A RE-EXAMINATION OF THE DEMAND FOR MONEY IN UGANDA: NATURE AND IMPLICATIONS FOR MONETARY POLICY

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Abstract

The existence of a stable relationship between money and prices is generally regarded as a prerequisite for a monetary targeting framework. The stability of such a relationship is assessed via a money demand function. A stable money demand function ensures that the impact of monetary policy is predictable and that monetary policy actions are consistent with the desired objectives of price stability and long-run growth.

This paper uses contemporary empirical methods to model the demand for money. In particular, cointegration analysis is used to establish the existence of a long-run relationship and the short-run dynamics are modeled via the error correction model. Using quarterly data for the period 1990 to 2004, the study establishes that both real base money and real M2 are positively related to real GDP (with the income elasticity of 1.5 and 1.0, respectively), and negatively related to the relative interest rate and the nominal exchange rate (with the interest rate elasticities of –0.01 and –0.2 and the exchange rate elasticities of –1.2 and –0.9 for the real base money and real M2 models, respectively).

The short-run models vindicate the existence of cointegrating relationships. For the real base money model, 39.7 percent of adjustment to an exogenous shock occurs in one quarter, while for the real M2 model, only 13.2 percent of the adjustment occurs during the first quarter. Tests on parameter stability indicate that the short-run models do not reveal any sign of instability. The Chow forecast test fails to reject the null hypothesis of no structural change in both models. The recursive coefficients and residual estimates for both the real base money model and the M2 also exhibit parameter constancy indicating that there is no evidence of a major instability over the sample period. The implication of this result is that monetary growth is a good predictor of future inflation and real output in Uganda. Thus, there is no sufficient evidence that the monetary targeting framework is ineffective.

Keywords: Demand for money; income and interest elasticity; stability; financial sector reforms; monetary policy; cointegration; error correction model
I. INTRODUCTION

The demand for money serves as a conduit in the monetary policy transmission mechanism and also helps in determining the welfare implications of monetary policy actions in the economy. Estimates of the money demand function such as the income elasticity helps in determining the rate of monetary expansion consistent with long-run price stability, while the interest rate semi-elasticity aids in calculating the welfare costs of inflation. The presence of a well-defined and stable money demand function\(^1\) is crucial for the reliable transmission of the impact of changes in money supply to aggregate spending. A stable money demand function thus ensures that monetary policy has predictable impacts on macroeconomic variables and that monetary policy actions are consistent with the desired objectives of price stability and long-run growth.

The trend of monetary aggregates is important for monetary authorities, especially in the context of monetary targeting frameworks, in which programme benchmarks are determined by limits on the monetary base or on other monetary aggregates. In Uganda, where a monetary targeting framework is in use, estimating a money demand function becomes a vital focus, as the empirical relationship represented by the money demand equation enables one to examine the interaction between monetary aggregates and other economic indicators. In addition, the Ugandan financial system has undergone fundamental changes in the last decade or so. The implementation of various structural reforms and deregulations together with the introduction of new financial products has changed the structure of the financial system. In the view of the fact that broad money comprises a wider range of financial instruments reflecting the consequences of the financial innovations and the recent changes in the Ugandan financial system, the study investigates money demand using a broad range of monetary aggregates.

The objective of this paper is thus to provide empirical foundations for the conduct of monetary policy in Uganda by examining the nature and stability of the money demand function. The rest of the paper is structured as follows. Section 2 presents a brief overview of the nature of the financial system and monetary policy framework in Uganda. The theoretical and empirical literature on money demand is presented in Section 3 while the specification of the empirical model, data issues, variable characteristics and the time series properties of the data are discussed in Section 4. The estimation framework and empirical findings are presented in Section 5, and finally, the conclusions and policy recommendations are presented in Section 6.

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\(^1\) The stability of the money demand function also improves its predictability. The money demand function is considered stable if the estimated demand function is predictable; its coefficients are accurate; the out-of-sample estimations are fair; it is a function of relatively few variables; and the explanatory variables in the estimated function represent theoretically and economically plausible relationships between money and real economic activity.
II THE FINANCIAL SYSTEM AND MONETARY POLICY FRAMEWORK IN UGANDA

2.1 The financial system

Uganda’s financial sector has undergone considerable reform since the late 1980’s. Before 1988, the formal financial sector was highly regulated with direct government controls over credit, interest rates and exchange rate policy. Major liberalization measures were introduced in 1992, but controls in both interest rates and credit allocation were removed in several steps over the two-year period, till 1994 when interest rates were fully liberalized. Since then interest rate management has been effected through indirect monetary policy instruments with the Treasury bill rate as the anchor. While the main focus was on the removal of controls on interest rates, some institutional reforms were also initiated. This process was complemented by parallel measures to strengthen bank supervision and foster financial discipline through new legislation and regulations, and policies to improve the efficiency and profitability of financial institutions.

In addition to freeing interest rates and credit allocation, liberalization of the financial system also allowed freer entry of institutions into the system, with the main objective of increasing competition and efficiency. This saw a fast expansion of the banking and non-banking sector after 1994. The government has also reduced its role in the allocation of credit and ownership of financial institutions.

2.2 The monetary policy framework

The Bank of Uganda has been implementing a monetary aggregate targeting framework, the Reserve Money Programme (RMP), since 1993 when it assumed its primary responsibility of formulation and implementation of monetary policy, following enactment of the Bank of Uganda Act (1993). Under the RMP, the overall macroeconomic objectives on desired real GDP growth, inflation, and balance of payments are defined. Broad money (M2) growth is then projected consistent with these macroeconomic objectives, given assumptions on velocity. The growth of the monetary base, the operating target, is then projected in line with the broader monetary aggregate and inflation.

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2 The removal of interest rate controls affected the Treasury bill rates as the Treasury bill market changed from one of ad-hoc issues by government to a market-based auction for the determination of interest rates. From then, the key interest rates were linked to the weighted average of the Treasury bill rate as determined in the four preceding Treasury bill auctions.

3 The RMP rests on strong underlying economic relationships between base money, broader monetary aggregates, economic growth, and inflation. The relationship between broad money (M2) and the money base is relayed through the multiplier effect of financial intermediation and the propensity of people to hold cash.

4 Base money was adopted as the operating target since was available with a shorter lag than data on broader Monetary aggregates.
The annual growth target for base money is converted into monthly targets that reflect seasonality in the demand for money. From the monthly targets, the desired levels for daily movements are computed. Other things being equal, the direction of monetary policy stance is determined by the gap between the outcome and desired levels of base money: ease if base money is below desired, tighten monetary policy if base money is above desired, and leave monetary policy unchanged/neutral if base money is in line with desired levels.

III. THEORETICAL AND EMPIRICAL LITERATURE

3.1 Theoretical contributions to money demand

Money demand theories date back to the quantity theory of money, developed in the classical equilibrium framework by two different but equivalent expressions. Fisher (1911) provided the famous classical equation of exchange, which relates the quantity of money in circulation ($M_s$) to the volume of transactions ($T$), the price level ($P_t$), and the transactions velocity of money ($V_t$) as shown in equation (3.1) below.

$$TPVM_t = M_sV_t$$  \hspace{1cm} (1.1)

In this formulation, money is held simply to facilitate transactions and has no intrinsic value. The alternative paradigm, the Cambridge approach, is associated with the neo-classical economists, Pigou (1917) and Marshall (1923). The Cambridge approach stressed the demand for money as public demand for money holdings, especially the demand for real balances, which was an important factor in determining the equilibrium price level consistent with a given quantity of money (Sriram, 1999).

Keynes (1936) built on the Cambridge approach to provide a more rigorous analysis of money demand, focusing on the motives of holding money. Keynes’s liquidity preference theory emphasizes the role of interest rates in the demand for money. He distinguished three motives for holding money: the transactions motive, the precautionary motive and the speculative motive. All the three motives influence a particular person’s holdings of money. Keynes argued that the demand for money for transactions and precautionary motives depends on the level of income, while speculative demand for money depends on interest rates. From Keynes perspective, the demand for real money balances ($m^d$) is a positive function of real income ($Y$) and a negative function of interest rate ($r$) as depicted by the “liquidity preference function” given in equation (1.2).

$$m^d = f(Y, r) ; f_y > 0, f_r < 0.$$  \hspace{1cm} (1.2)

According to the liquidity preference theory of the demand for money velocity is not constant, but depends on interest rates. The main proposition of the Keynesian analysis is that when interest rates are low, economic agents
will expect a future increase in interest rates; thus, preferring to hold whatever amount of money is supplied. Therefore, the aggregate demand for money becomes perfectly elastic with respect to the interest rate (liquidity trap).

Following the Keynesian exposition of the motives for holding money, a number of models were developed to confirm the relationship between the demand for real money and, income and interest rates. Baumol (1952) and Tobin (1956) independently developed similar demand for money models, which demonstrated that even money balances held for transactions purposes are sensitive to the level of interest rates. The Baumol - Tobin model analyses the costs and benefits of holding money for transactions purposes. The benefit is convenience (i.e people have money to make everyday transactions) and the cost of this convenience is the interest forgone. A person can thus hold a portfolio of monetary assets and non-monetary assets . If \( r \) is the difference in the return between monetary and non-monetary assets and \( b \) as the cost of transferring non-monetary assets into monetary assets, such as a brokerage fee, then a person minimizes the sum of brokerage costs and interest income forgone. This leads to a well-know “square-root formula” given in equation (1.3) below.

\[
\frac{m}{P} = \sqrt{\left(\frac{bY}{2r}\right)} 
\]

This states that the demand for real money balances \( m \) is directly proportional to transactions costs \( b \) and real income \( Y \), and inversely proportional to the interest rate \( r \). The decision about how often to pay the brokerage fee is analogous to the decision about how often to make daily transactions, that determines how much money to hold. In the ideal world of the Baumol-Tobin model, the elasticity of money demand in response to income and interest rate must be 0.5 and -0.5 respectively.

In 1956, Friedman developed the modern quantity theory of money. He applied the theory of portfolio choice and postulated that the demand for money must be influenced by the same factors that influence the demand for any asset. Thus according to Friedman, the demand for money function is given by equation (1.4) below.

\[
\left(\frac{M}{P}\right)^d = f\left(Y_p, r_b - r_m, r_e - r_m, \pi_e - r_m\right) 
\]

where \((M/P)^d\) is the demand for real money balances, \( Y_p \) is a measure of wealth or permanent income, \( r_m \) is the expected return on money, \( r_e \) is the expected return on bonds, \( r_b \) is the expected return on equity, and \( \pi_e \) is the expected inflation rate.

Friedman’s theory implies that a rise in market rates raises the expected return on money so that \((r_b - r_m)\) remains fairly stable. Interest rates therefore have little or no effect on the demand for money. Permanent income is thus the primary determinant of the demand for money.
Recent developments in the theory of the demand for money incorporate scenarios where both domestic and foreign monies provide liquidity services in financing the exchange of goods and services, including non-tradables, between domestic residents. These are the currency substitution models of the demand for money.

### 3.2 Empirical issues in the estimation of money demand functions

The empirical literature on modeling and estimating money demand underscores two important points: variable selection and representation, and estimation framework. The proper specification of the scale and opportunity cost variables, and the appropriate choice of an empirical framework that is free of theoretical and estimation problems are both important for robust results to obtain. Studies that have not accorded due consideration to these issues have tended to yield poor results (Sriram; 2001).

#### 3.2.1 Variable selection and representation

The general analytical framework, which derives from money demand theories, takes the form:

\[
\left( \frac{M}{P} \right)^d = f(S, A)
\]

Where M and P represents the selected monetary aggregate\(^5\) in nominal terms and the price level, respectively. S is the chosen scale variable to represent economic activity\(^6\), and A is the alternative foregone or the opportunity cost of holding money. The opportunity cost of holding money involves two components: the own rate of return and the rate of return on alternative assets. Ericsson (1998) argues that it is important to include both interest rates in the estimation of a money demand function to avoid the collapse of the estimated function. He further states that the own-rate is important in economies where financial innovation has been taking place. The return on real assets is usually proxied by the expected rate of inflation (Sriram; 1999). The real value of money falls with inflation whilst the value of real assets is maintained. Therefore, there is a strong incentive for persons to switch out of

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\(^5\) Money is broadly classified into two groups, narrow and broad money. Narrow money consists of those assets, which are readily available for transactions while broad money encompasses a wider range of assets. Empirical literature suggests that the choice of an appropriate monetary aggregate is an empirical matter. As such, several definitions of money have been used in various studies. Indeed, Sriram (1999) argues that measures of money have been selected based on the objectives of the researchers.

\(^6\) The most commonly used measures are gross national product (GNP), gross domestic product (GDP) and net national product (NNP). Recent empirical work has however focused on other scale variables involving more comprehensive measures of transactions and the division of transactions into different components on the grounds that not all transactions are equally “money intensive” (see Goldfeld and Sichel, 1990). However this notwithstanding, Goldfeld and Sichel (1990) argue that there is no firm evidence to the effect that the categorization of GNP into various components leads to an improvement in the behaviour of the money demand function.
money into real assets when there are strong inflationary expectations. Foreign interest rates and the expected rate of depreciation usually represent the returns on foreign assets (Sriram, 1999). The currency substitution literature provides the necessary support in choosing the appropriate variables that account for foreign influence. Direct currency substitution concentrates on the exchange rate variable while the capital mobility or indirect currency substitution literature focuses on foreign interest rates (see Leventakis; 1993).

3.2.2 Estimation specifications

Earliest empirical work on money demand primarily involved producing estimates of velocity, characterizing its behaviour over time and identifying the institutional factors responsible for long-run movements in velocity. Before the 1970s, another popular approach, which tended to produce precise and consistent estimates of the money demand function, was the partial adjustment model (PAM). The PAM, a log-linear specification extensively used for estimating money demand, was originally introduced by Chow (1966) and later popularized by Goldfeld (1973). The PAM augments the traditional formulation of money demand function by distinguishing between “desired” and “actual” money holdings, and introducing a parameter by which the actual money holdings adjust to the desired levels (Sriram, 1999). The PAM takes the general form depicted in equation (1.6) below.

\[
\ln\left(\frac{M_t}{P_t}\right) - \ln\left(\frac{M_{t-1}}{P_{t-1}}\right) = \gamma \left[ \ln\left(\frac{M^*_t}{P_t}\right) - \ln\left(\frac{M_{t-1}}{P_{t-1}}\right) \right]
\]

(1.6)

where \(M^*_t/P_t\) is the desired level of real money balance, \(\gamma\) is a parameter that governs the speed of adjustment, \((t-1)\) is a subscript denoting the previous time period, and all other variables as defined earlier. The actual level of money balances adjusts in each period only partly towards its desired level (Mishkin; 1998). According to Sriram (1999), this model fared well prior to 1973, but failed to explain the instability in the money demand function experienced since then, on account of both theoretical and empirical problems. As an alternative, the buffer stock models (BSM) and error correction models (ECM) were developed. Unlike in the PAM, monetary shocks are explicitly modeled in the BSM. This notwithstanding, there have been mixed results in the empirical application of this approach (see Boughton and Tavlas, 1991 and Cuthbertson and Taylor, 1987). Contemporary empirical work on money demand has thus tended to use cointegration for establishing the existence of a long-run relationship and error correction model for short-run dynamics.

3.2.3 Empirical findings on money demand in Uganda

A review of the existing empirical work on the demand for money in Uganda is important, both for comparison of empirical findings and identification of
existing gaps. In what follows, we review the empirical findings of three studies, Katarikawe and Sebudde (1999), Nachega (2001) and Kararach (2002). Katarikawe and Sebudde (1999) estimated a money demand function for Uganda using monthly data for the period January 1990 to December 1996. They used an income index computed as a weighted average of index of industrial production and coffee procurement as a proxy for income\(^7\). Price changes were found to be stationary in levels and thus did not enter the cointegrating equation.

Save for the exchange rate, all coefficients had expected signs and were statistically significant in both cases. The nominal exchange rate was found to have a positive elasticity in the base money model, implying that the depreciation of the shilling has a positive impact on the demand for base money\(^8\). In the M2 model, exchange rate elasticity was negative, meaning that as the Uganda shilling depreciates, and agents shift away from the domestic currency. In general, the long-run money demand function was found to exhibit a stable relationship.

Using the partial and weak exogeneity assumptions proposed by Johansen (1988), they found that while real M2 is strongly endogenous, real base money is not. Thus for base money, the short-run relationship was estimated using nominal balances. The short-run dynamics suggest that while interest rates and exchange rates affect base money with a lag of up to four and three months, respectively, changes in income affect base money with a lag of one month. A one-period lag of base money and a three-period lag of prices were also found to affect base money levels. The dynamic equation for M2 indicated that the Treasury bill rate, deposit rate and inflation affect base money with a lag. Thus, there is no contemporaneous policy variable that can induce movements in M2.

Nachega (2001) using quarterly data for the period 1982-1998 also used cointegration analysis and error correction modeling to examine the behaviour of the broad money demand function in Uganda. His results were consistent with economic theory as all coefficients had the expected signs. The demand for broad money was found to be positively related to real income and the relative own rate of return\(^9\). The income elasticity of M2 was close to unity and significantly different from zero, which is consistent with the quantity theory of money. The semi elasticity of the relative own rate of return was also positive and statistically different from zero. On the other hand, the LIBOR was found to exert a negative influence on the demand for money. Overall, there was sufficient evidence to support the stability of the money demand function. Kararach (2002) estimated a demand function for Uganda using quarterly data for the period 1981 – 1998. The long-run money

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\(^7\) The weights used were 0.7 and 0.3 for coffee procurement and industrial production, respectively.

\(^8\) This holds for the case of transactions demand. A depreciation of the shilling leads to a higher demand of domestic currency to purchase foreign currency for financing imports.

\(^9\) The relative own rate of return was defined as the annual interest rate offered on time deposits minus the 91-day Treasury bill rate.
demand function was estimated using the Cochrane-Orcutt method. Income and interest rates were found to be significant and theoretically plausible in explaining the demand for money\textsuperscript{10}. The behaviour of the inflation variable was however contrary to theoretical expectations, as the desire to hold money grew with inflation. Expected inflation, proxied by the previous inflation, however had the correct sign.

The error correction model was also estimated to capture the short-run dynamics of the money demand function. The results of the ECM suggest that the speed at which the economy returns to equilibrium after a shock is –2.5. The results also indicated that there is statistical evidence of instability in the money demand function in Uganda. This result is however contrary to the findings of Katarikawe and Sebudde (1999) and Nachega (2001).

IV METHODOLOGY

4.1 Specification of the empirical model
Following the traditional approach, the demand for money is specified as a function of income, interest rates, and exchange rates. The exchange rate captures the effect of expected depreciation on the demand for money. All variables enter the model in logarithmic form. The basic long-run model is thus specified as:

\[
\ln\left(\frac{M^d}{P}\right) = \beta_0 + \beta_1 \text{LGDP}_t + \beta_2 \text{LTBR91}_t + \beta_3 \text{LDEP}_t + \beta_4 \text{NER}_t + \beta_5 \text{Inf}_t + \varepsilon_t \tag{1.7}
\]

Where \(\frac{M^d}{P}\) is a measure of money divided by the CPI, that is,

- real money
- GDP is real monetary Gross Domestic Product
- TBR91 is the 91-day Treasury bill rate\textsuperscript{11}
- NER is the nominal exchange rate.
- DEP is the average annual savings and time deposit rate
- Inf is Inflation rate
- \(\varepsilon\) is the random error term
- \(t\) is a subscript denoting time.

Further, equal elasticity (in absolute value) for the 91-day treasury bill rate (TBR91) and the average deposit rate on savings and time deposits is assumed. Thus, equation (1.7) is transformed to equation (1.8).

\[
\ln\left(\frac{M^d}{P}\right) = \alpha_0 + \alpha_1 \text{LGDP}_t + \alpha_2 (\text{LTBR91}_t - \text{LDEP}_t) + \alpha_3 \text{NER}_t + \alpha_4 \text{Inf}_t + \varepsilon_t \tag{1.8}
\]

\textsuperscript{10} The interest rate coefficient was however low.

\textsuperscript{11} The average time and savings deposit rate (DEP) is used as the own rate of return and the 91-day treasury bill rate (TBR91) as the rate on alternative non-monetary financial assets (i.e. the opportunity cost of holding money)
Based on cointegration analysis and weak exogeneity tests, a short-run money demand function is then modeled in a single equation context using the error correction model (ECM). The short-run model shows how the adjustment mechanism works to revert to equilibrium condition when it is disturbed by exogenous shocks, which lead to deviations from the long-run equilibrium. The order of the Autoregressive distributed lag (ARDL) in the short-run model will be determined by the order of the VAR of the appropriate cointegrating relationship. Thus, the general short-run model, the error correction model, is given by equation (1.9).

\[
\Delta(M_t|P_t) = \sum_{i=1}^{\rho} \Delta(M_{t-i}P_{t-i}) + \sum_{i=0}^{\rho} \Delta L \text{GDP}_{t-i} + \sum_{i=0}^{\rho} \Delta L \text{TBRI} - \text{DER}_{t-i} \\
+ \sum_{i=0}^{\rho} \Delta L \text{NER}_{t-i} + \sum_{i=0}^{\rho} \Delta L \text{CPI}_{t-i} + \gamma_0 \text{ECT}_t + \text{CONSTANT} + \gamma_4 \text{DUMMY}_{t4} \tag{1.9}
\]

Where a dummy captures a policy change from controlled to fully liberalized interest rates in 1994.

### 4.2 Variables and data characteristics

#### 4.2.1 Variables used in the study

As noted in the theoretical presentation of the model, we hypothesize that the fundamental variables that determine money demand in Uganda are real GDP, interest rates, exchange rate and the domestic price level. For estimation purposes, we use the logarithmic transformation of quarterly data for the period 1990:01 – 2004:04. The study of the behaviour of the variables is worthwhile before estimation.

#### 4.2.2 Money

Estimations are based on two widely used measures of money in Uganda, namely, the monetary base and M2\(^{12}\). The nominal money balances are deflated using the Composite Consumer Price Index (CPI). Figure 1(b) shows the natural logarithm of the various real monetary aggregates during the period 1990:01 to 2004:04. All monetary aggregates display an upward trend during the period. By visual inspection, it is apparent that all monetary aggregates are non-stationary. Consequently, any further analysis should be preceded by test of existence of unit roots.

#### 4.2.3 Real monetary GDP

The study uses Henstridge’s quarterly GDP series for the period 1990 - 1996, and for the subsequent period, Friedman’s (1962) linear interpolation method was used. This involved adjusting a linear interpolation of the annual GDP series with the weighted percentage errors between actual quarterly data on the capacity to import (defined as exports deflated by the import unit price

\(^{12}\)Monetary base include currency in circulation plus commercial bank reserves at the central bank and M2 includes M1 (currency in circulation and demand deposits) plus time and savings deposits.
index) and the linear interpolations of the capacity to import. The resulting series were then seasonally adjusted to minimize the impact of the cyclical components. Figure 1(a), plots the seasonally adjusted quarterly monetary GDP against time. As shown in the figure, the seasonally adjusted quarterly monetary GDP series GDP portray an upward trend, and by visual inspection the series seem to be non-stationary.

4.2.4 Interest rate spread
The spread between the 91-day Treasury bill rate and the average annual interest offered on time and savings deposit is used to determine the relative interest rate elasticity. This spread represents the return on domestic non-monetary financial assets relative to domestic monetary assets. An increase in the interest rate spread will make non-monetary financial assets more attractive, thus leading to a decline in the demand for money. Trends in nominal interest rate spreads are shown in figure 1(c).

4.2.5 Nominal exchange rate
The nominal exchange rate used in the study is defined as units of Uganda shillings per United States Dollar. A priori, it is expected that a depreciation of the domestic currency will induce economic agents to increase their holdings of foreign currency since expected returns from holding foreign currency increase. Figure 1(d), plots the natural logarithm of the real exchange rate against time. By visual inspection, one can conclude that the series is non-stationary.

4.2.6 Inflation
Inflation is computed from the composite consumer price index. Since the real value of money falls with inflation while the value of real assets is maintained, there is a strong incentive for economic agents to switch out of money into real assets when there are strong inflationary expectations. Thus a priori, inflation is expected to have a negative impact on the demand for money. Trends in inflation and the consumer price index are depicted in figure 1(e) and figure 1(f) respectively. By visual inspection inflation is expected to be stationary.

4.2.7 Time series properties
Most macroeconomic variables have been found to have unit roots, which makes the testing procedures for causality complex. The time series properties of the variables are examined using the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. The null hypothesis under both tests is that unit root processes generate the time series. As shown in table 1, there is insufficient evidence to reject the null of a unit root for all

\[ \text{Following arguments by Sachs and Larrain (1993) that nominal interest rates are widely recognized appropriate} \]

\[ \text{determinant of the demand for real balances, nominal interest rates are used to determine the spread.} \]
variables in levels\textsuperscript{14}. However, using both the ADF and the PP test, the null of a unit root in the first difference of all the variables is rejected. The variables thus become stationery after the first difference. Hence all variables are I(1).

V ESTIMATION AND EMPIRICAL RESULTS

5.1 Estimation framework

Having established the time series properties of the variables, the I(1) variables are entered into the cointegrating vector to empirically test the hypothesis postulated in equation (1.8). Inflation is excluded from the cointegration analysis since it was found to be stationary\textsuperscript{15}. A dummy, to capture the full liberalization of interest rates in 1994, is included as an exogenous variable. Johansen (1991; 1995) cointegration test is used to establish the existence of a long-run relationship between the variables. The appropriate lag structure of the VAR is determined using the Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC). After determining the lag structure of the VAR, diagnostic tests of the preferred lag are conducted.

Having established the existence of a long-run relationship, the short-run dynamic relation for real monetary aggregates is specified, if the null of weak exogeneity of the real monetary aggregate is rejected. The dummies included in the VAR are also included in the error correction model. A reduction based on Hendry (1987) general to specific simplification methodology is used to step-by-step eliminates the statistically as well as economically most insignificant regressors. The last remaining equation with all variables being significant is thus reported.

Finally, parameter stability tests are conducted to ascertain the stability of the money demand. In particular, Chow breakpoint and forecast tests, and parameter constancy tests via the recursive estimation of the coefficients and residuals of the model are conducted.

5.2 Empirical Results

5.2.1 The real Base Money model

The cointegration results for the base money model are presented in table 1.2 in the appendix. The maximal eigenvalue rejects the null of no cointegrating vector in favour of one cointegrating relationship. However, the trace test statistic points to the existence of two cointegrating vectors at the 10 percent

\textsuperscript{14} We reject the null of a unit root against a one-sided alternative if the test statistic is less than the critical value.

\textsuperscript{15} Inflation is however included in the ECM in order to capture the impact of inflation dynamics on the money demand function.
level of significance. As the maximal eigenvalue and trace test statistic do not unambiguously confirm the existence of more than one cointegrating vector, the cointegrating vector consistent with economic theory is adopted as a long-run money demand relationship for base money. Figure 1.5 confirms that this cointegrating vector is stationary. The long-run money demand function for base money can thus be written as:

\[ LRBMOM = 1.516LQGDP - 0.018L(TBRI - DEP) - 1.228LNER \]  

(1.10)

5.2.2 Interpretation of the coefficients

All coefficients in equation (1.10) have expected signs. The income elasticity of the demand for money of 1.5 is positive and is significant in explaining the demand for real base money\(^{16}\). This is consistent with economic theory, which postulates that an increase in real income increases the level of transactions, and consequently the demand for real money balances to finance the high level of transactions in an economy.

The elasticity of the relative interest rate is negative and statistically significant in explaining the demand for base money. An increase in the differential between the two rates reduces the demand for base money as agents restructure their wealth portfolio in favour of the high yielding assets\(^{17}\). However, the interest rate has a low impact on the demand for base money as suggested by the low relative interest rate elasticity.

The exchange rate elasticity of −1.2 indicates that the exchange rate depreciation has negative impact on the demand for money. An increase in expected nominal depreciation will lead economic agents to substitute domestic currency for foreign currency. Thus as the domestic currency unit depreciates, agents shift away from domestic currency to foreign currency denominated or physical assets.

Table 1.2 also contains the adjustment matrix, which contains the weight with which the cointegrating vectors enter the equation in the system. Each nonzero column measures the speed of short-run response to disequilibrium in the endogenous variables of the VAR. Specifically, the first column measures the speed at which LRBMOM, the dependent variable in the first equation of the VAR moves towards restoring long-run equilibrium. From table 2, the coefficient −0.4 is the estimated feedback coefficient for the money demand equation. It shows that 39.9 percent of the adjustment is achieved in the first quarter. The negative coefficient signifies that lagged excess money induces smaller holdings of current money. The weak

\(^{16}\) When the unit income homogeneity restriction was imposed, the \(x^2\)-statistic was found to be 0.000941 with a p-value of 0.975523, which suggests that the unit income elasticity cannot be rejected for the long-run relationship.

\(^{17}\) An increase in the Treasury bill rate increases the relative interest rate where as an increase in the deposit rate reduces the relative rate assuming that one rate does not change.
exogeneity tests reveal that real base money and the nominal exchange rate are not weakly exogenous, but weak exogeneity cannot be rejected for real GDP and \((\text{TRR91} – \text{DEP})\). However, a high adjustment coefficient for real base money compared to the nominal exchange rate suggests that real base money is more likely to be endogenously determined than the nominal exchange rate.

5.2.3 Error correction model
Based on cointegration analysis and weak exogeneity tests, the short-run relationship for real base money is modeled in a single equation context using the error correction model. Consequently, the short-run dynamic relationship for real base money is as shown in equation (1.10), where the figures in parenthesis are t-values.

\[
\begin{align*}
\Delta \text{LRBMO} &= 0.269 - 0.14 \Delta \text{LRBMO} + 0.734 \Delta \text{LQGDP} + 0.52 \Delta \text{LQGDP} \\
+ 0.558 \Delta \text{LQGDP} + 0.44 \Delta \text{LQGDP} - 0.026 \text{TRR91} - 0.032 \Delta \text{LNER} \\
+ 0.36 \Delta \text{LNER} - 0.25 \Delta \text{LCP4} + 0.01 \Delta \text{LCP4} + 0.005 \text{DUMMY} \\
- 0.39 \text{ECM}_{t-1}
\end{align*}
\] (1.10)

The results suggest that GDP can affect base money with a lag of up to three quarters. Other variables also affect base money but with varying lags as shown in equation (1.10). The negative coefficient of the ECM is significant, thus validating that the cointegrating relationship between the variables is valid. It essentially implies that when an exogenous shock disturbs the equilibrium condition, 39 percent of its effect is adjusted in one period.

Tests on parameter stability indicate that the short-run model does not reveal any sign of instability. The results of the Chow forecast test reported in table 1.3 fail to reject the null hypothesis of no structural change in the money demand function. Parameter constancy tests are also implemented via the recursive estimation of the coefficients and the residuals of the model, the results of which are presented in figure 1.3 and figure 1.4, respectively. As shown in figure 1.3, the model exhibits stable coefficients with the \(\pm 2\) standard error interval narrowing quickly. The recursive residual tests also confirm parameter stability as the recursive residuals are within the band (see figure 1.4). Thus, the model exhibits parameter constancy, indicating that there is no evidence of a major instability over the sample period.

---

18 The results of the diagnostic tests reported in table 3 show that the model is econometrically well specified. From residual tests, we are unable to reject the nulls that there is no serial correlation in the residuals, and no autoregressive conditional heteroscedasticity (ARCH) in the residuals. Whites Heteroscedasticity test also fails to reject the null of homoscedasticity. The Jarque-Bera statistic also shows that the residuals are normally distributed.
5.2.4 The real M2 model

Long-run demand for M2
As shown in table 4, both the maximal eigenvalue and the trace test statistic reject the null of no cointegrating vector in favour of one cointegrating relationship. The long-run money demand function can thus be specified as shown in equation (1.12) below.

\[
\text{Ln}(RM_{t}) = 1.0196 \text{Ln}(MGDP)_{t} - 0.1988 \text{Ln}(TBR91 - DEP)_{t} - 0.8754 \text{Ln}(NER)_{t}
\]

(1.12)

All coefficients are significant and have expected signs as postulated by economic theory. The income elasticity of demand for money is 1.0, which is close to 1 as suggested by the quantity theory of demand for money. The relative interest rate elasticity (−0.2) is lower than the exchange rate elasticity (−0.9). Thus, in the long-run, when compared to the interest rate, the exchange rate has a higher impact on the demand for real M2.

In terms of the adjustment matrix, estimated feedback coefficient of −0.2 shows that 21.5 percent of the adjustment is achieved in the first quarter. The weak exogeneity tests reveal that while weak exogeneity can be rejected for real M2, it cannot be rejected for real GDP, (TBR91 - DEP) and the nominal exchange rate. Thus a short-run relationship for real M2 can be modeled using and ECM

Error correction model
As shown in table 1.4, weak exogeneity is rejected for real M2. Thus, the short-run dynamic relationship for real M2 is modeled as shown in equation (1.13), where the figures in parenthesis are \(t\)-values. \(^{19}\)

\[
DLRM2 = 0.040 + 0.189DLRM2_{t-1} + 0.249DLRM2_{t-4} + 0.261DLOGDP_{t} + 0.144DLOGDP_{t-3} + 0.014D(TBR91 - DEP)_{t} - 0.023D(TBR91 - DEP)_{t-3} - 0.056DLNER_{t-2} - 0.035DLCPI_{t-4} + 0.016DLCPI_{t-4} - 0.027DUMMY - 0.132ECM_{t-1}
\]

(1.13)

The results suggest that GDP affects real M2 with a lag of up to only one quarter. Other variables also affect base money but with varying lags as shown in equation (1.13). The ECM coefficient is negative and significant, thus vindicating the existence of a cointegrating relationship. It essentially implies that when an exogenous shock disturbs the equilibrium condition, 13 percent of its effect is adjusted in one period.

Just like the base money model, short-run M2 model does not reveal any signs of instability. The Chow forecast test reported in table 1.5 fails to reject the null hypothesis of no structural change in the money demand function. Recursive parameter coefficients and residuals estimates presented in figure

---

\(^{19}\) The diagnostic tests reported in table 5 show that the model is econometrically well specified.
1.5 and figure 1.6 indicate that there is no evidence of a major instability over the sample period.

VII CONCLUSION AND POLICY RECOMMENDATIONS

The cointegration analysis indicates that there is a long run relationship for both base money and M2. In both cases, the income elasticity is found to be close to unity, a result that is consistent with the quantity theory of money. The relative interest rate and exchange rate elasticities are found to be negative, which is also consistent with economic theory. However in both cases, the exchange rate elasticity is higher than the interest rate elasticity, suggesting that the exchange rate channel is stronger than the interest rate channel in the monetary policy transmission mechanism. The short-run elasticities are also to a large extent consistent with economic theory. Further, there is no sufficient evidence in support of the instability of the money demand functions, which implies that monetary growth is a good predictor of future inflation and real output in Uganda.
## APPENDIX

### Table 1.1: Time series properties of the data

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF</th>
<th>PP</th>
<th>ADF</th>
<th>PP</th>
<th>ADF</th>
<th>PP</th>
<th>ADF</th>
<th>PP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LRBMON</td>
<td>-0.647</td>
<td>-0.767</td>
<td>-3.408</td>
<td>-3.199</td>
<td>AΔLRBMON</td>
<td>-6.262</td>
<td>-7.567</td>
<td>-6.204</td>
</tr>
<tr>
<td>LRM2</td>
<td>-1.054</td>
<td>-1.479</td>
<td>-3.324</td>
<td>-2.627</td>
<td>AΔLRM2</td>
<td>-7.023</td>
<td>-5.763</td>
<td>-7.056</td>
</tr>
<tr>
<td>LQGDP</td>
<td>-1.229</td>
<td>-1.269</td>
<td>-1.764</td>
<td>-1.532</td>
<td>AΔLQGDP</td>
<td>-6.693</td>
<td>-7.313</td>
<td>-6.936</td>
</tr>
</tbody>
</table>

The superscripts ** and * denote rejection of the hypothesis of a unit root at 1 percent and 5 percent significance levels respectively.

Source: Authors

### Table 1.2: Cointegration analysis of the real base money model

#### Eigenvalue Analysis (trended case) - Johansen maximum likelihood procedure

<table>
<thead>
<tr>
<th>Eigenvector</th>
<th>0.5579</th>
<th>0.3923</th>
<th>0.2061</th>
<th>0.1519</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null hypothesis</td>
<td>r=0</td>
<td>r=1</td>
<td>r=2</td>
<td>r=3</td>
</tr>
<tr>
<td>( \lambda_{max} )</td>
<td>35.707</td>
<td>22.895</td>
<td>12.923</td>
<td>9.233</td>
</tr>
<tr>
<td>( \lambda_{trace} )</td>
<td>75.757</td>
<td>41.049</td>
<td>22.154</td>
<td>9.233</td>
</tr>
<tr>
<td>95% critical value</td>
<td>31.79 (63.00)</td>
<td>25.42 (42.34)</td>
<td>19.22 (25.77)</td>
<td>12.39 (12.39)</td>
</tr>
<tr>
<td>90% critical value</td>
<td>29.13 (59.16)</td>
<td>23.10 (39.34)</td>
<td>17.18 (23.08)</td>
<td>10.55 (10.55)</td>
</tr>
</tbody>
</table>

#### Standardized eigenvector \( \beta' \)

<table>
<thead>
<tr>
<th>Variable</th>
<th>LRBMON</th>
<th>LQGDP</th>
<th>L(TBR91-DEP)</th>
<th>LNER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vector 1</td>
<td>-1.000</td>
<td>1.5164</td>
<td>-0.0182</td>
<td>-1.2283</td>
</tr>
<tr>
<td>Vector 2</td>
<td>-1.000</td>
<td>0.9841</td>
<td>0.1453</td>
<td>0.0744</td>
</tr>
</tbody>
</table>

#### Adjustment coefficient \( \alpha \)

<table>
<thead>
<tr>
<th>Variable</th>
<th>LRBMON</th>
<th>LQGDP</th>
<th>L(TBR91-DEP)</th>
<th>LNER</th>
</tr>
</thead>
<tbody>
<tr>
<td>AΔLRBMON</td>
<td>-0.39901</td>
<td>0.3628</td>
<td>0.01172</td>
<td>0.05506</td>
</tr>
<tr>
<td>AΔLQMGDP</td>
<td>-0.03003</td>
<td>0.03043</td>
<td>0.00427</td>
<td>0.00149</td>
</tr>
<tr>
<td>AΔRELINT</td>
<td>1.49970</td>
<td>-1.26201</td>
<td>-0.31458</td>
<td>0.28512</td>
</tr>
<tr>
<td>AΔLNER</td>
<td>0.013937</td>
<td>0.17785</td>
<td>-0.022471</td>
<td>-0.16390</td>
</tr>
</tbody>
</table>

#### Weak exogeneity tests

<table>
<thead>
<tr>
<th>Variable</th>
<th>LRBMON</th>
<th>LQGDP</th>
<th>L(TBR91-DEP)</th>
<th>LNER</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \chi^2(1) )</td>
<td>10.808</td>
<td>8.02</td>
<td>2.328</td>
<td>7.509</td>
</tr>
<tr>
<td>P-value</td>
<td>0.013</td>
<td>0.155</td>
<td>0.507</td>
<td>0.057</td>
</tr>
</tbody>
</table>

#### Testing significance of a given variable

<table>
<thead>
<tr>
<th>Variable</th>
<th>LQGDP</th>
<th>L(TBR91-DEP)</th>
<th>LNER</th>
<th>CONSTANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \chi^2(1) )</td>
<td>19.716</td>
<td>4.675</td>
<td>8.924</td>
<td>11.932</td>
</tr>
<tr>
<td>P-value</td>
<td>0.001</td>
<td>0.052</td>
<td>0.025</td>
<td>0.012</td>
</tr>
</tbody>
</table>

Source: Authors
1. Cointegration with real M2, real GDP, relative interest rate and the nominal exchange rate as endogenous variables.
2. R is the number of cointegration vectors.
3. The statistics $\lambda_{\text{max}}$ and $\lambda_{\text{trace}}$ are respectively the Johansen maximal and trace eigenvalue statistics for testing cointegration. The null hypothesis is in terms of r (the number of cointegrating vectors), and rejection of $r=0$ is evidence in favour of at least one cointegrating vector.
4. The critical value in parenthesis is for the trace statistic. The critical values for both the maximal and trace statistics are taken from Osterwald-Lenum (1992).
5. The Wu Hausman tests of weak exogeneity.
Table 1.3: Estimates and diagnostic tests for the Real base money ECM

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>3.269131</td>
<td>0.537358</td>
<td>6.083717</td>
<td>0.051858</td>
</tr>
<tr>
<td>ΔDLRBMON_{t-1}</td>
<td>-0.140521</td>
<td>0.056565</td>
<td>-2.480136</td>
<td>0.008563</td>
</tr>
<tr>
<td>ΔLQGDP</td>
<td>0.733821</td>
<td>0.233264</td>
<td>3.145882</td>
<td>0.001501</td>
</tr>
<tr>
<td>ΔLQGDP_{t-1}</td>
<td>0.522457</td>
<td>0.179396</td>
<td>2.912311</td>
<td>0.051858</td>
</tr>
<tr>
<td>ΔLQGDP_{t-2}</td>
<td>0.558104</td>
<td>0.258572</td>
<td>2.158410</td>
<td>0.018261</td>
</tr>
<tr>
<td>ΔLQGDP_{t-3}</td>
<td>0.445048</td>
<td>0.152507</td>
<td>2.918214</td>
<td>0.002792</td>
</tr>
<tr>
<td>Δ(TBR91-DEP)_{t-3}</td>
<td>-0.026248</td>
<td>0.012468</td>
<td>-2.105203</td>
<td>0.020577</td>
</tr>
<tr>
<td>ΔLNER</td>
<td>-0.323620</td>
<td>0.123471</td>
<td>-2.621042</td>
<td>0.006035</td>
</tr>
<tr>
<td>ΔLNER_{t-1}</td>
<td>0.367352</td>
<td>0.149812</td>
<td>2.452121</td>
<td>0.009169</td>
</tr>
<tr>
<td>ΔLCPI</td>
<td>-0.150401</td>
<td>0.084557</td>
<td>-2.961340</td>
<td>0.002485</td>
</tr>
<tr>
<td>ΔLCPI_{t-1}</td>
<td>-0.010916</td>
<td>0.004073</td>
<td>-2.676212</td>
<td>0.005247</td>
</tr>
<tr>
<td>DUMMY</td>
<td>-0.054906</td>
<td>0.020516</td>
<td>-2.451234</td>
<td>0.009188</td>
</tr>
<tr>
<td>ECM_{t-1}</td>
<td>-0.396647</td>
<td>0.095947</td>
<td>-4.134024</td>
<td>0.000618</td>
</tr>
</tbody>
</table>

R-squared: 0.717813   Durbin-Watson stat: 1.916672
Adjusted R-squared: 0.681572   F-statistic: 5.686030
S.E. of regression: 0.047325   Prob(F-statistic): 0.000004

Diagnostic tests

Tests on residuals

**Breusch-Godfrey Serial Correlation LM test**

<table>
<thead>
<tr>
<th>Lag length=1</th>
<th>F-statistic</th>
<th>Probability</th>
<th>0.706480</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obs*R-squared</td>
<td>0.217141</td>
<td>Probability</td>
<td>0.641227</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lag length=3</th>
<th>F-statistic</th>
<th>Probability</th>
<th>0.634621</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obs*R-squared</td>
<td>2.634721</td>
<td>Probability</td>
<td>0.451435</td>
</tr>
</tbody>
</table>

**ARCH test**

<table>
<thead>
<tr>
<th>Lag length=1</th>
<th>F-statistic</th>
<th>Probability</th>
<th>0.868035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obs*R-squared</td>
<td>0.028913</td>
<td>Probability</td>
<td>0.864980</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lag length=3</th>
<th>F-statistic</th>
<th>Probability</th>
<th>0.496612</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obs*R-squared</td>
<td>6.363308</td>
<td>Probability</td>
<td>0.395212</td>
</tr>
</tbody>
</table>

**Whites Heteroskedasticity test**

<table>
<thead>
<tr>
<th>F-statistic</th>
<th>1.182709</th>
<th>Probability</th>
<th>0.336810</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obs*R-squared</td>
<td>32.85234</td>
<td>Probability</td>
<td>0.328986</td>
</tr>
</tbody>
</table>

**Normality test**

| Jarque-Bera Statistic | 2.417371 | Probability | 0.298590 |

**Stability tests**

Chow forecast test: forecast from 1997:4 to 2004:4
F-statistic: 0.868913   Probability: 0.643506

Source: Authors
### Table 1.4: Cointegration analysis of the real M2 model

<table>
<thead>
<tr>
<th>Cointegration Analysis (trended case)(^1) - Johansen maximum likelihood procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eigenvalue</strong></td>
</tr>
<tr>
<td><strong>Null hypothesis</strong>(^2)</td>
</tr>
<tr>
<td><strong>(\lambda)(_{\text{max}})</strong></td>
</tr>
<tr>
<td><strong>(\lambda)(_{\text{trace}})</strong></td>
</tr>
<tr>
<td><strong>95% critical value</strong>(^4)</td>
</tr>
<tr>
<td><strong>90% critical value</strong>(^4)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Standardized eigenvector (\beta)'</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variable</strong></td>
</tr>
<tr>
<td><strong>Vector 1</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Adjustment coefficient (\alpha)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LRBMON</strong></td>
</tr>
<tr>
<td><strong>P-value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Weak exogeneity tests</strong>(^5)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LRBMON</strong></td>
</tr>
<tr>
<td><strong>P-value</strong></td>
</tr>
</tbody>
</table>

**Source:** Authors

1. Cointegration with real M2, real GDP, relative interest rate and the nominal exchange rate as endogenous variables and inflation as an exogenous variable.
2. R is the number of cointegration vectors.
3. The statistics \(\lambda\)\(_{\text{max}}\) and \(\lambda\)\(_{\text{trace}}\) are respectively the Johansen maximal and trace eigenvalue statistics for testing cointegration. The null hypothesis is in terms of r (the number of cointegrating vectors), and rejection of r=0 is evidence in favour of at least one cointegrating vector.
4. The critical value in parenthesis is for the trace statistic. The critical values for both the maximal and trace statistics are taken from Osterwald-Lenum (1992).
5. The Wu Hausman tests of weak exogeneity.
### Table 1.5: Estimates and diagnostic tests for the Real M2 ECM

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.040007</td>
<td>0.01398</td>
<td>2.861762</td>
<td>0.003241</td>
</tr>
<tr>
<td>ΔLRM2,t-1</td>
<td>0.189834</td>
<td>0.068855</td>
<td>2.75001</td>
<td>0.003995</td>
</tr>
<tr>
<td>ΔLRM2,t-4</td>
<td>0.249301</td>
<td>0.101267</td>
<td>2.461815</td>
<td>0.008955</td>
</tr>
<tr>
<td>ΔLQGDP</td>
<td>0.261116</td>
<td>0.088067</td>
<td>2.964955</td>
<td>0.002461</td>
</tr>
<tr>
<td>Δ(TBR91-DEP) t-1</td>
<td>0.143535</td>
<td>0.061453</td>
<td>2.335672</td>
<td>0.012121</td>
</tr>
<tr>
<td>Δ(TBR91-DEP) t-3</td>
<td>-0.020543</td>
<td>0.009776</td>
<td>-2.101424</td>
<td>0.020751</td>
</tr>
<tr>
<td>ΔLNER,t-2</td>
<td>-0.056052</td>
<td>0.022245</td>
<td>-2.496738</td>
<td>0.008222</td>
</tr>
<tr>
<td>ΔLCPI</td>
<td>-0.034924</td>
<td>0.006031</td>
<td>-5.791095</td>
<td>0.000000</td>
</tr>
<tr>
<td>ΔLCPI,t-4</td>
<td>0.015892</td>
<td>0.007763</td>
<td>2.047278</td>
<td>0.023386</td>
</tr>
<tr>
<td>DUMMY</td>
<td>-0.02723</td>
<td>0.010762</td>
<td>-2.530293</td>
<td>0.007572</td>
</tr>
<tr>
<td>ECM,t-1</td>
<td>-0.13204</td>
<td>0.030711</td>
<td>-3.348722</td>
<td>0.000849</td>
</tr>
</tbody>
</table>

R-squared 0.723866  Durbin-Watson stat 1.793706
Adjusted R-squared 0.653227  F-statistic 10.24739
S.E. of regression 0.030711  Prob(F-statistic) 0.000000

#### Diagnostic tests

**Tests on residuals**

**Breusch-Godfrey Serial Correlation LM test**

<table>
<thead>
<tr>
<th>Lag length=1</th>
<th>F-statistic</th>
<th>Probability</th>
<th>0.415863</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lag length=4</td>
<td>F-statistic</td>
<td>Probability</td>
<td>0.258002</td>
</tr>
<tr>
<td>Obs*R-squared</td>
<td>1.396161</td>
<td>Probability</td>
<td>0.156830</td>
</tr>
</tbody>
</table>

**ARCH test**

<table>
<thead>
<tr>
<th>Lag length=1</th>
<th>F-statistic</th>
<th>Probability</th>
<th>0.451334</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lag length=3</td>
<td>F-statistic</td>
<td>Probability</td>
<td>0.447450</td>
</tr>
<tr>
<td>Obs*R-squared</td>
<td>0.943498</td>
<td>Probability</td>
<td>0.424311</td>
</tr>
</tbody>
</table>

**Whites Heteroskedasticity test**

<table>
<thead>
<tr>
<th>F-statistic</th>
<th>Probability</th>
<th>0.171174</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obs*R-squared</td>
<td>3.268055</td>
<td>Probability</td>
</tr>
</tbody>
</table>

**Normality test**

<table>
<thead>
<tr>
<th>Jarque-Bera Statistic</th>
<th>Probability</th>
<th>0.909773</th>
</tr>
</thead>
</table>

**Stability tests**

Chow forecast test: forecast from 1997:4 to 2004:4

<table>
<thead>
<tr>
<th>F-statistic</th>
<th>Probability</th>
<th>0.979962</th>
</tr>
</thead>
</table>

**Source:** Authors
Figure 1.1: Trends in variables used in the study

Source: Authors
Figure 1.2: Error correction term (Base money model)

Source: Authors
Figure 1.3: ECM for real Base Money: Recursive coefficient estimates for testing parameter constancy (Dotted lines represent ± 2 standard errors)

Source: Authors
Figure 1.4: ECM for real M2: Recursive coefficient estimates for testing parameter constancy
(Dotted lines represent ± 2 standard errors)

Source: Authors
Figure 1.5: ECM for real Base Money: Recursive residuals for testing parameter constancy (1995:01 – 2004:04)

Source: Authors
Reference


