An Econometric Analysis of Demand for Money and its Stability in Tanzania

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Abstract. This paper examines the determinants of demand for money and its stability in Tanzania using annual time series data spanning from 1966 to 2015. Economic analysis of the money demand function is facilitated by the Johansen cointegration, vector autoregressive-vector error correction model (VAR-VECM) and variance decomposition with the main objective of analyzing the factors which, in both short run and long run, influence its movements. The study is thought to be significant because the demand for real money balances serves as the core link between the monetary policy and the real sector of the economy. Based on the annual data under the period of study, cointegration results reveal that there is a long-run relationship between real money balances and the explanatory variables namely, real GDP, deposit interest rate, real exchange rate and inflation rate. Consistent with money demand theory, the VECM results show that the demand for real money balances is positively related with scale variable (real GDP) but it responds inversely to opportunity cost of holding money (deposit interest rate and inflation rate). Moreover, results provide evidence that the demand for real money balances and real exchange rate are positively associated. Furthermore, after incorporating the stability tests, the empirical results show that real money demand function is stable over the 1966-2015 period, suggesting that it is possible to use the narrow money aggregate as target of monetary policy in Tanzania.

Keywords. Money demand, VAR-VECM model, Stability.

JEL. C32, E41, E52.

1. Introduction

Studies on the demand for money and its stability remain in the domain of rigorous investigation because demand for money plays a major role in macroeconomic analysis, especially in selecting appropriate monetary policy actions. Markedly, the relationship between the demand for money and its main determinants is an important building block in macroeconomic theories and is a crucial component in the conduct of monetary policy (Goldfeld, 1994). Thus, understanding the robust determinants of demand for money and its stability can inform the setting of monetary policy. Conventionally, a good understanding of the stability and robust determinants of the demand for real money balances forms the core in the conduct of monetary policy as it enables a policy-driven change in monetary aggregates to have predictable influences on output, interest rate, and ultimately price through transmission mechanism (see also Sriram, 1999; Nachega, 2011; Halicioglu & Ugur, 2005). The central argument here is that the relationship between real money balances and the scale variable (real GDP) that measures the level of economic activity and opportunity cost (of holding money) variables (deposit interest rate and inflation rate) plays an important role in macroeconomic analysis of a country.

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The specification of an appropriate money demand function is vital in determining the optimal quantity of money to be supplied in the economy. Moreover, deducing from the estimations of money demand equations, the monetary authority can implement the best monetary policy under the current economic conditions (Dritsaki & Dritsaki, 2012). Chiefly, effective monetary policy implicitly assumes a stable money demand function. However, if the relationship is not stable, money supply targeting might not be an effective policy option for controlling factors such as inflation. Thus, examining the robust determinants and stability of money demand in the economy such as Tanzania which suffers a number of economic problems such as high and persistent inflation, wide use of foreign currency and shallow and volatile domestic financial market is crucial, mainly for understanding the transmission mechanism of monetary policy in the economy.

It is worth noting that determining the significant relationship between the demand for real money balances, scale variable and opportunity cost variables is not straightforward. Even the distinguishable works of Keynes (1936) and Friedman (1956) do not go unchallenged. Keynes (1936) develops the liquidity preference theory of money demand which explicitly shows that people demand money for transaction, precautionary and speculative motives. He argues that money demand depends on both income and interest rate. In particular, the Keynesian speculative theory suggests that relationship between money demand and the rate of interest is negative. By the same token, the fact that the stability or instability of money demand is a major determinant of liquidity preference, Poole (1970) argues that the rate of interest should be targeted if liquidity preference is unstable while the money supply should be targeted if the investment-savings relationship is unstable and the demand for money is stable. However, as Laidler (1977) points out, the most important innovation in the analysis of Keynes (1936) is on speculative demand for money but not on the demand for money arising from the transactions and precautionary motives as technically fixed in their relationships with the level of income. Significantly, Friedman (1956) opposes the Keynesian view that money does not matter and presents the quantity theory as a theory of money demand. Still, the quantity theory of money has been criticized on its assumptions of permanent and transitory incomes.

Undoubtedly, because the demand for money serves as the core link between the monetary policy and the real sector of an economy, the level and stability of the demand for money have received enormous attention by economists, researchers and policy makers in developed and developing countries. As a result, modeling, estimating and examining the stability of money demand function in the economy has become a fertile area for research (See for example Arango & Nadiri, 1981; McNown & Wallace, 1992; Hoffman et al., 1995; Teriba, 1974; Darrat, 1986; Arize et al., 1990; Adam, 1992; Kallon, 1992; Simmons, 1992; Kumar, et al., 2013; Fielding, 1994; Gharacey, 1998; Nachega, 2001; Anoruo, 2002; Nwaobi, 2002; Nell, 2003; Bohl, 2000; Gerlach & Svensson, 2004; Weliwita & Ekanayake, 1998; Arize et al., 1999; Bahmani-Oskooee & Tanku, 2006; Bahmani- Oskooee, & Gelan, 2009; Akinlo, 2006; Nwafor et al., 2007; Owoye & Onafowora, 2007 and Sterken, 2004). Nevertheless, controversies remain in the literature with the robust determinants and the stability of the demand for real money balances across the countries using both velocity and conventional approaches. Despite the fact that theoretical and empirical evidences suggest that variables such as real income, interest rate, exchange rate and inflation rate affect the demand for real Money balances, there are seem to be mixed conclusions about the direction of their relationships and the stability of the function of demand for money. The mixed conclusions on the determinants and stability of money demand in different economies might be attributed to the fact that the factors that affect money demand vary in accordance to the realities of different economies.
The lack of consensus regarding the stability of money demand function is evident. Central banks in many developing economies have switched towards monetary policies directed at the interest rate (Kumar, et al., 2013). According to Kumar et al. (2013), this policy switching is mainly grounded on the view that financial market reforms and liberalization might have contributed to the instability in money demand functions. However, other studies raise concern about the validity and strength of central bank interest rate targeting in developing economies (see for example Bahmani-Oskooee & Rehman, 2005; Rao et al., 2009; Rao & Kumar, 2009a and 2009b). Notable, Darrat (1986) and Adam (1992) show that monetary aggregates are stable in African countries and hence support the perspective favouring monetary targeting by central banks.

These important controversies in the findings call forth a further investigation with recent data and methods, to explore the stability of money demand function and the extent to which variables such as real GDP, inflation rate, deposit interest rate and real exchange rate as discussed in the theoretical and empirical literature determine the demand for real money balances. In this perspective, it is important to examine the robust determinants and stability of the real money demand in a low income country like Tanzania covering a large sample, spanning from 1966 to 2015. The empirical results of this paper are expected to contribute to the ongoing debate on the robust determinants and stability of money demand and optimal monetary policies.

2. Theoretical Framework

Money demand theories have evolved overtime. Fisher (1911) provides the earliest quantity theory of money demand through the equation of exchange. Fisher (1911) argues that the demand for money is solely a function of income. However, it is worth noting that the concept of money holdings started to take a formal shape in the quantity theory by Pigou (1917). In another development, Keynes (1936) develops the liquidity preference theory of money demand. The general argument under liquidity preference is that people demand money for transaction, precautionary and speculative motives and that, money demand depends on income and interest rate. Similarly, inventory theories of money demand hypothesize that transaction demand for money is positively associated with income but it has a negative relationship with nominal interest rate earned on alternative assets. The Baumol-Tobin model is a good example of the most well-known inventory theory of money demand. In other theories, for example portfolio theories of money demand, money is treated like any other asset and therefore assets’ demand theory is used to derive the money demand theory. Because money offers different combination of risk and return than other assets, people hold money as part of their portfolio of assets. This section briefly discusses the theories and models of demand for money.

2.1. Classical Economics

The four major functions of money-medium of exchange, store of value, unit of account, and source of deferred payment provide the basis to formulate theories of money. In the classical theory, money is held for transaction purposes or as a medium of exchange. Here, money is a commodity whose unit is used to express the prices and values, but whose own value remains unaffected by its role. In this theory, the role of money as a store of value is limited of perfect information and negligible transaction costs. The quantity theory of money is based on the assumptions that money supply, $M^s$ is exogenous and the income velocity of money, $V^*$ is constant as a results, the demand for money is stable. According to this theory, the economy is always in full employment levels except for the transitory deviations as a result of real balances so that income, $y$ in the equation of exchange could be treated as constant in the short run (Equation 1)
This also suggests that changes in the quantity of money lead to proportional changes of the price level, $P^T$. The most important feature of this theory is that, it suggests that interest rates have no effect on the demand for money. In the long run, the price level depends upon the quantity of money in the economy. Notable, in this theory demand for money is not mentioned, instead what is stressed is transactions velocity of circulation of money, $V^T$.

### 2.2. Quantity Theory of Money Demand

As reported above, the quantity theory provides a direct and proportional relationship between the quantity of money and the price level. This relationship is developed in the classical equilibrium framework by two alternative but equivalent expressions: Fisher’s equation of exchange (Fisher, 1911) and Cambridge approach (Pigou, 1917). Both versions yield models of the transaction demand for money because they are primarily concerned with money as a means of exchange and hence, they yield models of the transaction demand for money (Sriram, 1999).

The Fisher (1911) approach is based upon the exchange equation. In this theory, the demand for money is solely a function of the volume of transaction in the economy. The relationship between money in circulation, $M^T$ and the volume of transactions, $T$ is expressed as

$$M^T V^T = P^T T$$

Equation (2) is not an identity rather an equilibrium condition. Money is held simply to facilitate transactions and has no intrinsic utility. The velocity variable incorporates the technological factors and institutional arrangements of the monetary system governed by non-monetary factors and it is assumed to be stable in the short run (Sriram, 1999). The theory suggests that the demand for money is inelastic to interest rate changes because people demand money only for transaction purpose.

This equation is modified by the Cambridge School also known as neoclassical economists, Pigou (1917) in particular and Marshall (1923), among others. The modification is based on individual choice rather than on market, that is the focus changes from a model where $V^T$ is determined by payments mechanism to one where people have a desired demand for money (Cuthbertson & Barlow, 1991). Also, in the cash balance approach, money is held not only as a medium of exchange, but also a store of value. Moreover, the cash balances postulate the role of wealth and the interest rate in determining the demand for money. With this modification, the equation of exchange becomes

$$M^T V^T = P^T y$$

Output, $y$ is used as a proxy for transaction because the more an economy produces, the more goods and services are bought and sold. Equation (3) can be transformed into the quantity theory of money demand by solving for the real money balances, $(M/P)^T$. Thus, equation (3) becomes

$$m^T = \left( \frac{M}{P} \right)^T = \left( \frac{1}{V} \right) \cdot y$$

Equilibrium in the money market is achieved where the quantity of real money supplied $m^T = (M/P)^T$ is equal to the demand for real money balance, $m^T = (M/P)^d$. Since the income velocity of circulation, $V$ is fixed or stable, it follows that $1/V = k$.
reflecting institutional and technological features of the economy which are stable in the short run. Hence, the quantity theory of money demand can be expressed as

\[ m^d = \left( \frac{M}{P} \right)^d = k \cdot y \]  

(5)

Since \( k \) is fixed, the level of transactions generated by a fixed level of income determines the quantity of money that individuals demand. In this regard, equation (5) suggests that the demand for real money balances is solely determined by real income, with interest rates having no effect.

### 2.3. Liquidity Preference

As has been noted, Keynes (1936) theorizes that individuals hold money with three motives: transactions, precautionary, and speculative. According to Keynes (1936) transactions demand for money depends on the level of income. If the level of income increases, the demand for real money balances for transactions also increases. The precautionary demand depends on the level of income as well, because money serves as a medium of exchange in this motive. The precautionary motive provides a contingency plan for unforeseen expenditure. The speculative demand for money is what Keynes (1936) calls as liquidity preference. The store of value function of money is emphasized in the speculative demand for money (Sriram, 1999). Individuals can hold wealth into either money or bonds. It is expected that individuals will hold more assets into bonds and less into money if the interest rate or the rate of return on bonds, \( i \) increases. Contrary, a decrease in the interest rate should induce individuals to shift some assets out of bond and into money. In this case, money demand for speculative motives is interest rate elastic because interest rate is the opportunity cost of holding money. Thus, the Keynesian money demand function is expressed as

\[ m^d = \left( \frac{M}{P} \right)^d = f(y, i) \]  

(6)

where the demand for real money balances, \( m^d \) is a function of real income, \( y \) and nominal interest rate, \( i \). As explained above, money demand is positively related with income and inversely related with interest rate. It is assumed in this model, that the income velocity of money is not stable. Further, implicitly, the liquidity preference function captures the effect of inflation on the demand for money. Fisher (1930), hypothesizes that the nominal interest rate, \( i \) in any period is equal to the sum of the real interest rate, \( r \) and the expected rate of inflation, \( \pi' \). This refers to the Fisher Effect. The Fisher effect is presented as

\[ i = r + \pi' \]  

(7)

The Fisher equation (7) states that there is a one-to-one relationship between expected inflation and nominal interest rates, with real interest rates being unrelated to the expected rate of inflation and determined entirely by the real factors in the economy, such as the productivity of capital and investor time preference. Incorporating the Fisher effect (7) into the Keynesian money demand function (6), we obtain the Keynesian money demand function (8) that captures the effect of inflation on real money demand.

\[ m^d = \left( \frac{M}{P} \right)^d = f(y, r + \pi') \]  

(8)
Both inflation rate and interest rate are cost of holding money. In this case, the demand for real money balances also depends negatively on the expected rate of inflation. Henceforth, demand for real money balances is an increasing function of income and a decreasing function of both interest rate and expected rate of inflation. However, a problem arises due to lack of any direct measure of the expected rate of inflation. For this reason, a proxy variable for inflationary expectations is employed. Some studies use form of distributed lag on past inflation rates to proxy for inflationary expectations (see for example Cagan, 1956; Meiselman, 1962; Sargent, 1969 and Gibson, 1970).

2.4. Inventory Theoretic Approach

Inventory theories of money demand consider the money demand for transactions motive. Baumol (1952) and Tobin (1956) use inventory theoretic approach to develop a theory of money demand in which money is viewed as an inventory held for transactions purpose by analyzing the costs and benefits of money holding. To enumerate, the inventory models assume the presence of stores of value i.e. money and an interest bearing assets. The benefit of holding money is liquidity and the cost of holding money is the forgone interest, \( r \). These models also assume that there is a fixed cost of making transfers between money and alternative assets. All the payments are made with money. One of the most appealing insights of these models is that the income and interest elasticity of money demand are constant and both equal to 0.5. This suggests that average money demand should increase by 0.5 percent if real income increases by 1 percent and that average money demand should decline by 0.5 percent if interest rate increases by 1 percent. Thus, income elasticity and interest elasticity are the key parameters for determining the demand for money. Because a brokerage fee or a fixed transaction cost, \( b \) is involved per money withdrawal, individuals hold inventories of cash and make currency conversion only infrequently (see also Li, 2007). This leads to the famous square-root formula with average cash holdings expressed as

\[
m^* = \left( \frac{M}{P} \right)^{\frac{1}{2}} = \frac{by}{2r} \tag{9}
\]

where as defined above, \( b \) is the cost of converting interest-bearing assets into money, \( r \) is interest rate, \( P \) is the price level and \( y \) is real income. Model (9) is obtained by minimizing the sum of interest forgone on total money holdings and total transaction costs. The model postulates that optimal demand for real money balances, \( m^* \) is directly proportional to transactions costs, \( b \) and real income, \( y \) and inversely proportional to the interest rate, \( r \) earned on alternative assets.

2.5. Portfolio Theories of Money Demand

Friedman (1956) and Tobin (1958) develop the portfolio theoretic approach models while treating money like any other asset yielding a flow of services and use the assets’ demand theory to derive the money demand theory. According to Friedman (1956) velocity of money is highly predictable and that the demand for money function is highly stable and insensitive to interest rates. This implies that the quantity of money demanded can be predicted accurately by the money demand function (Kumar et al., 2013). Portfolio theories of demand for money emphasize that individuals hold money as part of their portfolio of assets. At a lower rate of interest or rate of return on bonds individuals will hold more money and fewer bonds in their portfolio. On the other hand, the increase in the rate of interest or rate of return on bonds, wealth holders will be generally attracted to hold a greater fraction of their wealth in bonds and thus reduce their holding of money. That is to say, the demand for money is a function of the risk and return offered by money and by the alternative assets that individuals can hold instead of money. In
addition, since the size of wealth determines the amount of the portfolio to be allotted between money and the alternative assets demand for money is also a function of wealth (see also Jammeh, 2012). Incorporating, wealth (permanent income), \( y_p \), expected rate of inflation, \( \pi^e \), expected return on bond, \( r_b \), expected returns on stock or equity, \( r_e \) and expected return on money \( r_m \), This version of demand for real money balances can be presented as

\[
m^x_t = \left( \frac{M}{P} \right)^{d^x} = f(y_t, \pi^e_t, r_b, r_e, r_m)
\]  

(10)

According to Friedman (1956), money demand function assumes that there is a stationary long-run equilibrium relationship between money balances, real income, and the opportunity cost of holding real money balances that formulate the demand for money function (10). The explanation of model (10) is that the demand for real money balances is positively related with permanent income. Higher wealth implies larger portfolio. Equally important, the incentive to hold money depends on the attractiveness of bonds, stocks and goods assets comparing to holding money. These assets measure the opportunity cost of holding money. Thus, expected returns on these assets are negatively related with demand for real money balances. Similarly, an increase in expected inflation tends to reduce demand for real money balances.

3. Methodology

3.1. Model Specification

As discussed above, there are various theories concerning the money demand function. By and large, there is a consensus among the money demand theories that the main determinants of the quantity of money demand are the scale variable, which can be real income, wealth, or permanent income and opportunity cost variables including inflation rate and interest rate. Keynes (1936) argues that both transactions motive and precautionary motive depends on the scale variable (i.e., output) and the speculative motive depends on the opportunity cost variable (i.e., interest rate). The money demand for real balances is summarized as

\[
m^d_t = \left( \frac{M_t}{P_t} \right) = f(y_t, R) \quad f_y > 0, \quad f_R < 0
\]  

(11)

where

- \( m^d_t \) Demand for real money balances
- \( P_t \) The price level
- \( y_t \) Scale variable (income, wealth or expenditure, in real terms)
- \( R \) Vector of expected rate of return (within and outside money)

Model specification (11) represents the long run real money function and assumes a long run unitary elasticity of nominal cash balances with respect to the prices level. This assumption of price homogeneity can be tested empirically (see also Nachega, 2001). The function \( f \) is hypothesized to be increasing in \( y \), decreasing in those elements of \( R \) representing rates of return on alternative assets, and increasing in rates of return associated with assets included in \( M \). For the purpose of this paper, the definition of money which is considered for estimation of real money demand function is \( M1 \). \( M1 \) includes currency in circulation and
demand deposits as defined by the Bank of Tanzania. The main argument here is that the analytical work on \( M1 \) is more amenable to control by the monetary authorities. Also, a number of studies on developing countries indicate that the models using narrow definition of money are better than those employing broad money reflecting the weak banking system and low level of financial sector development (see for example Moosa, 1992; Simmons, 1992; Kallon, 1992; Hossain, 1994; Metin, 1994; Pradhan & Subramanian, 1997; Suliman & Dafaalla, 2011; Maravić & Palić, 2005).

Either wealth or income or expenditure can be used as a scale variable which measures the level of economic activity. In this paper real GDP is used as a scale variable. It is worthy to note that the holding of money and thus the demand for money are related to the volume of the transactions. Also, the amount of the transactions is proportional to the level of income (see also Suliman & Dafaalla, 2011). Real GDP captures transactions and precautionary demand for money. A priori, it is expected that the sign of real income is positive. This is because as real income increases, people demand more money for transactions and precautionary motives. Opportunity cost of holding money in a demand for money function measures the yield on money against other assets that might be held. In this paper, the deposit interest rate and the rate of inflation are included to take account of the asset-substitution hypothesis. The relationship between the demand for real money balances, and interest rate and the rate of inflation has been empirically studied (see for example Khan & Sajjid, 2005; Maravić & Palić, 2005, Valadkhani, 2008 and Kjosevski, 2013). The demand for real money balances is expected to have an inverse relationship with deposit interest rate and the rate of inflation, since an increase in deposit rate and the rate of inflation increases the cost of holding money.

Moreover, taking the currency substitution hypothesis into account, many studies on the demand for money in developing countries often include exchange rate variable in money demand function. The inclusion of exchange rate variable in the standard function of money demand to take account of the currency substitution phenomenon is suggested by Mundell (1963). A similar approach is used by Sriram (2009) and Bahmani-Oskooee & Ng (2002). In addition, Bahmani-Oskooee & Malixi (1991), Simmons (1992), Akinlo (2006), Suliman & Dafaalla (2011) and Adam et al. (2012) include exchange rate in the model of demand for real money balances. Apparently, the relationship between real money demand and exchange rate is a matter of empirical investigation. According to Bahmani-Oskooee & Ng (2002), variation in the foreign exchange rate has wealth and the currency-substitution effects. Specifically, Bahmani-Oskooee & Ng (2002) argue that first, exchange rate depreciation may be perceived as an increase in wealth by wealth holders in foreign economies leading to an increase in the demand for money. Second, exchange rate depreciation may cause expectation of further depreciation leading to a reduction in domestic demand of money. Thus, the sign of the coefficient on exchange rate will eventually be determined by the predominant effect.

Accordingly, the specification of demand for real money balances takes the following semi-log linear functional form:

\[
\ln(m_d^t) = \lambda_1 + \lambda_2 \ln(y_t) + \lambda_3 r_t + \lambda_4 \ln(ex_t) + \lambda_5 \pi_t + u_t
\]

where:
- \( m_d^t \) Real money demand
- \( y_t \) Real GDP (scale variable)
- \( r_t \) Deposit interest rate (opportunity cost variable)
- \( ex_t \) Real exchange rate to capture currency substitute effect

\[ \text{(12)} \]
The vector autoregressive (VAR) model is expressed as

$$
\Delta \ln(m_t^i) = \sum_{j=1}^{4} \lambda_{yj} \Delta \ln(m_{t-j}^i) + \sum_{j=1}^{4} \lambda_{yj} \Delta \ln(y_{t-j}) + \sum_{j=1}^{4} \lambda_{c} \Delta c_{t-j} + \sum_{j=1}^{4} \lambda_{\sigma} \Delta \sigma_{t-j} = \mu_i^*,
$$

and the vector error correction model (VECM)\(^1\) for all the endogenous variables is specified as

$$
\Delta \ln(m_t^i) = \sum_{j=1}^{4} \lambda_{yj} \Delta \ln(m_{t-j}^i) + \sum_{j=1}^{4} \lambda_{yj} \Delta \ln(y_{t-j}) + \sum_{j=1}^{4} \lambda_{c} \Delta c_{t-j} + \sum_{j=1}^{4} \lambda_{\sigma} \Delta \sigma_{t-j} + \mu_i + \lambda_i \Delta c_i + \lambda_j \ln(m_{t-j}^i) + \lambda_j \ln(y_{t-j}) + \lambda_{rj} \ln(r_{t-j}) + \lambda_{\sigma} \ln(\sigma_{t-j}) + u_i,
$$

where \(\Delta\) is the difference operator and \(\lambda_i C_i\) is a vector of exogenous variable (intercept). The VECM is estimated for all the endogenous variables in the model. Also, the variance decomposition tests are carried out to further understand the interactions of the variables.

### 3.2. Unit Roots and Cointegration Tests

The unit root and cointegration tests are very important pre-estimation tests that are often used to examine the properties of the time series used in model in order to avoid spurious regression. The Augmented Dickey Fuller (ADF) (Dickey & Fuller, 1979; 1981) is used to determine the presence of unit roots in the data sets in this paper. Specifically, ADF test is employed to test whether the variables used in the estimation are stationarity or not. The test is estimated with the following regressions

$$
\Delta z_i = \beta_i + \beta_i t + \delta z_{i-1} + \sum_{i=1}^{q} \alpha_i \Delta z_{i-1} + u_i,
$$

$$
\Delta z_i = \beta_i + \delta z_{i-1} + \sum_{i=1}^{q} \alpha_i \Delta z_{i-1} + u_i,
$$

where \(z_i\) is the individual variable at time \(t\), \(\Delta z_i = z_{i-1} - z_i\), \(u_i\) is a pure white noise error term, \(\beta_i\) is the constant, \(q\) is the number of lags which should be large enough to ensure that the error terms are white noise and small enough to save degree of freedom, \(t\) is the trend variable in quarters and \(\delta = \rho - 1\). The equations above are the ADF with a constant and time trend, and ADF with only a constant. In each case, the null hypothesis is that \(\delta = 0\); which means that there is unit root or the time series is nonstationary. The alternative hypothesis is that \(\delta < 0\); this means that the variable is stationary, using tau \((\tau)\) statistics. At 95 percent confidence level, if the p-value is less than or equals to 0.05, we reject the null hypothesis that the variable in equation is non stationary or it has a unit root.

The presence of long run equilibrium relationship between dependent and independent variables is referred to as cointegration. The two common tests for cointegration are the procedure of Engle & Granger (1987) and the procedure of Johansen and Juselius (Johansen & Juselius, 1990; Johansen, 1992). In this paper

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\(^1\) VECM allows causality to emerge even if the coefficients of the lagged differences of the explanatory variables are not jointly significant.
both Engle-Granger two step method and the Johansen cointegration technique are used to examine the existence of an equilibrium relationship between money demand and its determinants. The Johansen cointegration model is a VAR-based test and it is presented as

$$\Delta z_i = \Pi z_{t-1} \sum_{i=1}^{k} \Gamma_i \Delta z_{t-1} + \mu + \Phi \tau + u_t$$  \hspace{1cm} (17)

Model (17) is an \((n \times 1)\) vector of endogenous variables and is also an \((n \times 1)\) vector of white noise error term, where \(n\) is the number of all the variables used in this paper. The rank of the matrix coefficient \(\Pi\) indicates the long run relationship among the variables. Full rank \(r = n\) means that the variables are cointegrated. Rank \(r = 0\) means that the variables are not cointegrated and reduced rank where \(r\) lies between zero and \(n\) means that there are \(r\) cointegrating vector among the variables.

### 3.3. Dataset and Sources of Data

Empirical analysis is based on annual time series data spanning from 1966 to 2015. As presented earlier, the basic estimation model has five main variables namely, real money demand \((M_1/P)\), real GDP \((y)\), deposit interest rate \((r)\), real exchange rate \((e_{x})\) and inflation rate \((\pi)\). The data on \(M_1\), real GDP, deposit interest rate, and the rate inflation were obtained from publications of the Bank of Tanzania “Tanzania Mainland’s 50 Years of Independence: A Review of the Role and Functions of the Bank of Tanzania (1961-2011) and Annual Report (various issues). \(M_1\) is considered in this paper as a proxy for the demand for money because the Central Bank is able to control this aggregate more accurately than broader aggregates such as M2 and M3. Real exchange rate data were obtained from the International Financial Statistics of the International Monetary Fund. Real exchange rates are derived by multiplying the nominal exchange rate by the ratio of the U.S. to local currency Consumer Price Index. Data on consumer price index \((CPI)\) was obtained from the Federal Reserve Bank of St. Louis. Nominal \(M_1\) was deflated by a weighted average of prices of consumer goods and services \((CPI)\) in order to compute its real value.

Figure 1 (1.1-1.5) and Figure 2 (2.1-2.5), respectively, give visual information about the data generating process in levels and in first difference. In Figure 1 it can be inferred that real money demand and real GDP have upward trends. Hence, they have no constant means and have a long memory in their increasing trend. Deposit interest rate and inflation rate are above their means for the 1980-2000 period. There is a very sharp increase in both deposit interest rate and inflation rate in the 1980s but during the second half of 1990s both variables declined drastically. In the last 15 years deposit interest rate, inflation rate, and real exchange rate seem to be stable. In general, however, all the variables seem to have unit root. The overall implication at this elementary stage is that all variables might be integrated of order one to make them stationary. Trends of variables may be affected by economic crisis of 1980s and financial liberalization of 1990s. Accordingly, it becomes inevitable to test the stability of the money demand equations in this analysis.
Figure 1.1. Real Money Demand, ln(\(M_1/P\))

Figure 1.2. Real GDP, ln(\(y_t\))

Figure 1.3. Deposit Interest Rate, \(r_t\)
As presented above, graphs of the levels of the real $M1$ variable, real GDP, deposit interest rate, real exchange rate and inflation rate appear to have non-constant mean, and give some information about the non-stationarity. Instead, the time series in first differences as displayed graphically in Figure 2 show no evidence of changing means.
Figure 2.2. Real GDP, $D(\ln(y_t))$

Figure 2.3. Deposit Interest Rate, $D(r_t)$

Figure 2.4. Real Exchange Rate, $D(\ln(ex_t))$
Furthermore, descriptive analysis is conducted to ascertain the statistical properties of the variables. Table 1 reports the descriptive statistics of the variables. Based on the skewness, the descriptive statistics suggest that real GDP, real exchange and rate of inflation are approximately normally distributed because their respective skewness is equal or less than 0.5 in absolute values. In addition, the probabilities of these variables fail to reject the null hypothesis of normal distribution at 5 percent level of significance. Also, based on kurtosis, real money demand and deposit interest rate tend to be mesokurtic because their values are approximately equal to 3. Overall, it can be concluded that there is evidence that there are no outliers in these respective time series causing the data sets to become relatively symmetrical.

Table 2 shows the correlation and covariance matrices for the system variables. The correlation matrix clarifies the direction and the degree of the relationships between variables in the system. Real $M_1$ is highly and positively correlated with real GDP. Thus an increase in the rate of growth of real GDP is expected to increase the demand for real money balances. Real $M_1$ seems to have a negative correlation with deposit interest rate and inflation rate. However, the degree of association seems to be low. In addition, money demand and real exchange seem to be positively associated.

Table 1. Descriptive Statistics of the Variables

<table>
<thead>
<tr>
<th></th>
<th>$\ln(m_1^t)$</th>
<th>$\ln(y_t)$</th>
<th>$r_t$</th>
<th>$\ln(ex_t)$</th>
<th>$\pi_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.270</td>
<td>6.843</td>
<td>9.130</td>
<td>2.986</td>
<td>16.408</td>
</tr>
<tr>
<td>Median</td>
<td>4.173</td>
<td>6.806</td>
<td>4.000</td>
<td>3.073</td>
<td>12.745</td>
</tr>
<tr>
<td>Maximum</td>
<td>4.811</td>
<td>7.350</td>
<td>27.000</td>
<td>3.264</td>
<td>36.146</td>
</tr>
<tr>
<td>Minimum</td>
<td>3.977</td>
<td>6.464</td>
<td>2.400</td>
<td>2.521</td>
<td>3.493</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.230</td>
<td>0.247</td>
<td>8.984</td>
<td>0.201</td>
<td>10.414</td>
</tr>
<tr>
<td>Skewness</td>
<td>-1.037</td>
<td>1.053</td>
<td>1.141</td>
<td>-0.536</td>
<td>0.473</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.909</td>
<td>2.229</td>
<td>2.500</td>
<td>2.089</td>
<td>1.757</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>8.971</td>
<td>3.429</td>
<td>11.365</td>
<td>4.301</td>
<td>5.082</td>
</tr>
<tr>
<td>Probability</td>
<td>0.011</td>
<td>0.180</td>
<td>0.003</td>
<td>0.116</td>
<td>0.079</td>
</tr>
<tr>
<td>Observations</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

Source: Author’s computations
Table 2. Correlation Matrix

<table>
<thead>
<tr>
<th></th>
<th>ln(m_t^d)</th>
<th>ln(y_t)</th>
<th>r_t</th>
<th>ln(ex_t)</th>
<th>( \pi_t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln(m_t^d)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ln(y_t)</td>
<td>0.866</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r_t</td>
<td>-0.378</td>
<td>-0.126</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ln(ex_t)</td>
<td>0.341</td>
<td>0.648</td>
<td>-0.327</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>( \pi_t )</td>
<td>-0.352</td>
<td>-0.339</td>
<td>0.623</td>
<td>-0.246</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: Author’s computations

3.4. Testing Stability of the Demand for Money

Testing for stability of money demand is important as money supply is one of the key instruments of monetary policy. Money supply is the most suitable monetary policy instrument if money demand function in the economy is stable. If the money demand happens to be unstable over the medium to long term, then the Central Bank should shift its targeting into another workable framework such as interest rate targeting as the most appropriate instrument for the conduct of monetary policy. Hence, parameter constancy is a critical issue for money demand function. In particular, to be able to interpret the estimated money demand function, it is necessary to assure that the parameters are stable over the estimation period. To examine the structural stability real money demand function, this paper applies the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMQ) of recursive residuals tests. These are conventional methods for the test of stability of the money demand function. They are proposed by Brown et al. (1975) and are commonly used by authors who examine the demand for money (see for example Payne, 2000; Bahmani-Oskooee & Shin, 2002; Owoye & Onafowora, 2007; Dritsaki & Dritsaki, 2012; Gaurisankar & Kwie-Jurgens, 2012 and Kjosevski, 2013). The CUSUM test which is based on the cumulative recursive sum of recursive residuals, is useful for detecting systematic changes in the regression coefficients whereas the cumulative sum of squares test that is based on the cumulative sum of squares of recursive residuals, is useful in a situation where the departure from the constancy of regression coefficients is abrupt and sudden. It should be noted that both the CUSUM and CUSUMQ test statistics are updated recursively and plotted against break points in the data and for stable real money demand function’s short-run dynamics and long-run parameters, the CUSUM and CUSUMQ statistics stay within the 5 percent critical bound.

5. Empirical Results

5.1. Unit Root and Cointegration Tests

The ADF unit root test is applied to test for the stationarity of the variables. The test is applied to both the series in levels and in the first differences. The 5 percent critical value is used for making a decision on whether to reject the null hypothesis or not. Results of both tests which are reported in Table 3, indicate that all the series are non-stationary in their level, \( I(0) \), when the model includes constant only and also when includes constant and trend. The variables become stationary in their first differences, \( I(1) \). Thus, we conclude that all series are integrated of order one, \( I(1) \) at the 5 percent level of significance. These results suggest that the model meets the requirement to proceed with the cointegration test. As it has been discussed in this paper, Johansen & Juselius’s (1990) cointegration and Engle-Granger two step methods are used for the cointegration analysis. The order of lag-length is determined by Sequential modified LR test statistic (LR) and Final prediction error (FPE) (Table 4). Based on LR and FPE, the appropriate lag length is 2. The results of the Johansen cointegration analysis with 2 lags order are presented in Table 5. The test statistics reject the null hypothesis of no
cointegrating relation at the 5 percent significance level. Both the trace test and the maximal-eigen value statistics for cointegration test indicate two cointegrating equations at the 5 percent significance level. In addition, cointegration test results based on Engle-Granger two step method suggests existence of equilibrium in the estimating model. The ADF test applied to the error term of the cointegrating equation is integrated of order zero \(I(0)\) (see Table 6). Figure 3 also confirms the existence of cointegration between variables. According to Thomas (1993), if an equilibrium relationship exists, then the disequilibrium error should fluctuate about zero (Figure 3). This implies that there is a long run relationship between real money demand, real GDP, deposit interest rate, real exchange rate and inflation rate over the sample period under investigation.

\[
\begin{align*}
\text{Table 3. ADF Unit Root Test} \\
\begin{array}{cccccc}
\text{Lag} & \text{Levels} & \text{First Difference, } \Delta \\
\hline
\text{Optimal} & \text{Constant} & \text{Constant and Trend} & \text{Constant} & \text{Constant & Trend} & \\
0 & \beta_1 = 0 & \beta_1 = \beta_2 = 0 & \beta_1 = 0 & \beta_1 = \beta_2 = 0 & \\
\hline
\text{L}(\text{M1}) & -0.198 & -0.882 & -4.656 & -4.798 & \\
\text{L}(\text{Y}) & -1.937 & -0.116 & -3.574 & -4.135 & \\
R & -1.208 & -1.167 & -5.947 & -5.981 & \\
\text{L}(\text{RER}) & -1.187 & -1.789 & -6.200 & -6.134 & \\
\pi & -2.019 & -2.225 & -7.904 & -7.894 & \\
\hline
\text{5% Critical Value} & -2.924 & -3.506 & -2.924 & -3.306 & \\
\text{Note: Null Hypothesis: there is a unit root} \\
\text{Source: Authors computations} \\
\end{array}
\end{align*}
\]

\[
\begin{align*}
\text{Table 4. VAR Lag Order Selection Criteria} \\
\begin{array}{cccccc}
\text{Lag} & \text{LogL} & \text{LR} & \text{FPE} & \text{AIC} & \text{SC} & \text{HQ} \\
\hline
0 & -239.01 & NA & 0.03 & 10.61 & 10.81 & 10.68 \\
1 & 81.16 & 556.82 & 7.50e-08 & -2.22 & -1.03* & -1.78* \\
2 & 108.03 & 40.88* & 7.19e-08* & -2.31 & -0.12 & -1.48 \\
3 & 131.64 & 30.79 & 8.48e-08 & -2.25 & 0.94 & -1.05 \\
4 & 161.64 & 32.62 & 8.44e-08 & -2.46* & 1.71 & -0.89 \\
\hline
\text{Notes: *indicates lag order selected by the criterion} \\
\text{LR: Sequential modified LR test statistic (each test at 5% level)} \\
\text{FPE: Final prediction error} \\
\text{AIC: Akaike information criterion} \\
\text{SC: Schwarz information criterion} \\
\text{HQ: Hannan-Quinn information criterion} \\
\end{array}
\end{align*}
\]

\[
\begin{align*}
\text{Table 5. Johansen Tests for Cointegration} \\
\begin{array}{cccc}
\text{Trend: Constant} & \text{Sample: 1968-2015} & \text{Number of obs} = 48 & \text{Lags} = 2 \\
\hline
\text{Maximum rank} & \text{eigenvalue} & \text{trace statistics} & \text{5 percent} & \text{critical value} \\
\hline
0 & 99.0023 & 68.52 & \\
1 & 0.56218 & 59.3563 & 47.21 \\
2 & 0.46617 & 29.2281* & 29.68 \\
3 & 0.35687 & 8.0403 & 15.41 \\
4 & 0.12555 & 1.6007 & 3.76 \\
5 & 0.03280 & & \\
\hline
\text{Maximum rank} & \text{eigenvalue} & \text{max statistics} & \text{5 percent critical} & \text{value} \\
\hline
0 & 39.6460 & 33.46 & \\
1 & 0.56218 & 30.1282 & 27.07 & \\
2 & 0.46617 & 21.1879 & 20.97 & \\
3 & 0.35687 & 6.4396 & 14.07 & \\
4 & 0.12555 & 1.6007 & 3.76 & \\
5 & 0.03280 & & \\
\hline
\text{Source: Author’s Estimations} \\
\end{array}
\end{align*}
\]
Table 6: Table Static model: Tests for Cointegration between M1/P and Explanatory Variables

<table>
<thead>
<tr>
<th></th>
<th>Optimal Constant</th>
<th>Levels</th>
<th>Probability</th>
<th>Levels</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lag = 1</td>
<td>( \alpha_1 = 0 )</td>
<td></td>
<td>0.000</td>
<td>( \alpha_1 = \alpha_2 = 0 )</td>
<td>0.000</td>
</tr>
<tr>
<td>M1/P Residuals</td>
<td>-7.810***</td>
<td>-7.818***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% Critical value</td>
<td>-3.588</td>
<td>-4.181</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5% Critical value</td>
<td>-2.930</td>
<td>-3.516</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: Null Hypothesis: Residuals are non-stationary
***denote rejection of the null hypothesis at 1% critical value

5.2. Regression Results

Table 7 reports the results of the vector error correction model for real money demand. The t-statistics are in brackets. Overall, the coefficients of the estimated money demand model are consistent with a prior expectation and theoretical postulations regarding signs, and they are statistically significant. Real GDP has a positive sign. This suggests that the transaction and precautionary motives of money demand hold in Tanzania. Empirical results show that a percentage increase in real income may increase real money demand by more than two percent. Interestingly, income elasticity of money demand for real balances implies that money can be considered as a luxury good in the Tanzania consistent with Valadkhani (2008) for Asian-Pacific countries and Jammeh (2012) for Gambia. Interest rate has a negative sign implying that an increase in the deposit rate may lead to a decline in money demand for real balances. This also suggests that individuals hold money for speculative purposes. Similarly, the coefficient of inflation rate is negative, which suggests that a percentage increase in inflation rate may lead to a decline in money demand in Tanzania. These results also suggest that assets substitution is likely to be between money and physical assets rather than between money and financial assets (see also Nachega, 2001). As inflation rate increases, individuals tend to shift from money holding to asset holding. In fact, demand for money seems to have implications for portfolio decisions in Tanzania.
Moreover, empirical results show that real exchange rate have a positive impact on demand for real money balances in Tanzania. The positive estimated coefficient on exchange rate is consistent with the fact that depreciation of domestic currency raises the domestic value of dollar inflows which depreciates. A depreciation of the domestic currency may be perceived as an increase in wealth because it raises the value of an individual’s foreign assets, and if this is perceived as an increase in wealth, then money demand would increase (see also Arango & Nadiri, 1981). The implication here is that the wealth-effect of currency depreciation dominates the currency substitution-effect of currency depreciation in Tanzania postulating that money demand increases as domestic currency depreciates. A depreciation of the domestic currency may be perceived as an increase in wealth because it raises the domestic value of dollar inflows which would increase money demand in Tanzania (see also Jammeh, 2012). An adjusted R-squared of 0.55, used to measure the goodness-of-fit of the estimated model, indicates that the model explains about 55 per cent of the behavior of money demand.

In addition, the variance decomposition results are reported in Tables 8-12. The variance decomposition determines the amount that the forecast error variance of each of the variables can be explained by exogenous shocks to the other variables. Empirical results of variance decomposition of demand for real money balances are reported in Table 8. The results reveal that 100 percent of the forecast error variance of real money demand is explained by its own shock in the first year. In the subsequent years however, it declines significantly reaching 28.9 percent after a 10 year period. Real money demand apart, a significant proportion of the real money demand variance is caused by real GDP, which increases from 0.00 percent in the first period to 23.5 percent in the tenth year. Similarly, both the rate of

| Table 7. Vector Error Correction Estimates |
|------------------|------------------|------------------|------------------|------------------|
| Error Correction: | \( \Delta \ln(m^r_1) \) | \( \Delta \ln(y_1) \) | \( \Delta r \) | \( \Delta \ln(e_1) \) | \( \Delta \pi \) |
| CointEq1 [-4.01364] | 0.292121 | -0.755967 | 3.889257 | -2.0631 |
| CointEq2 [-1.054775] | 1.966879 | -0.769256 | 7.9431 |
| \( \Delta \ln(m^d_{t-1}) \) | 0.071587 | -0.033801 | -1.38812 | 2.123569 | -6.99187 |
| \( \Delta \ln(m^d_{t-2}) \) | -0.060055 | -0.042894 | -0.828154 | 1.134494 | -2.69004 |
| \( \Delta \ln(y_{t-1}) \) | 2.482664 | -0.182754 | 7.12152 | 5.072869 | 2.7858 |
| \( \Delta \ln(y_{t-2}) \) | 2.080551 | 0.007919 | 7.55123 | -1.360844 | 8.47624 |
| \( \Delta r_{t-1} \) | -0.004876 | 0.001128 | 0.231649 | 0.001105 | 0.224314 |
| \( \Delta r_{t-2} \) | -0.002273 | 0.000118 | -0.204684 | 0.002391 | -0.315699 |
| \( \Delta \ln(e_{t-1}) \) | 0.009954 | 0.035136 | -8.260228 | -0.499780 | 9.160893 |
| \( \Delta \ln(e_{t-2}) \) | 0.322690 | 0.018800 | -12.93115 | -0.236707 | 5.685530 |
| \( \Delta \pi_{t-1} \) | -0.001805 | 0.000455 | -0.172384 | -0.002391 | 0.278676 |
| \( \Delta \pi_{t-2} \) | -0.002065 | 0.000344 | -0.145830 | 0.001601 | 0.136143 |
| \( C \) | 0.001740 | 0.000447 | -0.019248 | -0.002428 | 0.027559 |
| R-squared | 0.690261 | 0.475727 | 0.676416 | 0.787807 | 0.720518 |
| Adj. R-squared | 0.553378 | 0.238958 | 0.530281 | 0.691978 | 0.594300 |
| S.E. eq. | 0.034171 | 0.007966 | 2.896871 | 0.053759 | 6.190309 |
| F-statistic | 4.934580 | 2.009250 | 4.628709 | 8.220950 | 5.708526 |

Source: Author’s estimations

Moreover, empirical results show that real exchange rate have a positive impact on demand for real money balances in Tanzania. The positive estimated coefficient on exchange rate is consistent with the fact that depreciation of domestic currency raises the domestic currency value of an individual’s foreign assets, and if this is perceived as an increase in wealth, then money demand would increase (see also Arango & Nadiri, 1981). The implication here is that the wealth-effect of currency depreciation dominates the currency substitution-effect of currency depreciation in Tanzania postulating that money demand increases as domestic currency depreciates. A depreciation of the domestic currency may be perceived as an increase in wealth because it raises the domestic value of dollar inflows which would increase money demand in Tanzania (see also Jammeh, 2012). An adjusted R-squared of 0.55, used to measure the goodness-of-fit of the estimated model, indicates that the model explains about 55 per cent of the behavior of money demand.

In addition, the variance decomposition results are reported in Tables 8-12. The variance decomposition determines the amount that the forecast error variance of each of the variables can be explained by exogenous shocks to the other variables. Empirical results of variance decomposition of demand for real money balances are reported in Table 8. The results reveal that 100 percent of the forecast error variance of real money demand is explained by its own shock in the first year. In the subsequent years however, it declines significantly reaching 28.9 percent after a 10 year period. Real money demand apart, a significant proportion of the real money demand variance is caused by real GDP, which increases from 0.00 percent in the first period to 23.5 percent in the tenth year. Similarly, both the rate of
Table 8. Variance Decomposition of Money Demand, ln($m^d_t$)

<table>
<thead>
<tr>
<th>Period</th>
<th>S.E.</th>
<th>ln($m^d_t$)</th>
<th>ln($y^c_t$)</th>
<th>$r_t$</th>
<th>ln(ex$_t$)</th>
<th>$\pi_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.030</td>
<td>100.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>2</td>
<td>0.041</td>
<td>78.009</td>
<td>3.972</td>
<td>3.950</td>
<td>13.423</td>
<td>0.646</td>
</tr>
<tr>
<td>3</td>
<td>0.050</td>
<td>57.540</td>
<td>2.902</td>
<td>5.960</td>
<td>26.602</td>
<td>6.997</td>
</tr>
<tr>
<td>4</td>
<td>0.056</td>
<td>47.827</td>
<td>3.958</td>
<td>13.165</td>
<td>27.383</td>
<td>7.667</td>
</tr>
<tr>
<td>5</td>
<td>0.061</td>
<td>42.444</td>
<td>11.851</td>
<td>15.366</td>
<td>23.807</td>
<td>6.532</td>
</tr>
<tr>
<td>6</td>
<td>0.065</td>
<td>44.148</td>
<td>14.287</td>
<td>14.068</td>
<td>21.332</td>
<td>6.165</td>
</tr>
<tr>
<td>7</td>
<td>0.075</td>
<td>41.553</td>
<td>15.441</td>
<td>10.589</td>
<td>22.383</td>
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</tr>
<tr>
<td>8</td>
<td>0.095</td>
<td>36.420</td>
<td>18.975</td>
<td>6.961</td>
<td>21.817</td>
<td>15.827</td>
</tr>
<tr>
<td>9</td>
<td>0.116</td>
<td>32.137</td>
<td>21.859</td>
<td>6.214</td>
<td>20.723</td>
<td>19.066</td>
</tr>
<tr>
<td>10</td>
<td>0.138</td>
<td>28.907</td>
<td>23.532</td>
<td>6.087</td>
<td>19.799</td>
<td>21.675</td>
</tr>
</tbody>
</table>

Table 9. Variance Decomposition of Real Per capita GDP, ln($y^c_t$)

<table>
<thead>
<tr>
<th>Period</th>
<th>S.E.</th>
<th>ln($m^d_t$)</th>
<th>ln($y^c_t$)</th>
<th>$r_t$</th>
<th>ln(ex$_t$)</th>
<th>$\pi_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.007</td>
<td>5.684</td>
<td>94.316</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>2</td>
<td>0.011</td>
<td>11.565</td>
<td>70.867</td>
<td>8.793</td>
<td>8.144</td>
<td>0.631</td>
</tr>
<tr>
<td>3</td>
<td>0.014</td>
<td>18.242</td>
<td>55.908</td>
<td>9.716</td>
<td>13.645</td>
<td>2.489</td>
</tr>
<tr>
<td>4</td>
<td>0.019</td>
<td>25.445</td>
<td>41.806</td>
<td>8.410</td>
<td>17.959</td>
<td>6.381</td>
</tr>
<tr>
<td>5</td>
<td>0.026</td>
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<td>33.388</td>
<td>6.692</td>
<td>20.422</td>
<td>10.027</td>
</tr>
<tr>
<td>6</td>
<td>0.033</td>
<td>28.989</td>
<td>30.712</td>
<td>6.809</td>
<td>21.406</td>
<td>12.084</td>
</tr>
<tr>
<td>7</td>
<td>0.041</td>
<td>28.532</td>
<td>28.223</td>
<td>7.117</td>
<td>21.645</td>
<td>14.483</td>
</tr>
<tr>
<td>8</td>
<td>0.049</td>
<td>28.815</td>
<td>25.995</td>
<td>7.578</td>
<td>21.067</td>
<td>16.545</td>
</tr>
<tr>
<td>9</td>
<td>0.057</td>
<td>28.858</td>
<td>25.029</td>
<td>7.639</td>
<td>19.836</td>
<td>18.639</td>
</tr>
<tr>
<td>10</td>
<td>0.065</td>
<td>28.729</td>
<td>24.763</td>
<td>7.612</td>
<td>18.619</td>
<td>20.278</td>
</tr>
</tbody>
</table>

Table 10. Variance Decomposition of Deposit Interest Rate, $r_t$

<table>
<thead>
<tr>
<th>Period</th>
<th>S.E.</th>
<th>ln($m^d_t$)</th>
<th>ln($y^c_t$)</th>
<th>$r_t$</th>
<th>ln(ex$_t$)</th>
<th>$\pi_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.012</td>
<td>0.994</td>
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<td>0.000</td>
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<td>2</td>
<td>3.323</td>
<td>0.447</td>
<td>3.562</td>
<td>69.202</td>
<td>11.270</td>
<td>15.519</td>
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<td>3</td>
<td>3.943</td>
<td>4.680</td>
<td>8.845</td>
<td>52.448</td>
<td>8.190</td>
<td>25.837</td>
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<td>4</td>
<td>5.045</td>
<td>7.126</td>
<td>14.230</td>
<td>38.100</td>
<td>5.257</td>
<td>35.290</td>
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<tr>
<td>5</td>
<td>6.448</td>
<td>7.402</td>
<td>27.424</td>
<td>24.016</td>
<td>3.606</td>
<td>37.553</td>
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<tr>
<td>7</td>
<td>7.545</td>
<td>10.898</td>
<td>30.153</td>
<td>17.545</td>
<td>2.884</td>
<td>38.592</td>
</tr>
<tr>
<td>8</td>
<td>7.885</td>
<td>12.755</td>
<td>29.215</td>
<td>16.365</td>
<td>2.992</td>
<td>38.672</td>
</tr>
<tr>
<td>10</td>
<td>8.814</td>
<td>18.404</td>
<td>27.824</td>
<td>13.896</td>
<td>4.167</td>
<td>35.709</td>
</tr>
</tbody>
</table>

Table 11. Variance Decomposition of Real Exchange Rate, ln(ex$_t$)

<table>
<thead>
<tr>
<th>Period</th>
<th>S.E.</th>
<th>ln($m^d_t$)</th>
<th>ln($y^c_t$)</th>
<th>$r_t$</th>
<th>ln(ex$_t$)</th>
<th>$\pi_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.049</td>
<td>6.590</td>
<td>1.410</td>
<td>20.778</td>
<td>71.222</td>
<td>0.000</td>
</tr>
<tr>
<td>2</td>
<td>0.054</td>
<td>13.720</td>
<td>1.561</td>
<td>22.664</td>
<td>59.297</td>
<td>2.758</td>
</tr>
<tr>
<td>3</td>
<td>0.067</td>
<td>15.800</td>
<td>2.270</td>
<td>22.657</td>
<td>42.249</td>
<td>17.023</td>
</tr>
<tr>
<td>4</td>
<td>0.084</td>
<td>18.418</td>
<td>1.578</td>
<td>20.952</td>
<td>47.382</td>
<td>11.670</td>
</tr>
<tr>
<td>5</td>
<td>0.101</td>
<td>19.236</td>
<td>1.951</td>
<td>23.756</td>
<td>46.836</td>
<td>8.221</td>
</tr>
<tr>
<td>6</td>
<td>0.121</td>
<td>19.355</td>
<td>1.464</td>
<td>23.702</td>
<td>48.564</td>
<td>6.914</td>
</tr>
<tr>
<td>7</td>
<td>0.135</td>
<td>20.101</td>
<td>1.189</td>
<td>22.684</td>
<td>48.999</td>
<td>7.028</td>
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<tr>
<td>8</td>
<td>0.142</td>
<td>18.572</td>
<td>1.089</td>
<td>24.171</td>
<td>48.435</td>
<td>7.733</td>
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<tr>
<td>9</td>
<td>0.145</td>
<td>17.877</td>
<td>1.131</td>
<td>25.001</td>
<td>47.884</td>
<td>8.107</td>
</tr>
<tr>
<td>10</td>
<td>0.146</td>
<td>17.997</td>
<td>1.406</td>
<td>25.050</td>
<td>47.531</td>
<td>8.016</td>
</tr>
</tbody>
</table>

---

*TER, 4(2), M. Epaphra, p.167-192.*
Table 12. Variance Decomposition of Inflation Rate, $\pi_t$

<table>
<thead>
<tr>
<th>Period</th>
<th>S.E.</th>
<th>$\ln(m^y_t)$</th>
<th>$\ln(y_t)$</th>
<th>$r_t$</th>
<th>$\ln(ex_t)$</th>
<th>$\pi_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.774</td>
<td>0.150</td>
<td>7.115</td>
<td>19.320</td>
<td>0.066</td>
<td>73.350</td>
</tr>
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<td>2</td>
<td>7.335</td>
<td>15.044</td>
<td>29.241</td>
<td>11.718</td>
<td>7.205</td>
<td>36.793</td>
</tr>
<tr>
<td>3</td>
<td>7.950</td>
<td>20.520</td>
<td>29.314</td>
<td>10.063</td>
<td>6.132</td>
<td>33.971</td>
</tr>
<tr>
<td>4</td>
<td>9.005</td>
<td>23.439</td>
<td>27.466</td>
<td>9.578</td>
<td>11.098</td>
<td>28.420</td>
</tr>
<tr>
<td>10</td>
<td>15.249</td>
<td>26.610</td>
<td>17.659</td>
<td>15.637</td>
<td>17.375</td>
<td>22.719</td>
</tr>
</tbody>
</table>

Source: Author’s estimations

5.2 Structural and Parameter Stability Tests

Structural and parameter stability tests are used to find out if demand for money is stable in Tanzania during the period under study. Figure 4 and Figure 5, respectively, report the results of the sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUM-SQ) tests. The straight lines represent critical bounds at 5 percent significance level. In Figure 4, the plot of the CUSUM is within the critical bounds at 5 percent significance level. The plot deviates with reversion to the zero line, hence confirming structural stability. Similarly, the plot of the CUSUM-SQ is within the critical bounds confirming both structural stability and parameter stability. Thus, real money demand is structurally stable and parameters are also stable over the period under study.

Figure 4. Plot of Cumulative Sum of Recursive Residuals (CUSUM)

Figure 5. Plot of Cumulative Sum of Squares of Recursive Residuals (CUSUM-SQ)

Source: Author’s estimations
5.3. Diagnostic Tests

Presence of autocorrelation and heteroscedasticity violates the classical assumptions of the OLS and hence invalidate statistical validity of parameter estimates. Thus, diagnostic analysis is crucial to ascertain if the model is statistically adequate. These tests are focused on the properties of residuals. The results of the diagnostic tests are reported in Table 13 and Figures 6-9. Generally, results show that the model is good because we fail to reject the null hypotheses of no serial correlation and no heteroscedasticity. The Breusch-Godfrey serial correlation Lagrange Multiplier (LM) test confirms that the residual terms in the model are not serially correlated (Table 13). Also, the ARCH LM test strongly suggests that there exists no heteroscedasticity in the residuals of the model. Moreover, the estimated $p$-value for RESET regression errors specification test fails to reject the null hypothesis of no model misspecification error, suggesting that the model is not misspecified (Table 13). Equally important, the diagnostic tests show that the error correction model does not suffer from non-normality. The histogram and Jarque-Bera normality test as reported in Figure 6 suggest that the residuals of the model are normally distributed as we fail to reject the null hypothesis of normality using Jacque-Bera at 5 percent.

In addition, Figure 7 suggests that residuals are normally distributed, they are not correlated and that their mean is zero. Specifically, probability values of Portmanteau test for white noise and Barlett’s periodogram-based white noise test fail to reject the hypotheses that residuals are random or independent, there is no serial correlation among residuals and that residuals are stationary. One simple diagnostic test that is applied to know whether the model is a reasonable fit to the data is to obtain residuals and the autocorrelation (AC) and partial autocorrelation (PAC) of these residuals at any different lags. The estimated AC and PAC are shown in Figure 8 and Figure 9. The Figures show that none of the autocorrelations and partial correlations is individually statistically significant at 5 percent level.

Table 13. Serial Correlation, Heteroskedasticity and Ramsey RESET Tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Value</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breusch-Godfrey Serial Correlation LM Test:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-statistic</td>
<td>1.150469</td>
<td>0.3387</td>
</tr>
<tr>
<td>Obs*R-squared</td>
<td>5.100367</td>
<td>0.0781</td>
</tr>
<tr>
<td>Heteroskedasticity Test: ARCH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-statistic</td>
<td>0.529096</td>
<td>0.4710</td>
</tr>
<tr>
<td>Obs*R-squared</td>
<td>0.547396</td>
<td>0.4594</td>
</tr>
<tr>
<td>Ramsey RESET Test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t-statistic</td>
<td>0.437279</td>
<td>0.6641</td>
</tr>
<tr>
<td>F-statistic</td>
<td>0.191213</td>
<td>0.6641</td>
</tr>
<tr>
<td>Likelihood ratio</td>
<td>0.222576</td>
<td>0.6371</td>
</tr>
</tbody>
</table>

Source: Author’s Computations

![Figure 6](image.png)
Figure 7. White noise Test of the Residuals

Figure 8. Autocorrelation of residuals

Figure 9. Partial autocorrelation of residuals

Source: Author’s computations
6. Conclusions

Investigation of the factors and stability of real money demand is very important because a good understanding of the stability and robust determinants of the demand for real money balances forms the core in the conduct of monetary policy as it enables a policy-driven change in monetary aggregates to have predictable influences on output, interest rate, and ultimately price. This paper investigates the main factors that determine demand for real money balances in Tanzania. The paper also examines the stability of the real money demand function over the 1966-2015 period. Both the Johansen Maximum Likelihood procedure and the Engle-Granger two step method show that there is a long-run relationship for real money. The VECM results show that scale variable (real GDP) and the currency substitution variable (real exchange rate) have a positive relationship with demand for real money balances. Moreover, consistent with the economic theory, empirical results suggest that opportunity cost (of holding money) variables (deposit interest rate and inflation rate) have a negative effect on the demand for real money balances. The results of stability tests reveal that demand for real money balances, $M_1/P$, in Tanzania is stable over the period of the study. These results suggest that it is possible to use the narrow money aggregate as target of monetary policy in Tanzania. Equally important, monetary policy makers in the Bank of the Tanzania should consider real income, interest rate, inflation rates and real exchange rates as key policy factors.
References


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