Statistics (IFS) of the International Monetary Fund (IMF). Finally, financial innovation is measured by the ratio of  $M2$  to  $M1$ , i.e.,  $M2/M1$ , in line with extant studies such as Bahmani-Oskooee *et al.* (2020) as well as Dunne and Kasekende (2018). Data on  $M1$  are sourced from the CBN's Statistical Bulletin. All the variables, except inflation and financial innovation, are expressed in their natural logarithmic forms.

## Results and Discussions

Prior to estimating equation (5), this study conducts some statistical tests in order to provide adequate information on the statistical features of the data employed for the econometric analysis. These tests are the descriptive statistics and unit roots or stationarity test.

### Descriptive Statistics

The outcomes of the examination of the descriptive statistics of the series employed by the study are displayed in Table 1. The outcomes show that the mean and median values of real money balances (RMB) are ₦71.20 billion and ₦39.70 billion, respectively. Since the former is greater than the latter, this is an indication of skewness to the right for the distribution of real money balances. This finding is also true for real income (INC), inflation rate (INF) and financial innovation (FIV). However, the opposite holds true for the nominal exchange rate (EXR) since its mean value of ₦100.74 is less than the median value of ₦106.46. The outcomes on skewness reveal that all the variables have values that are greater than zero, and hence, are positively skewed.

On the peakedness or flatness of the distribution of the series, the findings reveal that only exchange rate has a kurtosis value that is approximately equal to 3 which is the feature of a normal distribution. While inflation rate is peaked or leptokurtic (the kurtosis value being greater than 3), all the other variables have kurtosis values that are less than 3, and are therefore flat (platykurtic). On whether the series are normally distributed or not, the results show that only real income, exchange rate and financial innovation have a Jarque-Bera statistics with probability values that are greater than the 5% significance level. This implies that while these variables are normally distributed, the other two are not. Hence, the null hypothesis of a normal distribution cannot be accepted for the five series as a whole.

**Table 1:** Descriptive Statistics

	RMB	INC	INF	EXR	FIV
Mean	71.20	269000.50	19.00	100.74	2.09
Median	39.70	239635.10	12.72	106.46	1.82
Maximum	188.00	385349.00	72.84	358.81	3.12
Minimum	19.70	199039.10	5.39	0.62	1.47
Standard Deviation	60.60	67652.68	16.87	100.75	0.53
Skewness	0.81	0.51	1.83	0.89	0.79
Kurtosis	1.93	1.61	5.12	2.99	2.12
Jarque-Bera	6.24	4.96	29.94	5.26	5.40
Probability	0.04	0.08	0.00	0.07	0.07
Observations	40	40	40	40	40

### Stationarity Tests Results

After the examination of the descriptive features of the variables of interest, the next step in a study of this nature is to check the order of integration of the series. This is because estimation of ARDL models, whether linear or nonlinear, requires that none of the variables is stationary only after second differencing, i.e., I(2). Hence, the study uses the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests to confirm that this requirement is met in this study. Results of these tests, which are presented in Table 2, show that none of the variables is I(2) at 5% level of significance. Hence, the requirements for the application of ARDL cointegration test as put forward by Pesaran *et al.* (2001) are met (Kouakou, 2011). Thus, the study proceeds with the estimation of the NARDL model in equation (5).

**Table 2:** ADF and PP Unit Roots Tests Results

Variable	ADF		PP	
	Level	First Difference	Level	First Difference
lnRMB	-2.48	-4.27***	-2.23	-3.98**
lnINC	-1.75	-3.58**	-3.05	-3.80***
INF	-4.07**	-	-2.83*	-10.01***
lnEXR	-1.62	-5.18***	1.32	-5.28***
FIV	-2.30	-7.69***	-2.20	-8.66***

**Notes:** \*\*\*, \*\* and \* denote significance at 1%, 5% and 10%, respectively. The null hypothesis for the two tests is that each series has a unit root.

### Nonlinear ARDL Regression Results

The NARDL model in equation (5) is estimated by using the Akaike Information Criterion (AIC) in selecting the optimal lag for each of the first difference variables from a maximum of 4 lags. The results of the Wald *F*-test of cointegration, which is presented in Table 3, show *F*-statistic value of 5.28. This value exceeds the upper bound critical value even at 1% significance level (i.e., 4.15). Hence, this confirms the existence of a stable asymmetric long-run relationship among the variables captured in the estimating model.



**Table 3:** Bounds Cointegration Test Results

Significance Level	Critical Values	
	Lower Bound	Upper Bound
1%	3.06	4.15
5%	2.39	3.38
10%	2.08	3.00
F-Statistic		5.28***

**Notes:** \*\*\* denotes significance at 1% level. Critical values are cited from Pesaran *et al.* (2001) Table.

In view of the rejection of the null hypothesis of no asymmetric cointegration, the short-run and long-run results of the error-correction version of the NARDL model in equation (5) are presented in Tables 4 and 5, respectively. The short-run results in Table 4 reveal that the coefficient of increase (positive changes) in financial innovation is positive and significant at 5% level, with a magnitude of 0.50. This implies that, holding other variables constant, a 1 percent point increase in financial innovation will, on average, bring about 0.50% increase in money demand in the short run. On the other hand, the coefficient associated with decrease (negative changes) in financial innovation is negative and insignificant at 5% level.

**Table 4:** Short Run Estimation Results

Variable	Coefficient	t-statistic
$\Delta \ln RMB_{t-1}$	0.38***	4.14
$\Delta \ln RMB_{t-2}$	0.21*	1.75
$\Delta \ln INC_t$	-0.01	-0.02
$\Delta INF_t$	-	-
$\Delta \ln EXR_t$	-0.003	-0.07
$\Delta \ln EXR_{t-1}$	0.08**	2.28
$\Delta FIV_t^+$	0.50***	6.67
$\Delta FIV_t^-$	-0.25	-1.78
$ECT_{t-1}$	-0.61***	-6.82
$R^2$	0.79	
Adjusted $R^2$	0.73	
Wald – S	2.28**	
	(0.03)	

**Notes:**  $\Delta$  indicates first difference,  $\ln$  denotes natural logarithm, while  $RMB$ ,  $FIV$ ,  $INC$ ,  $INF$ , and  $EXR$  are as earlier defined. \*\*\*, \*\* and \* represent significance at 1%, 5% and 10% levels, respectively. *Wald – S* denotes the Wald test of short run symmetry or equality of the coefficients associated with positive and negative changes in financial innovation. The figure in parentheses denotes the associated probability value.

The finding on the negative changes in financial innovation is consistent with the findings of Mbazima-Lando and Manuel (2020) that financial innovation, proxied by ratio of private domestic credit to GDP, has a negative but insignificant effect on money demand in the long run in Namibia using the ARDL model. It can also be inferred from the short-run results that real money demand does not react at different speeds to increase and decrease in

financial innovation. This is because the lag orders of the two partial sum variables are not different, i.e., order zero. Hence, the phenomenon of short-run adjustment asymmetry is shown not to exist in Nigeria's demand for money function. In addition, results obtained are in support of the existence of short-run asymmetric effects of financial innovation on money demand. This is because of the significance of the t-statistic obtained from the Wald test which is reported as *Wald-S* in Table 4.

The results in Table 4 also show the effects of current levels of real income, inflation rate, exchange rate as well as lagged values of real money balances on demand for money in the short run. Current levels of both real income and exchange rate are shown to have negative and insignificant effects at 5% level. The results on real income are not in line with *a priori* expectations in terms of sign as well as statistical significance. They are, however, close to the findings of the study by Adil *et al.* (2020) as well as Nkalu (2020). Adil *et al.* (2020) find an insignificant short-run effect of income on money demand in the case of India, although the sign is positive. Similarly, Nkalu (2020) finds an insignificant but positive effect of income on money demand using panel data on Ghana and Nigeria. The negative sign on the coefficient of exchange rate suggests the expectation or currency substitution effect in the short run, although the effect is not significant. This is in line with the short-run evidence obtained by Hannan and Ishaq (2021) as well as Bangura *et al.* (2022) for Pakistan and Sierra Leone, respectively, using the linear ARDL approach.

Furthermore, the results show that one period lag of exchange rate has a significant positive effect on money demand which suggests the wealth effect. This implies that it is the one period lag of exchange rate and not the current level that exerts a significant effect on real money balances in the short run. In addition, the first two lags of real money balances are found to have positive effects on current money demand, although only the first lag has a significant effect at 5% level. Inflation rate is shown not to have any effect on Nigeria's money demand, and this is close to the results obtained by Dagher and Kovanen (2011) which show that inflation has no significant influence on money demand in Ghana. The one period lag error correction term,  $CointEq(-1)^*$ , meets the three basic criteria for validity as shown in Table 4. This is because it is negative and significant (even at 1% level) while its magnitude of about 0.61 in absolute terms lies between 0 and 1. The magnitude indicates that the speed of adjustment is about 61% which is high. It suggests that if there is any disequilibrium in the system, it takes an average speed of about 61% to adjust from the short run back to the long run. The implication of this is that money demand is responsive to stable long-run equilibrium. Also, it confirms the existence of long-run causality running from positive and negative changes in financial innovation as well as from the other explanatory variables to money demand. The values obtained for the coefficient of determination, denoted by *R-squared*, and *Adjusted R-squared* are about 0.79 and 0.73, respectively. These values, which are equal to 79% and 73%, respectively, show that the model has a good fit.

The long-run results presented in Table 5 indicate that positive changes in financial innovation have a positive and significant effect on money demand at 5% level. This result aligns with that of the short run and this implies that, contrary to *a priori* expectation, people tend to increase their demand for money both in the short run and long run as the ratio of *M2* to *M1* increases. The long-run results are, however, consistent with the findings of Mbazima-Lando and Manuel (2020) that the ratio of *M2* to *M1* has a significant positive long-run effect on money demand in Namibia using the ARDL model. The authors pointed out that the findings may be attributed to increased transactional demand brought about by the demand for innovative financial sector products. More importantly, this evidence may not be surprising for a country like Nigeria which is characterised by a large percentage of people without bank accounts. According to Global Economy (2023), the average percentage of the Nigerian population over 14 years of age without bank accounts from 2011 to 2021 was 60.4% with a minimum of 54.86% recorded in 2021. Hence, the introduction of new financial instruments, improved roles of financial institutions, etc., may not translate to a reduction in people's money holding if these aspects of financial innovation do not reduce the

unbanked population considerably. On the other hand, the coefficient associated with negative changes in financial innovation is found to be insignificant at 5% level just like the short run, although the sign is positive. This is consistent with the findings of Mbazima-Lando and Manuel (2020) that ratio of bank assets to GDP, as a proxy for financial innovation, has a positive but insignificant effect on money demand in the long run in Namibia using the ARDL model. This implies that decrease in financial innovation does not have any significant influence on money demand in both the short run and the long run.

**Table 5:** Long Run Estimation Results of the Asymmetric ARDL Model

Variable	Coefficient	t-statistic
$\ln INC_t$	1.70***	4.18
$INF_t$	-0.01*	-1.93
$\ln EXR_t$	0.04	1.50
$FIV_t^+$	0.37**	2.56
$FIV_t^-$	0.20	0.54
<i>Wald – L</i>	2.08** (0.04)	
<i>JB</i>	1.43 (0.49)	
<i>RESET</i>	0.88 (0.39)	
<i>HET</i>	0.89 (0.58)	
<i>LM</i>	0.39 (0.68)	

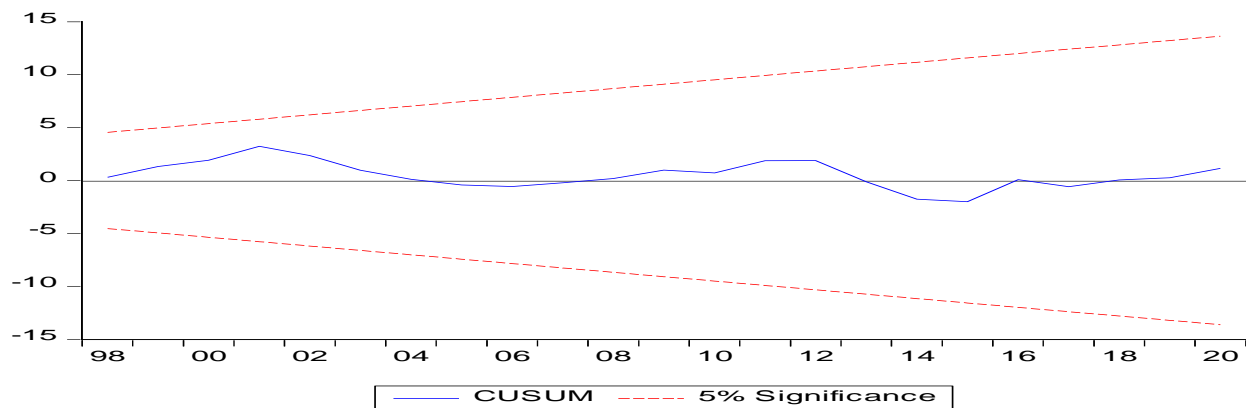
**Notes:** \*\*\*, \*\* and \* represent significance at 1%, 5% and 10% levels, respectively. *Wald-L* represents the Wald test of long run symmetry or equality of the coefficients associated with positive and negative changes in financial innovation. Figures in parentheses denote associated probability values.

Results in Table 5 also show that the long-run elasticity of demand for money with respect to real income is positive and significant at 5% level with a coefficient of about 1.70. This is not consistent with the coefficient obtained from the short-run results which is negative and insignificant. The long-run coefficient, which is also not consistent with the argument of the monetarist theory that the value should be about 1.00, is very close to the 1.72 obtained by Hannan and Ishaq (2021) for Pakistan. The authors attribute the result to the rigid nature of the financial systems in most developing countries. The effect of inflation rate is found to be negative as expected, but it is insignificant at 5% level. The results also reveal that the coefficient of exchange rate is insignificant at 5% level just like the one obtained in the short run, although it has a positive sign. The evidence of long-run asymmetric effect is confirmed by the results of the Wald test which is presented as *Wald-L* in Table 5. The results show a significant t-statistic value of 2.08 at 5% and this implies rejection of the null hypothesis of long-run symmetries.

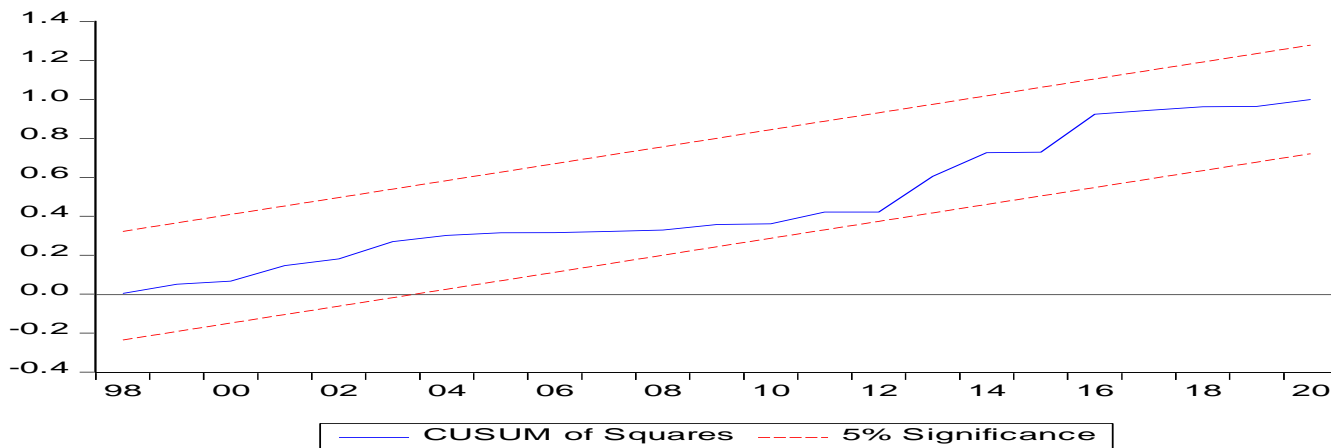
Results obtained from the four diagnostic tests confirm the overall predictive power of the model in equation (5) as reported in Table 5. The normality test results, presented as *JB* in the table, accept the null that the residuals are normally distributed since the Jarque-Bera statistic of 1.43 is not significant. The functional form test results, presented as *RESET*, show an insignificant test statistic of 0.88 which disproves the existence of specification error.

Results of the Breusch-Pagan-Godfrey test for heteroscedasticity, presented as *HET*, accept the null hypothesis of no heteroskedasticity. This is because the statistic value of 0.89 is not significant. Finally, the Breusch-Godfrey LM test results, presented as *LM*, show an insignificant LM statistic value of 0.39. This implies the acceptance of the null of no serial correlation among the residuals.

In line with the extant literature, the stability of the parameters of the asymmetric model, and hence, of the money demand function, is investigated using the CUSUM and CUSUMSQ tests. The results of the tests are shown in Figures 2 and 3. The figures show that the estimated parameters are stable since the CUSUM and CUSUMSQ lines remain within the upper and lower bounds at 5% level. In the final analysis, the results provide strong evidence that estimating the asymmetric model yields valid results upon which further inference can be drawn. These results also provide evidence of a stable demand function for Nigeria which is in line with the results obtained by Apere and Karimo (2014), Doguwa *et al.* (2014), Edet *et al.* (2017), El-Rasheed *et al.* (2017), Imimole and Uniamikogbo (2014), Nwude *et al.* (2018), as well as Okonkwo *et al.* (2014). However, the finding is not consistent with the results obtained by Aniekan and Moses (2018).



**Figure 2:** Plot of CUSUM of Recursive Residuals



**Figure 3:** Plot of CUSUM of Squares of Recursive Residuals

## **Conclusion**

Premised on how important a stable money demand function is to the effective conduct of monetary policy, empirical studies have continued to emerge to examine various determinants of demand for money with mixed and inconclusive results. It has been argued in subsisting studies that financial innovation is also an indispensable component of money demand function which must be well accounted for to ensure reliable estimates and decision on stability. Extant studies have been limited to symmetric effect of financial innovation without taking proper account of probable nonlinear and asymmetric effects of financial innovation on money demand. This may not accord well with reality. Thus, this study refreshingly deviates from existing studies by unraveling nonlinear and asymmetric effects of financial innovation on money demand and its stability in Nigeria within the framework of the NARDL model. Annual data for the period of 1980-2018 are utilised for the analysis while the stability of money demand function is explored using the CUSUM and CUSUMSQ tests.

Results show that the link between financial innovation and money demand is asymmetric and that of the two partial sum variables, only positive changes have significant effects with the sign being positive in both the short run and long run. This shows that assumptions of linearity and no asymmetric structure reported in extant studies for financial innovation are somewhat misleading. It could be deduced that models of previous studies which assumed linear and symmetric effects of financial innovation on money demand might have been overestimated. The research outcomes of the study also confirm the stability of demand for money in Nigeria. Hence, the study has been able to show that estimating money demand function without accounting for asymmetric structure in financial innovation does not accord well with reality.

The study concludes that the financial innovation-money demand nexus is asymmetric and that there is stability in the country's money demand function once asymmetry or nonlinearity is captured in the nexus. Therefore, it recommends the need for monetary authorities to pay attention to positive changes in financial innovation when policies on money demand are formulated for the purpose of enhancing the effectiveness and reliability of monetary policy as a tool for stabilising the economy. Future research efforts may complement this study by considering the probable asymmetric and nonlinear effects of other variables on the money demand function in a single model. Meanwhile, this has in no way undermined the relevance of the findings of this study. Other scholars are also encouraged to consider examining asymmetric and nonlinear effects of financial innovation on money demand for other countries.

## ***Declaration***

**Acknowledgment:** None

**Funding:** No financial support was received for the research, authorship and publication of this article.

**Conflict of Interest:** The authors declare no conflicts of interest with regard to the publication of this article.

**Authors' Contribution:** Eyitayo Oyewunmi Ogbaro: Provided the overall guidance and conceptualisation of the study, played a significant role in the determination and development of the methodology and analysis, as well as editing the entire work. Clement Olalekan Olaniyi: Played part in the conceptualisation of the study, review of literature as well as the coherence of the article. Oluwasegun Shadrach Eseyin: Played part in the review of literature. Bosede Comfort Olopade: Played part in the review of literature.

**Data Availability:** The data used by the study will be made available on request.

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