Determinants and Stability of Money Demand during Financial Liberalization in Sub-Saharan Africa: The Case of Uganda using an ARDL Approach

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Determinants and Stability of Money Demand during Financial Liberalization in Sub-Saharan Africa: The Case of Uganda Using an ARDL Approach

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Abstract

We analyse the determinants and stability of Uganda's real money demand function during financial liberalization. The study contributes to literature in 4 ways, i.e.: assessing the determinants and stability of Uganda's money demand function for the financial liberalization period; this is also done while incorporating the presumably disruptive financial innovations; assessing Uganda's money demand stability during this episode; and applying the ARDL estimation strategy on Uganda's Monetary Policy. GDP, exchange rate, inflation, interest rate spread and foreign interest rate explain Uganda's real money demand. The results confirm the existence of a stable long run money demand function. The error correction term is significant and negative. Fundamentally, the financial innovations have not caused structural divergence in Uganda's long run money demand function as would have been expected. Income is significant and close to unity and therefore a good money demand indicator in both the short and long run. Most importantly, financial innovation efforts in Uganda's monetary policy should be intensified since they haven't had negative effects on monetary stability.

Keywords: money demand, stability, financial liberalization, financial innovations

JEL Classification: E41; E52; E6; O23

1. Introduction

Money demand stability is the basis of a country's successful monetary policy because a stable money demand function implies a stable money multiplier making it easier to predict money supply effects on the aggregate economic performance (Laidler, 1982; Nachega, 2001). Baharumshah et al (2009) emphasize that the money demand function is analyzed for two prime purposes, that is: income elasticity of the money demand function informs the long-term consistent rate of monetary expansion; and interest elasticity of money demand allows for the calculation of welfare cost of long-term inflation.

The Ugandan financial sector has undergone different series of financial liberalization since the 1990's, which affect the country's money demand stability. These include among others: the crawling peg exchange rate system introduced in early 1990; the emergence of foreign exchange bureaus; gradual liberalization of domestic interest rates; creation of an interbank market; and introduction of the Treasury bill auction (Atingi-Ego and Matthews, 1996; Nachega, 2001). The financial sector consequently grew from 9 banks in 1991 to 25 banks by 2015**.** By June 2018, there were 647 bank branches and 834 Automated Teller Machines (ATMs). Additionally, by 2014, Uganda had 3 credit institutions with 55 branches and 3 microfinance institutions with 73 branches. Other new developments include; Electronic Funds Transfer (EFT) technologies, Real-Time Gross Settlement System (RTGS), debit and credit cards and mobile money innovations introduced (BoU, 2015; Nyorekwa and Odhiambo, 2014; Opolot, 2013; Nampewo and Opolot, 2016). By June 2018, Mobile Money Services (MMS) had registered significant growth in mobile money transactions increasing to 1.3 trillion from 1.1 trillion in the previous year; the corresponding value of these mobile money transactions increased to UGX. 73.1 trillion from UGX. 52.8 trillion within the same period. Mobile money activity growth has largely benefitted from diversified usage beyond the initial remittances, Bills' Payments and airtime purchases. It is contended that new developments like bank account to mobile money wallet and vice-versa have significant impact on the conduct traditional banking services and increased convenience of access to banking services. In general, it is expected that financial innovations witnessed during financial liberalization destabilize money demand because it is difficult to determine whether people are holding money or other monetary substitutes.

In other reforms, Bank of Uganda transitioned from the Reserve Monetary Programme (RMP) to the Inflation Target lite (ITL) monetary policy in 2011. The ITL was adopted to control inflation with a view that monetary targeting was no longer effective amidst the new innovations that constrained the effectiveness of the monetary targeting framework. It is however argued that this doesn't invalidate the long run relationship between money and prices (Mugume, 2011). The inflation targeting monetary policy framework still regards money stock and bank loan extension as critically important, and these are monitored closely with other macroeconomic variables like interest rate, Balance of Payment and exchange rate among others.

Financial liberalization affects the stability of money demand in various ways. Deckle and Pradha (1997) contend that financial liberalization increases competitiveness; introduces additional money substitutes; enhances the use of credit cards and Electronic Funds Transfers; increases liquidity of the time deposits and the raises the international capital mobility which make the demand for money function unstable. It may as well lower the demand for money; however, the demand for money may instead increase in many developing countries because of monetization.

Additionally, financial liberalization improves the quality of economic signals, alters the institutional environment and arguments the matrix of financial opportunities. This enhances the spectrum of potential causes of money demand shocks and uncertainty because the monetary authorities must now rely on new transmission mechanisms (Dobson and Ramlogan, 2001). Financial liberalization exposes the economy to international fluctuations under a flexible exchange rate and may also result in a very high real interest rate especially for banks that behave in an oligopolistic manner.

To date, results regarding the stability of Uganda's money demand function remain inconclusive**.** Whereas some studies like Guloba and Osoro (2009), Opolot (2007) and Nyorekwa (2007) confirmed stability; others like Kararach (2002) and Atingi-Ego and Mathews (1996) didn't. Additionally, only Opolot (2007) and Guloba and Osoro (2009) have used the dynamic estimation methods like the Auto-Regressive Distributed Lag (ARDL) models in their estimation methods.

It is important to reassess Uganda's money demand function especially during the post liberalization period while using dynamic estimation methods. This is because money demand stability is critical in monetary policy formulation especially in the presence of various financial innovations. The main purpose of this study therefore is to estimate the determinants and stability of Uganda's money demand function during financial liberalization (1994Q1 to 2018Q4). More specifically, the study objectives are threefold, i.e., to find out: the income elasticity of Uganda's money demand; the interest rate elasticity of Uganda's money demand; and the effect of financial innovations on Uganda's money demand. The findings of this study will build on the existing literature surrounding the determinants and stability of money demand in Uganda, and will also be relevant for policy purposes.

The rest of the paper is organized as: Chapter Two reviews the relevant literature regarding money demand and financial liberalization while Chapter Three presents the methodological aspect of how money demand is estimated. Chapter Four presents the estimated results and their explanations. Ultimately, Chapter Five concludes and provides Policy recommendations of this study.

2.1 Theoretical Literature

The money demand theory was first postulated by Irving Fischer (1911) in which it is argued that households and businesses demand money for only transaction purposes and the only function of money was being a medium of exchange. Velocity of circulation of money was fixed in the short run and changed slowly in the long run. This is stipulated in the classical equation of exchange (1): money in circulation (M_s) relates to the velocity of circulation (V), price level (P) and the level of transactions (T)

(1) $$M_s V = PT$$

It is assumed that if the change in velocity is equal to the change in transactions and equate to zero, then change in money supply is exactly equal to change in price. In equilibrium, money demand is equal to money supply

and so the model is re-estimated as: $(M^d = kPT)$where$k = \frac{1}{V}$. In summary, Fischer (1911) concluded that real money demand is a function of the level of transactions.

Pigou (1917) and Marshall (1923) argue that money is held for convenience purposes as it is an immediate purchasing power, it enables people to buy on favourable terms and that it acts as a store of value. In this formulation, transactions (T) are substituted for output(Y):

(2) $$\frac{M^d}{P} = kY$$

Keynes (1935) criticized the Cambridge equation precisely because it neglects the role of interest rates in determining the demand for money. liquidity preference is presented as an alternative formulation of money demand. Accordingly, people hold money balances for three basic reasons. They hold transaction balances in order to budget for the gap between planned receipts and expenditure. They hold precautionary balances to meet unexpected bills. Speculative balances are held if agents expect the market value of alternative assets to fall.

(3) $$M^d = f(Y, r); f_y > 0, f_r < 0$$

Keynes suggests that the speculative demand for money arises from the decision about the allocation of wealth. Accordingly, under liquidity preference, velocity is not constant but depends upon interest rates: when interest rates are low, economic agents expect a future increase in the rates and will hold whatever amount of money is supplied. Therefore, the aggregate money demand becomes perfectly elastic in respect to the interest rates hence the liquidity trap.

Baumol (1952) and Tobin (1956) pointed out that even money demand held for transaction purposes are affected by interest rates. A model is presented in which a cost-benefits analysis of holding money is made; the benefits in this case are convenience of holding money and the costs are the interest foregone. The economic

agent decides to balance his or her wealth portfolio between money and non-monetary assets. The square root formula of money demand is given by:

$$M^d = \sqrt{\frac{bY}{2r}} \quad (4)$$

In equation (4) above, r represents the interest rate differential between money and non-monetary assets; and b represents brokerage costs. The economic agent decides the optimal sum of brokerage costs and interest foregone. The optimal elasticity of brokerage costs is expected to be 0.5 and that of interest rate is expected to be -0.5.

Friedman (1956) treated money like any other asset; the study concluded that economic agents want to hold a certain quantity of real as opposed to nominal money balances. If inflation erodes the purchasing power of a unit of account, economic agents desire to hold higher nominal balances to keep their real money balances constant. The level of these real balances is a function of permanent income, relative rate of return on bonds versus money, relative rate of return on stocks or equities versus money and the expected inflation.

2.2 Empirical Literature

Various studies have been made on money demand especially on developed countries than on developing countries. The financial liberalization aspects on money demand stability have also not been fully and explicitly explored. The conclusions and implications of these studies depend on data frequency, the stability econometric tests and the development level of a country Sriram (2001).

Nyamongo and Ndirangu (2015) argue that financial development is negatively related to broad money M2 and M3 in both the short and long run. The study contends that a negative relationship would be expected with improvements in transaction efficiency and technological process which improve availability and use of money substitutes. The ARDL method of estimation is used and currency outside banks to time deposits as a proxy for financial development. However, failure to include a foreign interest rate proxy in the model ignores the effects of indirect money mobility on money demand.

Financial liberalization has a greater impact on broad money than narrow money. Dobson and Ramgolan (2001) reveal this for Trinidad and Tobago for the period 1982Q2 to 1998Q4. The study adds that financial liberalization may lead to a portfolio shift or end up affecting the income and interest rate elasticity of money demand. The study emphasizes the importance of a money demand model that incorporates openness of the economy. However, the study fails to explicitly analyse the effect of financial liberalization.

Niyimbanira (2013) finds out a stable money demand function for real M2 while using the ARDL estimation method for South Africa from 1990-2007. However, it is noted that it takes up to at least four quarters for any monetary policy to have real effects on the economy. On the other hand, Humavindu (2007) finds out that real M3 is stable and it should be used to target inflation. However, the study fails to capture the openness factors of the economy and it does not incorporate financial innovations.

Herve and Shen (2011) find out that real M2 is unstable in Cote d'Ivoire while using annual data for the period 1980-2007, however, real M1 is stable during the same period. The study employs co-integration and ECM methods to analyze the long run relationship between money supply and its determinants as real income (GDP) and interest rate. However, the study didn't include other variables that affect money demand other than income and interest rate.

Kumar et al. (2013) estimate the money demand function in Nigeria using annual data for the period of 1960-2008. The study finds out that money demand is unstable during the period and that the Central Bank of Nigeria was right to adopt a new monetary policy that stresses interest rates other than money supply as the primary monetary policy instrument. Money demand is estimated using canonical and extended specifications of $M1$ money demand using structural change methods. The study doesn't to include foreign interest rates and financial innovations in its analysis. However, the study's finding is different from Akinlo (2006) which used the $ARDL$ approach to find out that $M2$ was stable in Nigeria for the period 1970:1-2002:4. Akinlo (2006) concludes that money is co-integrated with real income, interest rate and exchange rate. The money demand function is also somewhat stable. Income elasticity is positive and almost unitary; however, the interest elasticity

estimates are small in absolute magnitude and therefore inelastic. Just like Kumar et al. (2013), the study also doesn't incorporate foreign interest rate and financial innovation in their estimation.

Baharumshah et al. (2009) use the ARDL co-integration framework to confirm a stable long run relationship between China's M2 monetary aggregate and its determinants as; real income, inflation, foreign interest rates and stock prices. On the contrary, Bahmani-Oskooee (2001) finds that M1 and M2 have a long run relationship with income and interest rates but that it is only $M1$ which is stable.

Ben-Salha and Jaidi (2014) also employ the $ARDL$ approach to find out that Tunisia's money demand function is stable between 1979-2011. However, the study disaggregates income into three components of final consumption expenditure, expenditure on investment goods and export expenditure. The study finds out that final consumption expenditure and interest rates are the only determinants of money demand in the long run. The same notion of disaggregated income is employed by Ziramba (2007) and Tang (2002), Tang (2004) and Tang (2007) who all find out a stable money demand in South Africa and Asia respectively. However, the studies fail to elaborate on the effects of financial innovation on money demand as well. Similarly, while using ARDL, Hye (2009) confirms that financial innovation positively affects money demand in the short run.

Maniragaba (2011) concludes that Uganda's financial liberalization policies have had positive impact on money demand and economic growth. The study uses the Johansen Maximum Likelihood estimation method and an individually constructed Financial Liberalization Indicator (FLI) to capture the financial liberalization processes.

Opolot (2007) contends that Uganda's money demand is stable for the period of 1990-2004. The study also finds that financial liberalization is positively related to narrow money but negatively related to broad money while using the ARDL method of estimation. Notwithstanding, the study fails to include financial innovation effects and foreign interest rates on money demand stability in its estimation.

The conclusions made by Opolot (2007) are similar to Guloba and Osoro (2009) who estimated Uganda's money demand only for the period of economic liberalization, 1991-2006. The study finds out that money demand is stable during the economic liberalization period for both the short run and long run despite many

agents entering into the money demand function during the time. The study uses dynamic ordinary least squares in the estimation processes. However, the study emphasizes the wider economic liberalization reforms and not the specific financial liberalization forms per se.

Similarly, Nyorekwa (2007) finds that Uganda's money demand function is stable for the period of reforms 1986-2005. The economic dummy he employs turns out to be insignificant and a conclusion is made that economic and financial reforms do not impact on real money balances. The stability of real money balances in the long-run also implies that the enormous financial innovations do not impact on the stability of money demand. The study reflects financial innovations by using private sector credit to GDP ratio. However, the study does not include the foreign interest rate in its estimation processes and therefore risks leaving out the effects of direct capital mobility on money demand.

Uganda's money demand function is stable for the period 1986:1-2003:4 (Nabiddo, 2007). The study finds out that the financial liberalization dummy has a negative sign, an indication that people demand less money in the presence of financial liberalization. It is also revealed while using the currency to money ratio that financial innovations lead to a decrease in money demand. However, the study doesn't reflect the effects of foreign interest rates and its direct impacts on money demand.

Nachega (2001) confirms Uganda's stability of money demand during the period 1982 to 1998 using Johansen co-integration. The study captures for the opportunity cost variables using the interest rate spread between Treasury bill rates and the time and saving deposit rate, and the foreign interest rate with the London Interbank Offered rate (LIBOR). It is found out that the LIBOR is negatively related to money demand. The study also employs the dummy to capture for financial liberalization. The income elasticity of money demand is close to unity and significantly different form zero, a postulation consistent with the quantity theory hypothesis. The other Uganda studies which find out stability in money demand are Katarikawe and Sebudde (1999), Kateregga (1993) and Henstridge (1999). However, they all fail to reflect the effect of financial innovations and foreign interest rates on money demand stability.

In contrast, Kararach (2002) concluded that Uganda's money demand is unstable between 1981-1998. The study found that that there are other factors that equally influence the monetary policy environment, such as the character of credit and government budgetary processes and these may end up equally undermining Bank of Uganda's ability to pursue an effective monetary policy. Similarly, Atingi-Ego and Matthews (1996) concluded that broad money demand M2 is unstable while narrow money demand M1 is stable between 1970-1993. The study concludes that real narrow money could therefore be used in analyzing the financial asset market behaviour during both sample and post sample periods.

Nampewo and Opolot (2016) find out that financial innovations have significant negative and positive effects of financial innovations on the money velocity in the short and long run, respectively. Additionally, long-run money velocity is stable despite the evolution of financial innovations over time. Other macroeconomic determinants of money velocity, including real income, the 91-day treasury bill rates, inflation expectations and the exchange rate exhibited a significant and positive long-run relationship with money velocity except for real income. Their results suggested that financial innovations have not altered the long-run stability of money velocity in Uganda.

In summary, the literature survey shows that different conclusions are made about the determinants and stability of Uganda's money demand. Whereas some studies conclude that it is stable (Opolot, 2007; Guloba and Osoro, 2009; Nabiddo, 2007; Nyorekwa, 2007 and Nachega, 2001; Nampewo and Opolot, 2016), others contend that it is unstable (Kararch, 2002; Atingi-Ego and Matthews, 1996). Few studies have attempted to take cognizance of the impact of financial innovations on money demand (Nampewo and Opolot, 2016; Nabiddo, 2007; Nyorekwa, 2007) and few have used the ARDL methodology of estimation (Nampewo and Opolot, 2016; Opolot, 2007). This study therefore intends to fill these gaps in the literature of money estimation in Uganda.

3. 0 Methodology

3.1 Theoretical Framework and Theoretical Specification

The study is based on Friedman (1956) since money demand is looked at as a function of permanent income whose proxy is taken as Uganda's Gross Domestic Product (GDP). Money is considered as any other durable good and so this incorporate the concept of inflation since an individual must make a choice between holding money and investing it in a durable good. GDP is chosen because it is a good proxy of the country's wealth and therefore permanent. Friedman (1956) argued that velocity of money is highly predictable and that the demand for money function is highly stable and insensitive to interest rates. The specification of Friedman's money demand function is as shown in equation 5 below.

(5) $$\left(\frac{M}{P}\right) = f(Y, r_1, r_2, \pi)$$

From equation six; $\left(\frac{M}{P}\right)$ indicates money demand, Y indicates permanent income, r_1 indicates the relative return on bonds versus money where as r_2 and π indicate the relative return on stocks & equities and inflation respectively.

However, Sriram (2000) emphasizes that whereas there are different theoretical spectrums of money demand, they all have a similar strand since they share important variables among them. Additionally, Judd and Scadding (1982) contend that these models reflect the relationship between the quantity of money demanded and a set of key important economic variables linking money to the real sector. Given that these models consider similar variables to explain the demand for money, they so much differ in the specific role attached to each variable in the explanation of money demand. Sriram (2001) argues that variable selection, representation, and estimation framework are critical in estimation and modelling of money demand equations. Proper specification of scale and opportunity cost variables and a proper empirical model cannot be overemphasized in estimation which guarantees the robustness and accurateness of results.

The general functional framework for all money demand functions adopted from Sriram (2001) is as stipulated in equation 6;

(6) $$\frac{M}{P} = f(SV, OCV)$$

The demand for real money balances is a function of the chosen scale variable(SV) and opportunity cost variables (OCV). The scale variable is a representation of the level of economic activity taking place in the country while opportunity cost variables represent the opportunity cost of demanding for money. The opportunity cost of holding money is a two-dimension component involving both the own rate of return of money and the rate of return on alternative assets. Ericsson and Sharma (1999) contend that inclusion of both rates of return prevents the collapse of the model. It helps to show the degree of substitutability between money and the other financial assets as a result of financial liberalization. M indicates the nominal monetary aggregate and $P$is the general price level. Economic theory also stipulates that demand for real money balances is homogeneous of degree zero in prices; this is an implication that money demand functions are modelled in real terms other than nominal ones.

With the openness of the economy, currency substitution theories incorporate other rates to account for the foreign effects on money demand. Whereas exchange rate reflects direct currency substitution, foreign interest rate reflects the indirect currency substitution or capital mobility Leventakis (1993).

3.2 Empirical model

The current study follows the theoretical expressions of Friedman (1956) and Sriram (2001). It is also based on the previous studies like Opolot (2007), Guloba and Osoro (2009) and Nyamongo and Ndirangu (2015). Uganda's money demand is modelled as a function of income, interest rates, the exchange rate for direct currency substitution, foreign Interest rate for the indirect currency substitution and the currency to time deposit ratio as the proxy for financial innovations. The model is therefore stipulated as:

(7) $$\frac{M}{P} = f(SV, OCV, FINL)$$

Real money balances are used as the dependent variable and this explicitly reflects price homogeneity in the model.GDPrepresents the scale variable $(SV)$and the other variables $TBR, DPR, NEXR, INF, FIR$ represent the opportunity cost variables(OCV). $FINL$ is the currency to time deposits ratio and it is used as the proxy for financial innovation.

(8) $$\frac{M}{P} = f(GDP, TBR, DPR, NEXR, INFR, FIR, FINL)$$

where $\left(\frac{M}{P}\right)$ is the real money demand; GDP is the real Gross Domestic Product; TBR is the 91 day Treasury Bill Rate; DPR is the average annual time and savings deposit rate; $NEXR$ is the nominal exchange rate; INF is the inflation rate; FIR is the Foreign Interest rate; $FINL$ is the financial liberalization or innovation proxy; $\varepsilon$is the stochastic term and $t$is a subscript attached to signify time.

The model is expressed in its functional form as below;

(9) $$\left(\frac{M}{P}\right)_t = \alpha_0 + \alpha_1 GDP_t + \alpha_2 TBR_t + \alpha_3 DPR_t + \alpha_4 NEXR_t + \alpha_5 INF_t + \alpha_6 FIR_t + \alpha_7 FINL_t + \varepsilon_t$$

Expressing the variables in logarithmic form save for all the rates following Sriram (2001).

(10) $$ln\left(\frac{M}{P}\right)_t = \alpha_0 + \alpha_1 lnGDP_t + \alpha_2 TBR_t + \alpha_3 DPR_t + \alpha_4 lnNEXR_t + \alpha_5 INF_t + \alpha_6 FIR_t + \alpha_7 FINL_t + \varepsilon_t$$

Following Opolot (2007) and assuming equal elasticity in absolute terms for the 91-day Treasury bill rate (TBR) and the time and savings deposit rate (DPR) so as to reflect the interest-rate spread, the above equation becomes;

(11) $$ln\left(\frac{M}{P}\right)_t = \alpha_0 + \alpha_1 lnGDP_t + \alpha_2 (TBR_t - DPR_t) + \alpha_3 lnNEXR_t + \alpha_4 INF_t + \alpha_5 FIR_t + \alpha_6 FINL_t + \varepsilon_t$$

It is equation 11 that will be estimated for this paper.

The study is based on the hypotheses that: money demand is unstable; money demand is positively related to income; money demand is negatively related to interest rate elasticity and financial innovations negatively affect money demand. The determinants of money demand adopted for this study are; real GDP, domestic interest rates, price levels, exchange rate, the foreign interest rate and the financial innovations proxy taken as the currency to time deposit ratio. Quarterly data series are used in the logarithmic form model following Sriram (2001) for the period of 1994(1)-2018(4).

3.3 Data

Data used for the study is collected from the International Financial Statistics (IFS) of the IMF, World Development Indicators (WDI) and Bank of Uganda. Annual GDP data from World Development Indicators is interpolated to obtain quarterly series; it is also seasonally adjusted to get rid of the cyclical trends. CPI data is obtained from the IMF IFS database; while data for the 91-day Treasury bill rate, monetary aggregates and nominal exchange rate is obtained from Bank of Uganda. Data for the foreign interest rate estimated as the London Interbank Offered Rate (LIBOR) is obtained from the Federal Reserve Bank of St. Louis. Quarterly data is used in the estimation processes.

3.4 Estimation Techniques

Estimation of a model using time-series data without testing for stationarity gives spurious results leading to false conclusions. Spurious regressions are characterized by a fairly high R^2statistic, highly uncorrelated residuals and significant coefficients of the regressands. Stationarity of a stochastic process requires that the variances are finite and independent of time. Stationary is tested by checking for the existence of unit roots or by the use of a correlogram. Upon this background, the current study adopts the Augmented Dickey Fuller (ADF) and the Phillips- Perroni (PP) Unit root tests.

The ADF unit root test is a modification of the unit root test developed by Dickey and Fuller (1979). It augments the Dickey Fuller test by including additional higher ordered lagged terms to account for auto-correlation in the error term especially when the process is more complicated than a simple Auto- regressive

process. The error term is taken to be homoscedastic as well. The non-parametric method is used in the Phillips-Perroni (1988) since it takes care of serial correlation in the error term without necessarily adding the lagged difference terms. The Phillips-Perroni tests are more robust to general forms of heteroskedasticity in the error term and one does not have to specify lag length for the test regression. The null hypothesis in both the ADF and the Phillips-Perroni tests is that the unit root processes generate the time series. The number of lags is determined by minimizing the Akaike Information Criteria (AIC) and the Schwarz- Bayesian Information Criteria (SBC) or lags are dropped until the last lag is significant. The study therefore adopts the ADF and the Phillips-Perroni for this purpose.

The $ARDL$ method of estimation does not necessitate the checking of unit roots since it integrates both the stationary and non-stationary variables, however, it is a requirement that the variables in the estimation matrix are not integrated of order two. It is upon this background that unit root testing becomes necessary.

3.5 Data Exploration Technique: The Auto Regressive Distributed Lag (ARDL) Method

The $ARDL$ method as proposed by Pesaran et al. (2001) is used for the estimation of the co-integration properties of the estimated equation. The$ARDL$method is used because of the many advantages it enjoys over other co-integration techniques like Engle and Granger (1987) and Johansen and Juselius (1990) methods, i.e.; (i) the $ARDL$ model has been chosen because it can be applied for a small sample size as it happens for this specific study; (ii) The$ARDL$ method is relieved of the order of integration amongst variables in such a way that it incorporates both the$I(0)$and$I(1)$variables;(iii) the $ARDL$ method can further estimate the short-run and long-run dynamic relationships in the demand for money functions simultaneously; (iv) the $ARDL$ method distinguishes between dependent and explanatory variables and allows for the testing of the existence of a long run relationship between the variables; and (v) the $ARDL$ method can be applied even when the variables have differing optimal number of lags.

For this model of estimation, all variables in the model are assumed to be endogenous. The ARDL version of the equation is therefore written as:

(12) $$\Delta ln\left(\frac{M}{P}\right)_t = \alpha_0 + \sum_{j=1}^{P}\beta_j\,\Delta ln\left(\frac{M}{P}\right)_{t-j} + \sum_{j=0}^{P}\delta_j\Delta\, lnGDP_{t-j} + \sum_{j=0}^{P}\theta_j\Delta\,[TBR - DPR]_{t-j} + \sum_{j=0}^{P}\omega_j\Delta lnNEXR_{t-j} + \sum_{j=0}^{P}\gamma_j\Delta INF_{t-j} + \sum_{j=0}^{P}\mu_j\Delta FINL_{t-j} + \sum_{j=0}^{P}\tau_j\Delta FIR_{t-j} + K_1 ln\left(\frac{M}{P}\right)_{t-1} + K_2 lnGDP_{t-1} + K_3[TBR - DPR]_{t-1} + K_4 lnNEXR_{t-1} + K_5 lnINF_{t-1} + K_6 FINL_{t-1} + K_7 FIR_{t-1} + \varepsilon_t$$

Where Δ denotes the first difference operator, α_0 is the drift component and ε_t denotes the white noise residual. The first term of the summation on the right-hand side sums up the differences of monetary aggregates starting from the first lag whereas the other summations on the independent variables sum up the differences of the independent terms from the zero lag. The differences terms capture the short run effects while the variables in their levels capture the long run effects. Equation 13 is the standard VAR model of lagged level variables linearly combined and added as proxy for lagged error terms which measures the departure variable from the independent variable as expressed in equation 12.

The starting point is testing for the presence of a long run relationship using the familiar F-test to determine the joint significance of lagged levels of the variable involved. There are two sets of asymptotic critical values for the F-test as developed by Peseran et al. (2001). One set, the lower critical bound assumes all the variables are I (0) and so there is no cointegrating relationship between the examined variables. The other set, the upper bound assumes that all the variables are I (1) meaning that there is no cointegration among the variables.

The F-statistic when money is the dependent variable against the other independent variables is denoted as:

(14) $$F_{ln\left(\frac{M}{P}\right)_t}\left[ln\frac{M}{P} \mid \ln GDP, (\ln TBR - lnDPR), \ln NEXR,\ INF,\ FIR,\ FINL\right]$$

In the same way, the F-statistic can be computed for when each of the independent variables in equation (14) is used as a dependent variable. When the computed F-statistic is greater than the upper bound critical value, then the null is rejected (The variables are co integrated). If the F-statistic is below the lower bound critical value, then the null cannot be rejected (there is no co integration among the variables). The results are however inconclusive when the computed F-statistic falls between the lower and the upper bound.In this case, prior

information about the order of integration of the variable is necessary to make a decision on the long run relationship.

The error correction version of the ARDL equation is then given as in equation 15 below.

(15)
$$\Delta ln\left(\frac{M}{P}\right)_t = \alpha_0 + \sum_{j=0}^{P}\beta_j \Delta ln\left(\frac{M}{P}\right)_{t-j} + \sum_{j=0}^{P}\delta_j \Delta lnGDP_{t-j} + \sum_{j=0}^{P}\theta_j \Delta(TBR - DPR)_{t-j} + \sum_{j=0}^{P}\omega_j \Delta lnNEXR_{t-j} + \sum_{j=0}^{P}\gamma_j \Delta CPI_{t-j} + \sum_{j=0}^{P}\mu_j \Delta FINL_{t-j} + \sum_{j=0}^{P}\tau_j \Delta FIR_{t-j} + \sigma_j ECT_{t-1} + \varepsilon_t$$

Where, the currency to time deposits ratio captures the financial innovations during the post financial liberalization period 1994-2014. $\sigma_j$is the speed of adjustment parameter and Error Correction Term$(ECT)$are the residuals obtained from the estimated equation in the model.

The diagnostic tests are carried out to check if the model satisfies the classical linear assumptions of Ordinary Least Squares (OLS). These include normality, homoscedasticity, absence of serial correlation and the correct functional specification of the model. The Jacque-Bera (JB) test is adopted to test for normality. The JB test follows a chi-square distribution. The null hypothesis of a normally distributed model with the JB test means we reject the hypothesis that the residuals are normally distributed, if the computed p-values are very low. If the p-values are adequately large; we do not reject the assumption of normality. The serial correlation notion posits that the residuals are correlated over time whereas the Homoscedasticity notion posits stable variance in the error term. On the other hand, Heteroscedasticity assumes that the coefficients are unbiased but their variances are biased. The study therefore adopts the Auto-Regressive Conditional Heteroscedasticity $(ARCH)$ Langrage Multiplier test to test for conditional heteroscedasticity.

After estimating a stable long run money demand function, the dynamic (short run) model is estimated as well. The empirical results are based on the re-parameterization of the estimated $ARDL$ model and it is at this stage that stability tests are carried out. Emphasis is given to both model stability and parameter constancy. The paper adopts the $CUSUM$ and $CUSUMQ$ stability tests, Brown et al (1975) to test for constancy of long run

parameters. The $CUSUM$ test is based upon the cumulative sum of recursive residuals based on the first set of n observations. It is updated recursively and plotted against the break points. If the $CUSUM$ statistics plot stays within the 5% significance level, then the estimates are stable. The same applies to the $CUSUMQ$ test which is based upon the squared recursive residuals.

4.1 Results

Table 1 below shows the descriptive characteristics of individual data series used in the study.

Table 1: Descriptive Statistics

	LRBM	LRGDP	CPI	LNEXR	IRS	FIR	FINL
Mean	10.193	11.577	90.241	3.279	-0.172	2.869	1.059
Median	10.199	11.570	71.583	3.264	-0.315	2.263	1.047
Max	10.621	11.649	175.16	3.575	8.238	6.6.699	1.544
Min	9.658	11.512	38.851	2.965	-5.359	0.228	0.492
Std. Dev.	0.265	0.039	44.75	0.170	2.623	2.281	0.204
Skewness	-0.128	0.247	0.616	-0.055	0.732	0.247	-0.103
Kurtosis	1.805	1.579	1.828	2.285	4.111	1.416	2.064
Jacque Bera	6.227	9.345	12.046	2.189	14.062	11.476	3.829
Probability	0.04	0.009	0.002	0.336	0.0008	0.003	0.147
Sum	1019.33	1157.79	9024.17	1019.3	-17.217	286.95	105.89
Sum sq. Dev	6.969	0.152	198269.7	6.97	681.36	515.01	5.738
Observations	100	100	100	100	100	100	100

Testing of the data for unit roots followed the Augmented Dickey Fuller and the Phillips Perroni methods. The null hypothesis for both the ADF and the Phillips Perroni is that; there exists a unit root against the

alternative that there is no unit root test. Table 4:2 shows that interest rate spread is stationary at levels. However, all the other variables are non-stationary at levels for both the ADF and Phillips Perroni unit root tests. The p-values of all the variables are above 0.05 with the exception of inflation which is significant at 1 percent for both the ADF and PP whereas the financial liberalization proxy (FINL) was significant at the 5 percent level for ADF and 10 percent level for the Phillips Perroni test.

Table 2: Unit Roots at Levels

VARIABLES	**ADF (levels)**		**PHILLIP-PERRONI (levels)**	
	Intercept	*Trend and Intercept*	*Intercept*	*Trend and Intercept*
LRM	-0.590	-5.385***	-1.804	-5.397***
LRGDP	-1.43	-1.617	-1.767	-1.892
LNEXR	-0.802	-2.409	-0.214	-2.158
CPI	1.275	-1.499	1.705	-1.461
IRS	-4.829***	-4.822***	-4.783***	-4.908***
FIR	-1.883*	-2.336	-1.564	-2.418
FINL	-2.618*	-3.021	-2.497	-2.936

*Note: *, ** and *** denote the 10, 5 and 1 percent level of significance respectively*

The analysis now shifts to the secondary level of the first differences as depicted in Table 4:3 below. The results are that the null hypothesis of no unit root is rejected at 1 percent confidence intervals for all the variables for both the ADF and Phillips Perroni tests.

Table 3: Unit Root Tests at First Differences

Variables	**ADF**	**PHILLIP-PERRONI**

	Intercept	Trend & Intercept	Intercept	Trend & Intercept
LRM	-8.959***	-8.903***	-19.213***	-22.235***
LRGDP	-5.629***	-5.708***	-8.716***	-8.883***
LNEXR	-7.960***	-7.900***	-7.863***	-7.890***
CPI	-4.857***	-5.252***	-5.940***	-6.583***
FIR	-5.554***	-5.538***	-5.514***	-5.549***
FINL	-4.756***	-4.72***	-13.160***	-13.139***

*, ** and *** denote the 10, 5 and 1 percent level of significance respectively

The table shows that all the series are difference stationary and integrated of order one. The ADF and Phillip Perroni findings are in line with the visual explanations that were made above.

It has been established that none of the variables is integrated of order two and that they have mixed orders of integration i.e. I (0) and I (1), thus satisfying one of the requirements for ARDL method to be used. The other conventional methods recommend that since the variables are difference stationary, estimations will yield spurious results if the variables are not estimated in their differences.

At the first stage, the ARDL model is estimated in its levels and model selection criteria is determined by both the Akaike Information Criterion (AIC) and the Schwartz Bayesian Criterion (SBC). However, the Schwartz Bayesian Criterion is chosen over the Akaike Information Criterion because it produces a parsimonious model. On the other hand, the AIC produces a model which has a lot of lags and this reduces the degrees of freedom. When the model is estimated in the order of *(Money, GDP, Exchange rate, Inflation, Interest rate Spread; Foreign interest rate, and financial innovation), the Sch*wartz Information Criterion (SBC) chooses ARDL models of order (1, 0, 1, 0, 0, 0, 1) for real base money model. On the other hand, AIC gives the ARDL model of order (4, 0, 2, 3, 0, 3, 3) respectively. A maximum of 4 lags is also chosen since we are dealing with quarterly data.

The bounds test is undertaken after preliminary estimation of the model has been done so as to ascertain the existence of co-integration. The results of the Bounds test are as shown in table 4below.

Table 4: F-Bounds Test Results

K=6	**LRBM**
F- Statistics	5.252
95% Bound (Lower, Upper) 99% Bound (Lower, Upper)	(2.27, 3.28) (2.88, 3.99)

Note: Figures in the parentheses represent both the lower and upper F-tests bound limits

The F-statistics for all the models are above the upper bound at all levels of significance. This therefore necessitates estimation of the ARDL at the second stage to give both the long run and short run coefficients as depicted in the table 5 and 6 below.

Table 5 below presents the long run results of all the three monetary aggregates obtained from the ARDL estimation method.

Table 5: First Level estimation (Long run Results)

Dep. Variable (LRM)	**Coefficient (Standard error)**
LRGDP	2.508*** (0.309)
CPI	-0.006*** (0.002)
LNEXR	-0.108 (0.176)
FIR	-0.007 (0.005)
IRS	0.0003 (0.003)
FINL	-0.0064 (0.044)
CONSTANT	-19.027*** (3.199)

*, ** and *** denote the 10, 5 and 1 percent levels of significance respectively. LRBM represents log of real base money M1.

Table 6 below shows the short run results of all the money demand model.

Table 6 The error representation for the ARDL model

Dep. variable is DLRM(i)	Coefficient (standard error)
	Log of Real Base Money (LRBM)
D (LRM1 (-1))	-0.356*** (0.079)
D(LRGDP)	0.891*** (0.207)
D(CPI)	0.002*** (0.0004)
D(LNEXR)	0.199* (0.115)
D (LNEXR (-1)	-0.038 (0.06)
D(FIR)	-0.002 (0.0017)
D(IRS)	0.0001 (0.001)
D(FINL)	0.109*** (0.018)
D (FINL (-1))	-0.0023 (0.0156)
CONSTANT	-6.756*** (1.745)
ECT (-1)	-0.355*** (0.053)
R^2	0.45
Adj. R^2	0.44
F-Statistics	1453.6***
S.E of Regression	0.022
Squared Residuals Sum	0.045
DW	1.932
Breusch-Godfrey Test	0.023 (0.972)
Arch-Heteroscedasticity	0.047 (0.954)
Jacque Bera Normality test	1.266 (0.531)

Note: *, ** and *** denote the 10, 5 and 1 percent levels of significance respectively. The figures in the parentheses indicate standard error for the estimated result but probability for the diagnostic tests.

The money demand model is tested for statistical adequacy of the results obtained. The R-square for the models is 0.45 while the adjusted R-Square is 0.44. This means that the determinants of money demand in Uganda are explained by the specified variables in the models by 0.44. The overall F-Statistics for the model is also statistically significant signifying that the overall model is amenable for analysis. The model's Durbin Watson Test is 1.932; it is therefore close to 2 and above the R-squared. The results therefore are not spurious and any conclusion made henceforth can be taken as reliable.

The Breusch-Godfrey Serial Correlation Test results in shows that all the F-statistic has probabilities above 0.05 and this means that the null hypothesis of no serial correlation cannot be rejected. The results also show that there exists no heteroscedasticity in the real money demand model since the probabilities are above 0.5.

4.6 Discussion of Results

The error correction term ECT (-1) is negative and statistically significant at 1 percent for the real monetary aggregates**.** The size of the estimated coefficient for the error correction term ECT (-1) indicates that the short run adjustments offset about 35 percent of the disequilibrium in real money.

Real income exerts a positive and significant impact on money demand in the short run dynamic model as expected a priori. The one percent increase in real income increases money demand by a magnitude of 0.89. This is also in line with the long run estimates where the long run coefficients of real income are positive and significantly different from zero. The result confirms that income is a good monetary indicator both in the short run and the long run. These results agree with the theoretical postulations and the prior studies on money demand like; Guloba and Osoro (2009), Opolot (2007), Nabiddo (2007) among others.

Inflation is significant at 1 percent for real money. Inflation has a positive money demand effect in the short run but a negative effect in the long run. The coefficient of inflation for real money indicates that, a one percent increase in inflation increases money demand by 0.002 in the short run. However, the inflation effect is negative in the long run with economic agents decreasing their money demand by 0.006 with an addition unit increase in inflation. Prior money demand studies on Uganda found a negative relationship between money demand

and inflation, these include; Opolot (2007), Guloba and Osoro (2009), Nabiddo (2004) and Kararach (2002). The positive relationship is also accordance to Friedman (1956) and the nature of the Ugandan economy wherein the presence of inflation, people would rather prefer to hold their money in other physical assets other than the transactionary balances; especially since inflation erodes the purchasing power of the transactionary balances.

Exchange rate is significant at 10 percent for real money in the short run. The results depict a positive relationship between nominal exchange rate and real money with a coefficient of 0.199. The appreciation of the Ugandan currency by one unit leads the economic agents to increase their demand for money by 0.0289. This result is in accordance to Bahmani-Oskooee and Rehman (2005) who argued that as a weak domestic currency yields expectation for further weakening, asset holders shift some of their portfolios away from domestic currency into foreign currency; and the reverse is true. This result is contrary to Arango and Nadir (1981) who argued that when domestic currency depreciates, it increases the value of foreign securities held by domestic residents and that if this increase is considered in wealth, the demand for domestic currency may rise.

Financial innovations are significant at 1 percent for real money in the short run. The short run results show that financial innovations are positively related to real base money. A one percent increase in financial innovation increases the demand for real base money by a magnitude of 0.1. This result is contrary to Ndirangu and Nyamongo (2013) who argue that a negative relationship for the broader monetary balances is expected because improvements in transaction efficiency and technological progression improve the availability and use of monetary substitutes. The positive result that this paper obtains probably points to the narrow monetary balances that this paper used.

The study employs the CUSUM and CUSUMQ tests to test for stability. These are augmented by the recursive residual tests. The CUSUM and CUSUMQ tests indicate that the Real Money was stable throughout the period. The recursive residual graphs are also generally within the standard error bands except in a few quarters when the spikes went out of the band. This leads to the conclusion that money demand is stable and erases the argument that financial innovations witnessed in the post financial liberalization reforms may have distorted

the stability of the money demand function. This finding is in line with Nampewo and Opolot (2016) who found out that financial innovations have not altered the long-run stability of money velocity in Uganda. In a related strand of analysis, Guloba and Osoro (2009) pointed out that stability is highly explained by the post-liberalization dataset.

5. Conclusions and Policy Recommendations

5.1 Summary of Findings

The major purpose of this study was to assess the determinants and stability of Uganda's money demand function during the post financial liberalization (1994Q1-2018Q4). Stability of money demand is important for any sound and effective monetary policy; yet the presence of financial liberalization and innovations has a bearing on this stability, which before empirical testing is not known a priori. Whereas there have been many money demand studies, they have found mixed results and the effect of financial innovations during the financially liberalized period hasn't been majorly prioritized save in a few studies like Nampewo and Opolot (2016). This study also estimates Uganda's money demand function using the ARDL methodology. The study therefore provides novel insights in the behaviourof Uganda's money demand function during financial liberalization in the presence of various financial innovations.

The results indicate that the fast-increasing innovations during the post financially liberalized period 1994-2018 have not caused structural divergences in the long run money demand function. Given that the estimated monetary aggregate has a co-integrating relationship in the long run, the error correction coefficients are as well statistically significant and have the negative signs as expected a priori. The CUSUM and CUSUMQ tests confirm stability for all the three monetary aggregates.

The study employs the ratio of currency-time deposits as the proxy for financial innovations during the financial liberalization episode 1994Q1-2018Q4. This is in addition to the other conventional money demand determinants like nominal exchange rate, inflation, income, interest rate spread, and the foreign interest rate. The statistically significant variables are income, inflation, exchange rate and financial innovation. Income elasticity is close to unity for the money demand estimation. Income is therefore a good monetary indicator for

money. However, interest rate spread is not a good monetary indicator since it is found to be insignificant. Inflation has a positive money demand effect in the short run but a negative effect in the long run. Exchange rate has a positive relationship in regard to money demand in the short run. The financial innovation ratio is positively related to real base money in the short run. The error correction term is negative and statistically significant for the real money demand model.

5.2 Policy Recommendations

The stability tests confirm that Uganda's money demand is stable during the post financial liberalization period. Monetary targeting can therefore be used as a monetary policy by Bank of Uganda, especially by looking at it as an operating target so as to formulate a cautious monetary policy.

The study has revealed that real money has a high-income elasticity that is close to unity, it is stable and has a negative and statistically significant error correction term. This income elasticity is a good monetary indicator and therefore Bank of Uganda will be able to predict the level of Uganda's economic activity more accurately. Bank of Uganda can also target exchange rate to affect money demand, especially in the short run.

Financial innovation initiatives should be used by Bank of Uganda and other commercial banks to control money demand, especially in the short run. Such financial innovation initiatives include e-banking, mobile banking, Real Time Gross Settlements, Electronic Fund Transfers and Auto-Teller Machines among others. Bank of Uganda should therefore strengthen its ITL monetary policy as an operating target through financial innovation initiatives. Towards this end, further financial deepening and widening should be undertaken. This is especially in the light that these financial innovations haven't caused structural divergencies in the stability of Uganda's narrow money demand.

LIST OF ABBREVIATIONS

ADF	Augmented Dickey Fuller
AIC	Akaike Information Criteria
ARCH	Auto-Regressive Conditional Heteroscedasticity
ARDL	Auto-regressive Distributed Lag
ATM	Automated Teller Machine
BoU	Bank of Uganda
CUSUM	Cumulative Sum
CUSUMQ	Cumulative Sum of Squares
DPR	Average Annual time and Savings deposit rate
EFT	Electronic Funds Transfer
IFS	International Financial Statistics
INF	Inflation rate
ITL	Inflation Target Lite
JB	Jacque Bera
LIBOR	London Interbank Offered Rate
FINL	Financial innovation proxy
FIR	Foreign Interest Rate
FLI	Financial Liberalization
GDP	Gross Domestic Product
MMS	Mobile Money Services
NEXR	Nominal Exchange Rate
OCV	Opportunity Cost Variable
OLS	Ordinary Least Squares
PP	Phillips-Perroni
RMP	Reserve Monetary Policy
RTGS	Real Time Gross Settlement
SV	Scale Variable
SBC	Schwarz Bayesian Information

TBR Treasury Bills Rate

DECLARATIONS

Availability of Data and Materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing Interest

The authors declare that they have no competing interests

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Authors' contributions

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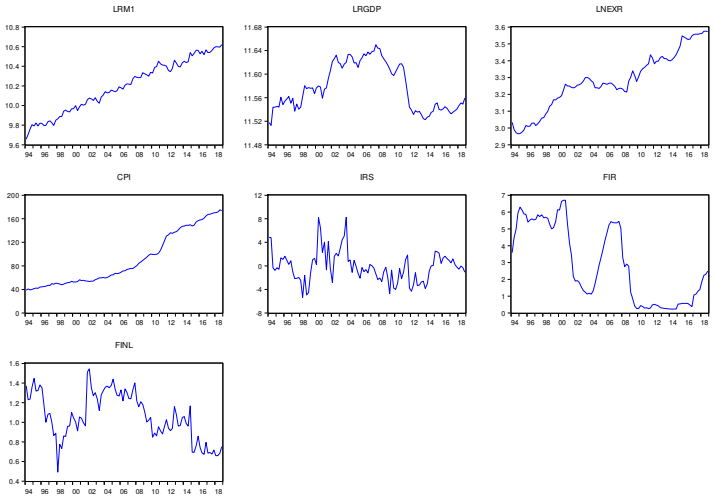
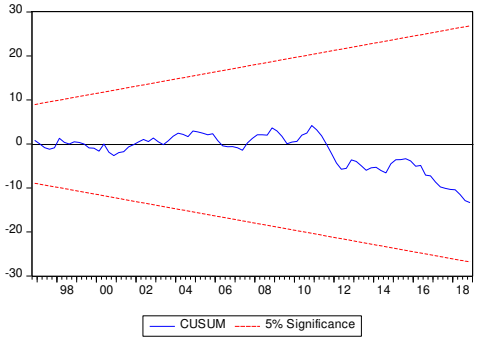
APPENDICES

Graphs of all the Variables at Levels

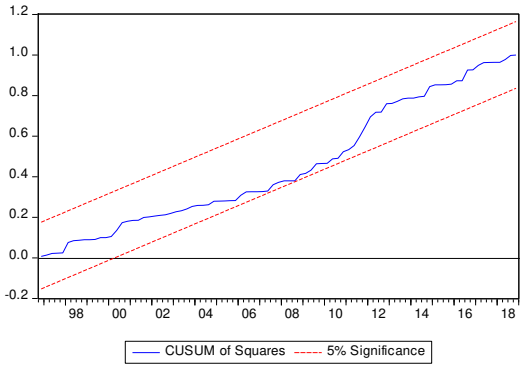


Stability Tests

LRBM (CUSUM)



CUSUMQ: LRBM



Recursive Residuals: LRBM