Tanzanian Economic Review, Vol. 12 No. 1, June, 2022: 1–17

Monetary Aggregation and Speculative Real Money-Demand Equation: Theories, Evidence and Policy

Peter Ng'ang'a*

Abstract

This paper uses Kenyan monetary data from 2000 to 2020 to examine whether new financial products have systematically changed the traditional relationship between monetary aggregates, interest rates and income by empirically analysing the log-linear money demand functions of the "partial adjustment" variety. In Kenya, financial market developments, financial deregulation and growth of cash-management methods offer a broad assortment of financial assets. Several assets possess investment and transaction abilities, which blurs the difference between holding money for transactions and assets and accounts for the erratic behaviour of broad money ($M2$). Varying growth rates of monetary aggregates provide evidence that monetary policy has been destabilizing, with the effects of the growth of money substitutes on real income and interest rate elasticities of demand for money in Kenya remaining unclear. The study finds that innovations in the payments process and changes in the regulatory environment have affected the demand for money in Kenya.

Keywords: money demand; interest-elasticity; income-elasticity; monetary policy, elasticities of substitution; financial assets; cash management; financial innovation;

JEL Classification*: E41 and E52*

1. Introduction

Many studies examine the function of demand for money because of its role in the Central Banks' formulation and implementation of monetary policy. Demand for money function has the potential to influence monetary policy, with a consequence to both economic activity and inflation. However, the performance of the empirical money demand function raises concerns about its predictableness. Many of the specifications that explain past occurrences of apparent money demand instability have achieved only limited success in predicting future money demand. Empirical research on money demand preceding the mid-1970s, and concluding in the work of Goldfeld's (1973) exhaustive study, proposed that demand for money displayed a stable relationship with a small conventional of macroeconomic variables.

Gordon (1984a), however, noted that Goldfeld's empirical associations were estimated using U.S.A data, which were generated from the comparatively calm economic period beginning in the early 1950s and ending in the early 1970s. This period is in severe contrast to the succeeding period, characterized by supply-side

* School of Economics, Department of Applied Economics, Kenyatta University, Kenya: nganga.peter@ku.ac.ke

©School of Economics, University of Dar es Salaam, 2022

shocks, extraordinary and volatile inflation, and large and erratic swings in economic activities. The United States Fed also began to formalize the use of $M1$ money stock as an intermediate target of monetary policy in the early 1970s. Moreover, the Fed espoused diverse monetary control measures in the October 1979 - October 1982 period. Consequently, the empirical money demand function in the pre-1974 period might fail to describe the latter period with the same precision.

Considerable disagreement, however, has taken place among economists during the past few years on the question of the appropriate specification of the demand function for money balances. This disagreement has centred around three main empirical hitches. Firstly, whether the definition of money should include time and/or savings deposits. Secondly, whether the appropriate constraint on money balances should be current income or wealth (or permanent income as measured by Friedman, as a proxy for wealth). Thirdly, the role of interest rate, whether changes in money balances are at all dependent on changes in interest rate; and if so, is it the short-run rate or the long-run rate to which money balances respond most?

Figure I shows that the behaviour of the monetary aggregates $M2$ defined by the central banks of Kenya has been appropriately erratic to provoke substantial concern about their usefulness in a well-designed monetary policy. Since the "missing money" episodes of the 1970s in the U.S.A, the traditional measures of M1 and M2 have delivered unpredictable and sometimes startling results (Hefer and Hein 1984). Moreover, velocity measures based on the same concepts have often gone off track, by almost any standard. Reservations regarding the stability of the demands for these entities also surface frequently and cannot be easily dismissed, given the current global financial engineering. The most impressive criticism focuses on the components of these aggregates themselves.

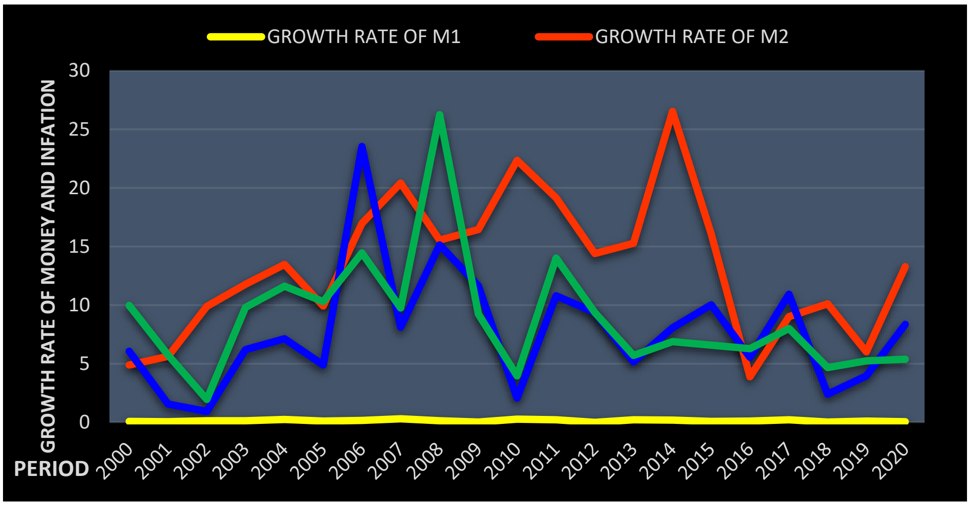

Figure 1: Growth Rate of Money and Inflation 2000-2020

The fundamental issue with aggregates is that the central bank's simple-sum technique of aggregation will not produce theoretically satisfactory definitions of money if the relative prices of monetary components fluctuate over time. The problem is an incorrect accounting for the substitution effects, resulting in a set of monetary aggregates that do not accurately measure the actual quantities of monetary services that optimizing economic agents select in the aggregate.

Figure 1 shows the behaviour of M1 and M2monetary aggregates. The unpredictability of M2 is echoed in its time series since early 2000, which is the consequence of financial innovation and deregulation. M1 seems to have ceased in practice. Also, it is indicative that the inflation rate in Kenya moves with the M2 monetary aggregate and not with the M1.

Figure 1 shows that between 2005-2014, there was a huge growth in $M2$ monetary aggregate. Why? (a) The supply of money rising in line with a rise in the money demand. This could happen due to portfolio shifts associated with financial innovation with the stance of monetary policy unchanged. (b) To a change caused by wobbly monetary policy that would unearth itself in higher inflation in the future. In case it was because of higher money demand, then this is an upward leftward shift in the LM curve. Central banks would accommodate this by letting the supply of money increase according to the increased demand for money, assuming that the output would remain unchanged. Otherwise, in case the money demand function was stable, witnessing increases in money balances would hypothesize the cause to be a rise in the money supply. This would lead to a change in the price level in the end.

The purpose of this paper is to contribute toward a better understanding of the role of the rate of interest as an argument in the demand function for money. Major studies on the topic, thus far, have used the current rate of interest as determining the demand for money balances. The use of the current rate of interest suggests that the money balances adjust instantaneously with the rapidity of interest changes. Nevertheless, this does not seem to be the case in practice. Ordinarily and in practice, change in money balances, consequent upon a change in the rate of interest, does not take place at once but in stages. It would seem, therefore, that the long-term rate of interest, which incorporates fully time adjustment, may be more appropriate as an argument in the demand function for money than the current rate of interest.

This paper also empirically examines how some key macroeconomic variables affect the demand for money. Even though I principally consider the aggregate or total demand for money, the same economic arguments relate to individual money demands. The aggregate demand for money is the sum of all individual money demands. The macroeconomic variables that have the greatest effects on money demand are real income, interest rates and the price level. Higher prices or incomes increase the need for liquidity and thus raise the demand for money. Interest rates affect money demand through the expected return channel: The higher the interest rate on money, the more money people will demand; however, the higher the interest rate paid on alternative assets to money, the more people will want to switch from money to those alternative assets.

1.1 Real Income

Empirical studies performed on the money demand function report the results in elasticities. The income elasticity of money demand is the percentage change in money demand resulting from a 1% increase in real income. If the income elasticity of money demand is 0.6667 as observed in this paper, a 2% increase in real income will increase money demand by 1.33% ($0.6667 \times 2\% = 1.33\%$). Econometric studies of money demand offer a range of elasticities; nonetheless, common results emerge. Economists postulate that the income elasticity of money demand is positive. Goldfeld (1973) found this elasticity to be about 2/3, using $M1$ data fromU.S.A. Positive income elasticity of money demand implies that money demand rises when income rises. Goldfeld's conclusion that the income elasticity of money demand is below 1.0 is comparable to that of many other econometric analyses. Some studies have found this value to be greater than 1.0. If a study concludes that the income elasticity of money demand is smaller than 1.0, it would mean that money rises less than proportionally with income. When economies or their citizens get richer, the demand for money grows more slowly than income. This is because the more transactions consumers and firms conduct, the higher the liquidity they need and the greater the demand for money gets. An important factor determining the number of transactions is real income. Because higher real income means higher transactions and a greater need for liquidity, the amount of money demanded should increase when real income increases.

Contrasting the influence of money demand to a change in the level of prices, a rise in money demand does not have to be proportional to an increase in real income. Characteristically, a 1% rise in real income should lead to a lower than 1% rise in money demand. Money demand should typically grow slower than real income because richer individuals and firms more often than not use their money efficiently largely. Individuals earning high income might open cash management accounts purposely for investing money that is not required for transactions. This could be a nonmonetary asset giving a higher return. Because of minimum-balance requirements and fees, such an account might not be sensible to a poor person.

1.2 Real Interest Rates

The model of portfolio allocation suggests that, with risk and liquidity taken as constant, demand for money depends on the expected returns of both money and alternative nonmonetary assets. An increase in the expected return on money increases money demand, and an increase in the expected return on alternative assets causes holders of wealth to switch from money to higher-return alternatives, thus lowering the demand for money. If the interest rate paid on money rises, holders of wealth will choose to hold more money. If the savings account begins paying higher than bonds you may sell your bonds, lowering your holdings of bonds and increasing your savings account. The sacrifice in return associated with the holding of money is less than before, so you increase your savings account balance and enjoy the flexibility and other benefits of extra liquidity. Thus a higher interest rate on money makes the demand for money rise.

In principle, the interest rate on each of the many alternatives to money should affect money demand. However, the many interest rates in the economy generally tend to move up and down together. Different types of savings accounts pay varying rates. The key conclusions are that an increase in the interest rate on nonmonetary assets, i, reduces the amount of money demanded and that an increase in the interest rate on money, i^m, raises the amount of money demanded (Hefer and Hein 1984, Brunner and Meltzer 1964, Poole 1970).

1.3 The Price Level

Economists have concluded that the higher the general level of prices, the more money people need for transactions and consequently the more money people will want to hold. The broad inference is that a higher price level, by raising the need for liquidity, increases the nominal demand for money. Therefore, *ceteris paribus*, nominal demand for money is proportional to the price level.

This paper evaluates a variety of the approaches and specifications proposed in previous money demand studies to explain the behaviour of the broadly defined money stock. In the process, fundamental econometric issues relating to proposed modifications to conventional money demand specifications are investigated. The interest elasticity of M2, an important factor in explanations of the 2000-2020 experience is examined more closely.

The paper is organized into five sections as follows: section 2 deals with the theoretical and empirical literature review; Section 3 describes the econometric modelling and methodology and discusses the empirical approach and the data used; Section 4 presents the empirical results and analyses the findings, and the last section concludes the study and give policy implications.

2. Literature Review

The money demand function is one of the most studied aggregate economic relations. For some developed economies, very long data series are obtainable permitting regression estimation to run from, say, the nineteenth century to the end of the twentieth century. A study for the United Kingdom estimates the demand for $M2$ from 1878 to 1993. The model assumes a long-run specification. Demand for real money balances is a function of real income (a scale variable) and the opportunity cost of holding money (Ericsson *et al* 1998).

In estimating the money demand function, a fundamental problem is to agree on what money is and how to deal with changes in its definition over time due to financial innovations and engineering. Money is a social institution invented by people to overcome the difficulties and costs of barter trade. Consequently, technological changes will occur and that money, hence, monetary aggregate, will become contaminated. This problem is linked to the commonly debated issue of the unpredictability of the money demand function. This intuition proposes that to model the money demand over a long period, it is essential to permit changes in the way that money is defined. In addition, one should allow for technological innovation and for changes in the institutional arrangement (for instance, changes in the government's regulation that impact the way non-bank financial institutions function) (Hefer and Hein 1984, Ericsson *et al* 1998).

A one-time period model might not be likely able to predict perfectly with current data if these exogenous factors are ignored. The study by Ericsson *et al* (1998) demonstrates these issues. Their model performs well for about a century (1878–1975). Then, they tested the same with "new" data for the 1976–1993 period. The money demand function does very poorly with the addition of the new eighteen years. Indeed the short-term interest rate become insignificant. They concluded that the mechanistic method of economic modelling of the money demand function is irrational. According to Heller (1965), changes in the financial and economic setting because of globalization call upon a new model.

Goldfeld (1973) investigated the demand for money using U.S. postwar quarterly data. He reported the two-stage least squares estimates of the long-run income and interest rate elasticities in conventional money-demand equations. His results are similar to single-equation estimates. They are consistently reliable given the corollary that regressing money on income and interest rates, simultaneity-equation biases are not sufficiently severe to distort the point estimates realized by single-equation estimation techniques. Some other researchers claim that money, income, and rates of interest are all simultaneously determined. They prefer instead regressing interest rates on money and income to recover estimates of income and interest rate elasticities. They are certain that interest rates are more endogenous than money and/or income (Poole 1970, Teigen 1964, Clinton 1973).

Leijonhufvud (1968) commented and interpreted more faithfully Keynesian speculative demand for money. The argument is that Keynes careful put three hypotheses vital in his money demand functions: Firstly, in Keynes' theory the demand for money equation is a function of income, market interest rate, and largely, investors' opinions regarding the "normal rate." Secondly, investors' sentiments about what is regarded normal rate of interest are defined to be inelastic. , Thirdly, investors' sentiments about what a normal interest rate is, are defined to be inelastic so that in the conduct of monetary policy the authorities must be at ease with having only short-term rates to control; their influence on long-term rates would be hindered by the sticky interest rate expectations. In the empirical plane, researchers meet numerous difficulties in bringing Keynes' theory into an actual collision with data. The most thoughtful is that in the long run, the influence of monetary policy tends to become merged with investors' expectations. That is to say, in the long run, central banks can and do affect expectations concerning what the rate is (Barnnett *et al* 1992). It is part of Keynes' device that central banks can influence investors to accept a normal rate that is not, altogether natural to equate investment and savings holding price constant.

Keynes hypothesized that investors' expectations influence rates of interest in the long run but the aggressive and consistent change of short-term rate of interest by the central bank can alter expectations.

Tobin (1956) advanced a universal justification for the negative dependence of the money demand and interest rate. This paper refutes Keynes's postulation that each investor is sure about what she expects the future rate of interest on bonds to be. This paper supports Tobin who focused on the insinuations of investor uncertainty. Tobin's model asserts that risk-averse investors allocate their portfolio between a riskless asset that pays no interest (money) and a risky one with a positive expected return (bonds). The utility of investors positively depends on the return they get holding the asset and negatively on the risk of having it. In this case, an investor holds a mixture of two assets for utility maximization. This enables trading the benefits off from higher expected returns vis-à-vis the risk associated with it, given the investors' preferences. The investor substitutes bonds for money (decrease money demand) driven by the higher interest rate because increased expected return on bond offsets the extra suffered risk. This gives rise to the seen inverse association between money demand and the rate of interest. If alternative assets have higher expected return holders of wealth switch from money to the higher nonmonetary assets, thus lowering the demand for money (Brunner and Meltzer 1964, Laidler 1966, Leijonhufvud 1968).

The definition of broad money in Kenya might have been changing rapidly since the late 2000s and this implies a change in the opportunity cost of holding money. As can be seen in Figure 1, $M2$ has been erratic and unsteady. Specifically, a new definition of money which is interest-bearing with the consequence of having a sharp reduction in the opportunity cost of holding money has been innovatively included. Moreover, financial innovation and deregulation were dramatic in the 2000s – with the introduction of interest-bearing saving accounts, credit cards, debits cards, cash machines, and mobile money transfer (MPESA and Airtel Money) systems, among other innovations. These financial innovations altered the roles of money as an asset in portfolios, as the foundation for liquidity, and as a key component of the medium of exchange. This paper sought therefore to find a different measure of interest rate elasticities to see the changes in the opportunity cost of money. Financial engineering resulted in numerous flexible interest-bearing savings accounts. When these were permitted, the opportunity cost of holding broad money went down and demand went up. Discussions in this research concern the interest elasticity of money demand. The focus is on the implications of the greater availability of close money substitutes paying market rates of return as well as the increasingly competitive rates of return that have been and will continue to be paid on transaction balances.

3. Model Specification and Methodology

3.1 Empirical Model

Strong multicollinearity prevents useful estimation through the inclusion of many different, T-bills, T-notes or T-bonds variables in the same equation.

Consequently, this paper defines the following function.

$$M_t = f(Y_t, r_{t_{91-day}}, P_t) \quad (1)$$
$$M_t = g(Y_t, r_{t_{182-day}}, P_t) \quad (2)$$
$$M_t = h(Y_t, r_{t_{364-day}}, P_t) \quad (3)$$
$$M_t = n(Y_t, r_{t_{5-year}}, P_t) \quad (4)$$
$$M_t = p(Y_t, r_{t_{10-year}}, P_t) \quad (5)$$

Where M_t denotes the M2 broad monetary aggregate. Y_t is nominal gross domestic product (GDP, P_t is the price level (implicit GDP deflator).

Many writers have used net national product (NNP) instead of gross national product. However, estimates for depreciation are not very reliable in Kenya. Therefore, GDP is used because even the measures of GNP do not yield good results. For the same reason, Heller (1965) uses GNP figures in his study. Laidler (1966) more vehemently though stresses the use of permanent income.

The interest rates used are designated i_{91}, i_{182}, $i_{364}i_5$, i_{10}, for the 3 months, 6 months, 1 year, 5 years, and 10 years yield respectively. $M_2 = M_1$ + non-personal term and notice deposits (corresponding to the M_2 often used for research in the US).

Specifically, the four interest rate variables are:

i_{91} = short-term average rate on 91–day (three months) government of Kenya Treasury bills; i_{182} =short-term average rate on 182–day (semi-annual) government of Kenya Treasury bills;
i_{364} = short-term average rate on 364–day (one year) government of Kenya Treasury bills;
i_5 = average rate on 5-year Treasury notes on the government of Kenya bonds;
i_{10}= average rate on 10-year long-term Treasury bond government of Kenya bonds.

Friedman (1959) uses money stock as a proxy for the demand for money. This procedure is now widely used by other economists. It assumes that the money market is almost always in equilibrium and that the variables which appear in the demand function for money do not show up in the supply function. A separate study by Brunner and Meltzer supports Friedman's position (Brunner and Meltzer, 1964). The above money demand function transforms into the real money demand function after dividing the above system by P_t and taking the natural log as follows:

$$m_t = \varphi(y_t, r_{t_{91-day}}) \quad (6)$$
$$m_t = \omega(y_t, r_{t_{182-day}}) \quad (7)$$
$$m_t = \vartheta(y_t, r_{t_{364-day}}) \quad (8)$$
$$m_t = \gamma(y_t, r_{t_{5-year}}) \quad (9)$$
$$m_t = \varpi(y_t, r_{t_{10-year}}) \quad (10)$$

The restriction to the homogeneity of degree one in price sidesteps the multicollinearity problems which arise when Y and P are entered separately as explanatory variables, and provides the desirable theoretical property of 'no money illusion'.

Traditional models of money demand consider the following typical specification of a money demand function:

$$m_t^* = \beta_0 + \beta_1 y_t + \beta_2 r_t + \varepsilon_t \qquad (11)$$

where m_t^* is the log of "desired" holdings of the real money stock ($M2$) in period t, y_t is the log of real GNP and r_t's are the logs of appropriate interest rates. The ε_t is a stochastic disturbance term which may be postulated to have a first-order autoregressive structure.

Generally, it is assumed that the log of actual money holding, m_t, adjusts to m_t^* according to the real partial adjustment hypothesis (RPAH).

$$m_t - m_{t-1} = \psi(m_t^* - m_{t-1}) + \mu_t^* 0 < \psi < 1 \qquad (12)$$

Where μ_t^* is a stochastic disturbance

$$lnM_t - lnM_{t-1} = \psi(lnM_t^* - lnM_{t-1}) \qquad (13)$$

Where, M_t is nominal $M2$; $lnM_t^* = m_t^* + p_t$; p_t is the natural logarithm of the price level; and ψ is the partial adjustment parameter.

Combining the nominal adjustment model (Equation 12) with desired money holding (Equation 11), the short-run demand for money gives rise to the following money demand function in the form of those typically estimated:

$$m_t = \beta_0 + \beta_1 y_t + \beta_2 r_t + \beta_3 m_{t-1} + \mu_t \qquad (14)$$

It is usually assumed that $\mu_t = \gamma\mu_t^*$ is generated by a first-order autoregressive, $AR(1)$, process.

$$m_t = \psi(\beta_0 + \beta_1 r_t + \beta_2 y_t + \boldsymbol{X_t}\beta) + (1-\psi)m_{t-1} + (1-\psi)(p_{t-1} - p_t) \qquad (15)$$

The real adjustment model in (Equation 15) differs from (Equation 14) in that the last term-which approximately equals the negative of actual inflation – has a coefficient equal to zero. However, if actual inflation serves as a proxy for expected inflation, a term such as $p_{t-1} - p_t$ may nevertheless appear as a statistically significant determinant in the real adjustment model. The demand function was also derived in real terms, with M_{t-1} deflated by P_{t-1}.

Customarily then, the specification of desired money balances:

$$m_t = \beta_0 + \beta_1 r_t + \beta_2 y_t + \boldsymbol{X}_t\boldsymbol{\beta} \qquad (16)$$

Where, m_t denotes desired real $M2$ broad money balances; r_t is the nominal interest rate on the riskless asset; y_t is real GNP (all in natural logarithms); $\boldsymbol{X_t}$ is a row vector of other possible explanatory variables; $\beta_0, \beta_1,$ andβ_2 are parameters.

The explanatory variables are represented by $\boldsymbol{X_t}$ may include rates of return on long-term assets (Hamburger 1977, 1983), wealth (B. Friedman, 1978), or expected inflation (Laidler 1977, 1980). To further permit the possibility of less-than-immediate adjustment to desired money holdings, the short-run demand for money is described by either the real (Chow 1966, Goldfeld 1973) or nominal (Goldfeld 1976) partial adjustment models.

Equation 16 calls for some comment. Firstly, statistical glitches emanate from the existence of lagged endogenous variables on the right-hand side of the equation because of the adoption of the stock adjustment principle. This is justified on grounds that full adjustment to desired money stock will not happen instantaneously. A considerable body of empirical evidence submits that time lags involved in financial adjustments at the aggregate level are somewhat long. Secondly, this paper does not have the lagged endogenous variable on the right-hand side of the equation. The deflation of M_{t-1} by P_{t-1}mirrors the idea that the adjustment mechanism of real cash balances displays the same degree of inertia concerning price as to a change in any of the arguments.

In the literature, the most appropriate specification of the money demand functions has been a subject of debate. This paper's basic objective is to compare the estimated elasticities. Following Zarembka (1968) and considering the results in Chetty (1969), the log-linear form is deemed appropriate. The estimated form follows Laumas and Mehra (1977) whose study showed that when annual data are used, a money demand function, with lagged money stock as one regressor, is stable. Both common sense and initial examination of the data recommend that allowance be made for the interest paid on the relevant components of $M1$, $M2$ and $M3$ to get a reasonable approximation of the opportunity costs of holding such deposits. Taking into account the financial innovation and deregulation since the early 2000s, this paper modifies existing money demand specifications. In particular, the money demand equation is selectively modified to reflect short-term, midterm and long-term interest rates. These have been included as explanatory variables. The paper also uses $M2$ (broad money) instead of the traditional $M1$ (narrow money) stock as indicated in Figure 1.

Despite the role of the long-term interest rates (i_{5-year} T-notes and $i_{10-year}$T-bonds) in determining the demand for money, the discussion relating to their role in the demand for money has been mainly indirect or theoretical to date. The use of short-term interest rates (i_{91-day},$i_{182-day}$ and $i_{364-day}$) suffices in illustrating the central point of this paper, even though some writers insist that the demand for money is a function of the short-term interest rates, as the short rate indicates the opportunity cost of holding money in place of a close substitute (Bronfenbrenner and Mayer 1960). As in Hafer and Hein (1984), a "log-rolling" procedure is adopted. But, unlike Hafer and Hein (1984) whose "log-rolling is a period one", this paper's "log-rolling" is in the term structure of the interest rates, starting with the i_{91-day} and increasing this period to $i_{182-day}$, $i_{364-day}$, i_{5-year}, and then finally to $i_{10-year}$ period. This allows us to estimate five equations and seven variables. It is during this period that financial innovation and deregulation which impact the interest elasticity of money demand takes place.

More formally, the regression results presented in the Table1 below follow the following five equations:

$$ln(M/P)_t = \beta_0 + \beta_1 ln(Y/P)_t + \beta_2 ln\left(i_{91-day}\right) + \beta_3 ln(M/P)_{t-1} + \varepsilon_i \quad (17)$$

$$ln(M/P)_t = \beta_0 + \beta_1 ln(Y/P)_t + \beta_2 ln\left(i_{182-day}\right) + \beta_3 ln(M/P)_{t-1} + \varepsilon_i \quad (18)$$

$$ln(M/P)_t = \beta_0 + \beta_1 ln(Y/P)_t + \beta_2 ln\left(i_{364-day}\right) + \beta_3 ln(M/P)_{t-1} + \varepsilon_i \quad (19)$$

$$ln(M/P)_t = \beta_0 + \beta_1 ln(Y/P)_t + \beta_2 ln\left(i_{5-years}\right) + \beta_3 ln(M/P)_{t-1} + \varepsilon_i \quad (20)$$

$$ln(M/P)_t = \beta_0 + \beta_1 ln(Y/P)_t + \beta_2 ln\left(i_{10-years}\right) + \beta_3 ln(M/P)_{t-1} + \varepsilon_i \quad (21)$$

3.2 Data

This paper uses yearly data for 2000 to 2020 in estimating the discussed models. With current definitions of the monetary aggregates, the central bank's M2 series is employed. As mentioned previously, real GDP is the proxy for the transactions variable and the GDP deflator represents the price level. To characterize the opportunity cost of holding transaction balances, yearly data for three-month, six-month, and one-year Treasury bill yields and the five-year Treasury notes coupled with ten-year Treasury bonds rates are used.

Data for Gross Domestic Product is taken from the Kenya National Bureau of Statistics (KNBS) (various issues), and the Central Bank of Kenya (CBK). Treasury bill rate data is from the Central Bank of Kenya (CBK) and International Financial Statistics (International Monetary Fund, Washington, D.C.). Data on money supply is from the International Financial Statistics. The period covered in the above study is from 2000 to 2020. The choice of this period was dictated by the limitations of the data. The relevant data for Kenya on yearly basis are available since 2000 only. The results of this study are presented in Table 1 below.

4. Empirical Results

Estimated coefficients of real income, interest rate (3 months T-Bill, six months T-Bill, 1-year T-Bill, 5 years T-Notes and 10 years T-bond), and the lagged money stock in demand-for-money equation with "partial adjustment" hypothesis (annual data for the period 2000-2020).

Table 1: Estimates of Income and Interest Elasticity Coefficients in the Speculative Real Money-Demand Equation

Eqn.	y_t	i_{91}	i_{182}	i_{364}	i_5	i_{10}	m_{t-1}	C	$\bar{R}^2$
(1)	0.1198[b]	-0.063[b]	…	…	…	…	0.9194[b]	0.3278	0.982
	(3.916)	(-1.892)					(29.764)	(0.1748)	
(2)	0.10925[b]	…	-0.0828[c]	…	…	…	0.9288[b]	0.3508	0.983
	(3.049)		(-1.969)				(26.35)	(1.3906)	
(3)	0.6697[b]	…	…	-0.0713[b]	…	…	0.46643[a]	-3.591[b]	0.994
	(4.14)			(-3.47)			(3.59)	(-3.68)	
(4)	1.2593[b]				-0.1876[b]		0.00077[c]	0.9372	0.828
	(5.281)				(-2.34)		(0.0209)	(0.3688)	
(5)	1.041[b]	…	…	…		-0.386[b]	0.0115	3.5316	0.869
	(4.558)					(-3.54)	()0.3568	(1.4213)	

Notes: Superscripts indicate levels of significance as follows: [a]1%, [b]5%, [c]10%. The t-Statistics are reported in parentheses.

Source: Author's estimations

The standard error of the regression estimates are as follows:

Result Eqn. 1 = 0.07225; eqn. 2 = 0.07289;

Result Eqn. 3 = 0.06281; eqn. 4 =0.1536 ; eqn. 5 = 0.134.

Functional form: $m_t = \beta_0 + \beta_1 y_t + \beta_2 i_t + \beta_3 m_{t-1} + \varepsilon_i$.

Adjusted R-squared is the coefficient of determination adjusted for degrees of freedom.

Five log-linear money demand functions of the "partial adjustment" variety are estimated and the results are summarized in Table 1. The results yield not only income and interest elasticities with expected signs, which are statistically significant, but in addition, they are tight-fit to the data. They support the proposition that real income has a stronger effect on demand for money than do T-bills, T-notes or T-bonds. The estimated real income elasticities range from 0.1198 (the lowest) in Result Equation 1 to 1.259 (highest) in Result Equation 4. The estimated interest elasticities range from -0.063 in Result Equation 1 to -0.386 in Result Equation 5. When progressively "log-rolling" higher term to maturity rates are used, the estimated elasticities increase in absolute terms. The estimated interest rate elasticity for the i_{91-day} is, in absolute term 0.063 while that of $i_{10-year}$ is maximized with an absolute value of0.386.

Result Equation 3 is worth noting. When the $i_{364-day}$ is used, its estimated interest elasticity becomes -0.0713 and real income estimated elasticity becomes 0.6697. This is in line with Goldfeld (1973). The standard error of the regression is minimized at 0.0628 and the coefficient of determination adjusted for degrees of freedom is maximized at $\bar{R}$ = 0.994. These results are robust. It is found that the estimated absolute long-term interest elasticity of' money demand for 10-year T-bonds (0.386) is somewhat larger in magnitude than that for 5-year T-notes (0.386), and the elasticity for 91-day T-bills is the smallest (0.063) in absolute terms. Such a structure in the elasticities is consistently observed. The differences between the elasticities are large and perhaps statistically significant. While these results are robust their relative magnitudes display a sturdy structure, which persists under a wide variety of estimating situations.

A consistent pattern is found regarding the relative magnitudes of the point estimates of the elasticities for the seven variables. While the high correlation between these variables prevents a useful estimation by including the variables pairwise in the same regression, estimation of the five separate regressions suggests that the difference between the estimated elasticities with respect to real income and T-bond is big and significant. The estimated coefficient on the lagged real money balances is also significant, except in Result Equation 5.

The short-term interest rate portrays a lower standard error of the regression estimate than do the longer terms. It is seen that the short-term interest rate (i_{91-day}) consistently provides lower estimated interest elasticities than the long-term rates. In addition, for the broader money concepts, equations with long-term term to maturity interest rates have yielded higher estimates for income elasticities that are statistically and significantly different from zero and that are greater than unity. The long-term interest elasticities display a familiar pattern - the longer the rate, the higher the elasticity. Long-term rates move in phase with short rates but with less variance. They will therefore appear to exert a lot of leverage on money demand even when this demand is responding to the short rate.

The estimated real income elasticities are below unity given the short-term interest elasticities. It appears that the best substitutes for money are at the short end of the money market. This substantiates the proposition due to Baumol and Tobin that there are economies of scale in the management of cash balances. The policy-maker should be made aware of such parametric changes in the relevant functions if any changes are found. Besides, policy decisions are often predicated on a view of the nature of certain crucial relationships. The most important feature of the results for this study is their consistency, in broad outline, with the kind of result one sees in the empirical literature. Elasticity estimates are within the range one expects; the level of explanatory power is very high for all specifications.

A specification for the broader monetary aggregates may be stable over time. The hypothesis that the demand for aggregates monetary balances is empirically not stable shows to be rejected. This paper finds a stable aggregate demand for money function when $M2$ monetary aggregate is used. Variations in the growth rate of some monetary aggregates are regularly alluded to as ***prima facie*** evidence that monetary policy has been destabilizing. This assertion is vitiated if the parameters of the demand function for money have shifted. The findings show that this is not the case in Kenya. Besides, the macroeconomic performance of the country has not experienced irrational swigs as found in developed countries. Higher values of Transaction as indicated by Result Equation 4 decrease interest elasticity and increase income elasticities, given the T-notes and T-bonds. This is demonstrated by comparing Result

Equations 4 and 5. In general, the interest elasticities are substantially below 0.5 as can be seen in all the estimates. Money demand in this case grows faster than income because low-income individuals and firms typically use their money less efficiently. However, income elasticity is 0.6697 in Result Equation 3.

4.1 Interest Elasticity and Money Demand in Kenya

The interest elasticity of money demand is the percentage change in money demand resulting from a 1% increase in the interest rate. Suppose the Central Bank of Kenya increases the interest rate from 5% per year to 6% per year, which is a 20% increase in the interest rate. The estimated interest elasticity of money demand in Kenya is $i_{364} = -0.0713$. In Kenya therefore, an increase in the interest rate from 5% to 6% reduces money demand by 0.01426% ($= -0.0713 \times 20\%$). The interest elasticity of money demand is found to be a small negative value in most studies. For example, Goldfeld (1973) found the interest elasticity of money demand to be about -0.1 or -0.2 for the U.S.A. A negative value for the interest elasticity of money demand implies that when interest rates on nonmonetary assets rise, people reduce their holdings of money, which is similar to the findings of this study. The empirical results presented here provide evidence that the interest rate elasticity of money demand increased when term to maturity increased. Estimated Treasury bill yield elasticities in Table 1 for the conventional log-levels specification are uniformly lower in Result Equations 1, 2, and 3. To capture greater economization on transaction balances supposedly originating primarily in the business sector, a variety of additional variables have been included in the conventional money demand equations. These variables are a lagged $M2$ real money stock, i_{5-year} T-notes and long-term i_{5-year} T-bond interest-rate.

4.2 Income Elasticity and Money Demand in Kenya

An increase in Gross Domestic Product (GDP) will cause an increase in transaction demand for money. If non-chequable deposits are not used for transactions purposes, transactors may reduce these deposits to build up their chequable accounts, so that the main effect of the increase in GDP is a redistribution within, say, M2 rather than an increase in a transaction. This results in a lower than usual estimated elasticity as seen in Result Equations 1 and 2. For the income elasticity, factors are working in opposite directions. An increase in income will induce some people to switch from n to n + 1 bond-money transactions, hence lowering their average money balances. This is so when the time to maturity is one year and below. Similarly, there will be some households induced to transfer their income and add more to their savings more frequently, hence lowering their money balances. Increasing term to maturity in the specification causes the robustness of the model to deteriorate.

Moreover, in the constrained specifications (Result Equations 4 and 5) the estimated coefficient on lagged money is much smaller than it is when short-term rates are used in specifications, implying more plausible speeds of adjustment in some equations. When the term to maturity of the short-term interest rate is considered, money demand grows more slowly than income. This is because Kenya's financial sophistication tends to increase as real income grows. In Kenya, people used to hold much of their savings in the form of money, for lack of anything better. Today, people have many attractive alternatives to money. Money substitutes, such as credit cards, MPESA and Airtel Money have become more common as Kenya's real GDP increases, again causing aggregate money demand to grow more slowly than income. The estimated real income elasticity in Result Equation 3 is 0.6697 given the 1-year interest rate. This substantiates the proposition that there are economies of scale in the management of cash balances. It seems the best substitutes for money are at the short end of the money market.

5. Conclusions

This paper has used log-linear money demand functions of the "partial adjustment" variety to examine empirically the inter-related problems of monetary aggregation and estimation of money demand. The reason is that several assets possess both investment and transaction abilities, consequently blurring the difference between money holding for transaction purposes and assets holding for portfolio purposes. Furthermore, the study maintains that this development of money substitutes is ambiguous in its influence on real income and interest rate elasticities of demand for money in Kenya. Hence, the paper examines whether new financial products have methodically altered the traditional relationship between the monetary aggregate, interest rates, and income in Kenya.

The study covers the period from 2000 to 2020 to determine the following:

(a) Innovations in the payments process and changes in the regulatory environment have explicitly affected the demand for money in Kenya.

(b) Various financial (and non-financial) assets are substitutes in use for each other. These include short-term (91-day, 182-day, 364-day) T-bill rates, mid-term (5-year) T-notes rates and long-term (10-year) T-bond rates.

(c) Traditional measures of money and the traditional log-linear demand for money functions are stable in Kenya.

(d) Kenya has not experienced the severe volatile financial environment that we see in developed countries. Even if financial disturbances produce sufficient changes in assets rates of return and bondholders get induced to make large enough adjustments in their portfolios, this has not irritated the traditional measures of money as well as the traditional log-linear money demand functions.

Several features of these results are the following. Firstly, the estimated real income elasticities are uniformly statistically significant and close. Secondly, the estimated elasticities of the short-term market rates are statistically significant and close. Thirdly, the estimated elasticities of the long-term market rates are statistically significant and close. Fourthly, the significantly larger coefficient estimate on lagged money seems contrary to assertions about greater cash management and overall economization on transaction balances at a lower interest rate. This is only possible at a one-year interest rate.

Limitations

In developing countries, the size of cash holding is difficult to explain. The complication is currency hoarding, the use of currency for illegal transactions in the underground economy and tax evasion. Rich people hold buffer stocks to use in case of uncertain streams in expenditures and receipts.

References

Barnett, W. A., Fisher, D. & Serletis, A. (1992). Consumer theory and the demand for money. *Journal of Economic Literature,* 30: 2086–119.

Baumol, W. J. (1952). The transactions demand for cash: An inventory theoretic approach. *Quarterly Journal of Economics,* 66: 545–556.

Bronfenbrenner, M. & Mayer, T. (1960). Liquidity functions in the American economy. *Econometrica*, 28(4): 810–834.

Brunner, K. & Meltzer, A. H. (1964). Some further evidence on the supply and demand functions for money. *Journal of Finance*, May: 340.

Central Bank of Kenya (CBK). (2021). *Annual report and financial statements* 2020/2021.

Chetty, V. K.. (1969). On the long-run and short-run demand for money: Some further evidence. *Journal of Political Economy*, 77(6): 92.1–31.

Chow, G. (1966). On the long-run and short-run demand for money. *Journal of Political Economy*, 74(2): 111–131.

Clinton, K. (1973). The demand for money in Canada, 1955–70: Some single-equation estimates and stability tests. *Canadian Journal of Economics,* 6(1): 63–61.

Ericsson, N.R., Hendry, D.F. & Prestwich, K.M. (1998). The demand for broad money in the united kingdom, 1878–1993. *Scandinavian Journal of Economics*, 100(1): 289–324.

Friedman, B. M. (1978). Crowding out or crowding in? Economic consequences of financing government deficits. *Brookings Papers on Economic Activity*, 3: 593–641.

Friedman, M. (1959). The demand for money: Some theoretical and empirical results. *Journal of Political Economy*, 67(4): 327–351.

Goldfeld, S. (1973). The demand for money revisited. *Brookings Papers on Economic Activity*, 3: 577–646.

Goldfeld, S. (1976). The case of missing money. *Brookings Papers on Economic Activity*, 7: 683–730.

Hafer, R.W. & Hein, S. E. (1984). Financial innovation and the interest elasticity of money demand: some historical evidence. *Journal of Money, Credit and Banking*, XVI: 2, May, 246–252.

Hamburger, M. J. (1983). Recent velocity behavior, the demand for money, and monetary policy. conference on monetary targeting and velocity. Federal Reserve Bank of San Francisco, 1983.

—. (1977). The behaviour of the money stock: Is there a puzzle? *Journal of Monetary Economics* 3 (July): 265–88.

Heller, H.R. (1965). The demand for money: The evidence from short-run data. *Quarterly Journal of Economics*, 291–303.

International Monetary Fund (IMF). (2021). *International Financial Statistics*. Washington, D.C.

Kenya National Bureau of Statistics (KNBS). (2021). *Economic Survey*.

Laidler, D. E. W. (1966). Some evidence on the demand for money. *Journal of Political Economy,*74(1): 55–68.

—. (1966). the rate of interest and the demand for money-some empirical evidence. *Journal of Political Economy*, December, 543–55.

—. (1977). *The Demand for Money: Theories and Evidence.* 2nd New York DunDonnelley.

—. (1980). The demand for money in the United States yet again. In: K. Brunner & A. H. Meltzer (eds.). *On the state of macroeconomics*, pp. 219–71. Carnegie-Rochester Conference Series on Public Policy, Vol. 12, Amsterdam: North-Holland.

Laumas, G. S. & Mehra, Y. P. (1977). The stability of the demand for money function. *Journal of Finance*, 32 June: 911–916.

Leijonhufvud, A. (1968). *On Keynesian economics and the economics of Keynes*, Oxford.

Poole, W. (1970). Whither money demand? *Brookings Papers on Economic Activity*, 3: 485–501.

Starleaf, D. R. & Reimer, R. (1967). The Keynesian demand for money: Some statistical tests. *Journal of Finance*, 22.

Teigen, R.L. (1964). The demand and supply functions for money in the United States: Some structural estimates, *Econometrica,* 476–509.

Tobin, J. (1956). The interest-elasticity of transactions demand for cash. *Review of Economics and Statistics,* 38: 241–247.

Zarembka, P. (1968). Functional form in the demand for money. *Journal of the American Statistical Association*, 63: 502–511.