

# LONG-RUN MONEY DEMAND USING DIVISIA AGGREGATES

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## 1. Introduction

One of the most eminent topics of the economic literature has been the search for a stable long-run relationship between the demand function for real balances and an interest rate given some measure of real economic activity or volume of transactions. The sophisticated nature of this research has been emphasized long ago. While summarizing the literature to date, **Boorman (1976)** argues:

"The first and most important result of this survey is that the evidence supporting the existence of a reasonably stable demand for money function would seem to be overwhelming. This is true both of long-term evidence covering the last seventy years or so and of the evidence from the postwar period until 1973. Second and perhaps next in importance of the conduct of monetary policy, the vast majority of this same evidence supports the hypothesis that the nominal interest rate plays a significant role in the determination of the public's desired money balances has been fairly narrow circumscribed, with the best possible results suggesting an elasticity of about -0.2 for the short rate and approximately -0.7 for the long-rate."(p.356)

Since then, the fallacy of the literature to provide robust specifications has been outlined by **Friedman and Kuttner (1992)** as:

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"...the evidence in favor of the kind of long-run stability of the money-income relationship that cointegration represents has become weaker over time, so much that any presumption in favor of such a relationship must reflect prior beliefs, rather than evidence contained in the data..."(p.490)

In the context of these controversies, this paper tries to incorporate the essentials of two recent specifications while analyzing the dynamics of the long-run money demand function.

First, unlike most studies of monetary phenomena in the 1980s which attribute changing empirical relationships to some aspects of financial innovations, this paper follows **Barnett (1980)** by making use of the Divisia aggregates. Deriving from Barnett, **Belongia (1996)** emphasizes that the reported simple-sum monetary aggregates are flawed index numbers and they fail to represent the thrust of monetary policy. This is due to the aggregation problems inherent in the weighting scheme of these variables. In this respect, simple sum-aggregates are liable to spurious shifts that would suggest a change in the utility derived from money holdings though no such change has occurred.

Second, cointegration analysis is applied to examine the long-run trend relationships, using data with a frequency of measurement appropriate to the study of monetary policy issues. Questions about the exogeneity or endogeneity of variables disappear as all variables are endogenous, including the money supply.

The organization of the paper is as follows: In section II, there is a brief summary of the empirical literature on the long-run demand function for real balances in the United States. In section III, the advantages of using the Divisia aggregates is discussed, as well as describing the cointegration modeling strategy. In section IV, the empirical analysis is presented, and section V is a brief conclusion.

## **2. A Short Background of Long-Run Money Demand for the US**

Starting from the late 1950s and early 1960s, empirical studies of the demand for real balances examined the long-run income and interest elasticity estimates. Their usual outcome was failing to reject a unitary long-run income elasticity with a coefficient ranging from -0.6 to -0.7 on the long-run interest elasticity (**Friedman (1959)**, **Meltzer (1963)**, **Chow (1966)**, **Laidler(1966)**). The inadequacy with these studies is found in their

interpretation of long-run as a reference to the time span of the data series rather than to the equilibrium of demand and supply curves for real balances.

With the supply shocks in 1970s, the economic literature had lost its faith in the conventional money demand functions. The so-called **Goldfeld puzzle (1976)** of too little money and too much velocity accompanied by the too much money and too little velocity in 1981-1983 underlined the fundamental changes associated with the demand for real balances.

As **Gordon (1984)**, argues the main distinction between long-run and short-run concepts of the money demand lies in the absence of adjustment costs in the former and their presence in the latter. Thus, long-run demand for money function assumes constant tastes and instantaneous and costless adjustment to any change in the vector of variables that determine money holdings.

In this context, the failure of the profession to explain the dynamics of the short-run money demand function (see **Goldfeld (1987)** for a survey), accompanied with the difficulties in analyzing the long-run money demand have led economists to believe that money's effects on economic activity and its role in monetary policy are issues wide-open for debate.

As a result, the main line of attack has focused on specifications that pay adequate attention to the long-run nature and short-run dynamics of money demand. However, as a stable long-run money demand is the key ingredient in the monetary theory of the balance of payments and monetary theory of exchange rate determination, the main focus has been on determining a robust long-run relationship.

### 3. Divisia Aggregates and Cointegration

Much of the recent empirical work on money demand has failed to find a stable and well-specified relationship between real money balances and interest rates, and output, especially in the 1980s. There were two starting points to correct the arising problems. One of these were to remodel the theoretical fallacies (**Rasche (1987)**, **Mehra (1989)**, **Hetzel and Mehra (1989)**), and the other applying the recently developed econometric techniques (**Hafer (1984)**, **Darby, Mascaro and Marlow (1989)**, **Hoffman and Rasche (1991)**, **Mehra (1992)**, **Hendry (1995)**).<sup>1</sup>

<sup>1</sup> **Judd and Scading (1982)** provide a thorough review of the different rationalizations that explain post-1973 developments in the money market.

Although these studies have made progress from different perspectives, the stability of the long-run money demand remains an important issue in much of the current literature (among others, **Gavin and Dewald (1989)**, **Hallman, Porter and Small (1989)**, **Miller (1991)**).

### **3.1. Divisia Aggregates**

Although there is consensus on the variables which determine the money holdings, there has been far less agreement on how to measure the aggregate quantity of money in the economy.<sup>2</sup>

It is a well-known feature of microeconomic theory that rational decision makers chose corner solutions when allocating resources over perfect substitutes. Therefore, simple sum monetary aggregation is only consistent with microeconomic theory in the case where economic agents hold only one monetary asset in their portfolio.

The appropriate method of aggregating monetary assets is an important question in macroeconomics. Although the microfoundations of money have been widely discussed (see among others, **Pesek and Saving (1967)**, **Samuelson (1968)**, **Fama (1980)**), prior to **Barnett (1980)** only a few studies had been concerned with application of aggregation and/or index number methods to monetary assets (**Hutt (1963)**, **Chetty (1969)**). Despite being a strong advocate of M2, **Friedman and Schwarz (1970)** emphasized the deficiencies related to high level simple sum aggregates as:

"The [simple sum aggregation] procedure is a very special case of the more general approach...[which]...consists of regarding each asset as a joint product having different degrees of "moneyness", and defining the quantity of money as the weighted sum of aggregates value of all assets, the weights for individual assets varying from zero to unity with a weight of unity assigned to that asset or assets regarded as having the largest quantity of "moneyness" per dollar of aggregate value. The procedure we have followed implies that all weights are either zero or unity. The more general approach has been suggested frequently but experimented with only occasionally. We conjecture that this approach deserves and will get much more attention than it has so far received."(p151-2)

Following this presumption, **Barnett (1980)** introduced the applica-

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<sup>2</sup> See **Poole (1992)** and **Belongia (1993)** among others as studies using different monetary aggregates.

tion of index number theory to the construction and estimation of monetary aggregates while underlining the deficiencies associated with the simple-sum aggregation. He argues that economic agents must be able to treat a monetary aggregate as the quantity of a meaningful single good in their decisions. Hence, it is possible for individuals to select their desired aggregate quantity of the monetary aggregate without regard to its composition. Beside, changing the relative quantities of the components within the monetary aggregate must not influence any change in tastes or technology over any other goods. In this respect, **Barnett (1980)** demonstrates the invalidity of simple sum index number formula.

Drawing on **Barnett (1982)** and **Barnett, Fisher and Serletis (1992)**, **Belongia (1996)** argues that simple sum aggregates are flawed index numbers because aggregating any set of commodities with equal weights means that each good is a perfect substitute for every other good in the group. However, this is not the condition as empirical evidence shows. Hence, the simple-sum aggregates are liable to internalize pure substitution effects as they are prone to spurious shifts. These shifts may be the reasons for the instability of the money demand functions, using simple-sum aggregates as their dependent variable. Replacing the simple-sum monetary aggregate by its Divisia counterpart, **Belongia (1996)** finds reversed qualitative inferences in four of five cases examined.

One of the indices **Belongia (1996)** uses is the Divisia, constructed by calculating expenditure shares for the financial assets to be aggregated and using these shares as the index weights, derived from **Barnett (1980)**. In this formulation, the household's utility function is assumed to be weakly separable in monetary assets. Hence, the marginal rate of substitution between any two monetary assets becomes independent of the quantities of all other goods. The household solves its utility maximization problem in two stages.

In the first stage, the shares of total household expenditure to be spent on real monetary services and on quantities of individual non-monetary goods and services is chosen. In the second stage, not exceeding the expenditure on monetary services selected in the first stage, the household determines the real stocks of monetary assets that will provide the largest possible quantities of monetary services. Hence, there exists an aggregator function which measures the total amount of monetary services that the household receives from its holdings of monetary assets. However, its functional form

is unknown but may be approximated by a statistical index number. In this respect, to incorporate the pure substitution effects and track the true, but unknown, subutility function associated with the monetary service flow from holding a given set of assets, monetary aggregates need to be constructed using an index formula from the class of superlative index numbers, discussed by **Diewert (1976, 1978)** and **Barnett (1980)**.

Following these studies, recently **Anderson, Jones and Nesmith (1997a)** have developed the Monetary Service Index (MSI), approximating many monetary aggregates.<sup>3</sup> As explained by **Anderson, Jones and Nesmith (1997b)**, the MSI includes the monetary quantity aggregate, and its dual user cost index. Unlike the official monetary aggregates published by the Board of Governors of the Federal Reserve System, the MSI and their dual user cost indices are statistical index numbers, based on economic aggregation and statistical index number theory depending on the theoretical advances of **Diewert (1976)**, and **Barnett (1978, 1980, 1982)**. Beside, the theoretical procedures used in the construction of MSI database are valid only under the assumption of risk neutrality.

Namely, the MSI contains monetary services indices constructed over the same set of assets (levels of aggregation) as the simple sum monetary aggregates M1A, M1, MZM, M2, M3 and L. These indices are both chained superlative index numbers, and have the same theoretical and statistical properties as other chained superlative index numbers, like the Gross Domestic Product (GDP) and GDP deflator produced by the Department of Commerce. In this framework, the methodology for construction of MSI is compatible with the mainstream of current macroeconomic research. Moreover, the MSI approach follows the contemporary general-equilibrium business cycle models which often begin with the hypothesis of an optimizing microeconomic agent (**Cooley and Hansen (1995)**).

### 3.2 Cointegration Analysis

Most economic variables are proposed to follow volatile paths, hence it is always a matter of question whether economic variables tend to revert back to some long-run trend following a shock or random walk process. In this respect, the underlying characteristics that generated the time series is to

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<sup>3</sup> The monetary services indices are sometimes called as Divisia monetary aggregates as their construction uses a discrete approximation to **Divisia's (1925)** continuous time index.

be examined in detail to discriminate spurious from real relationships. Foremost in this agenda is the use of recently developed cointegration techniques that allows one to estimate the long-run relationship using data with a frequency of measurement appropriate to the study of monetary policy issues.

Previous cointegration analyses of time series are primarily based on residual-based tests following the two step procedure of **Engle and Granger (1987)**. However, since its introduction, **Johansen's (1988, 1991)** method has been widely used. Its' superiority lies in the fact that it takes into account the error structure of the data and allows for interactions in the determination of the relevant economic variables, within the context of vector autoregressions. The procedure developed by **Johansen (1988)** builds on the cointegration literature by providing a maximum likelihood technique for estimating and testing for cointegration.

This paper examines the existence of a stable long-run relationship between the economic variables proposed to determine the demand for real balances. Cointegration is the approach to follow as it is at least a necessary (but not always sufficient) condition for economic variables to have a stable long-run (linear) relationship.

#### 4. Empirical evidence

Using the above discussed framework, this study employs real MSI aggregates of Divisia M1 and Divisia M2 as the appropriate measures of money, chain index of gross domestic product calculated by the Department of Commerce as the scale variable<sup>4</sup>, the three month T-bill rate as the opportunity cost variable. The price variable used is the GDP deflator as it is also a superlative chain index. The sample period is determined by the availability of consistent measures of the aggregate in question. In general, we use quarterly data from 1960.1 to 1996.4.

##### 4.1 An Overview of the data

Figures 1 and 2 introduce the comparisons of the growth rates of simple-sum M1 and Divisia M1, and simple sum M2 and Divisia M2, for the

<sup>4</sup> **Lucas (1980)** and **McCallum (1989)** demonstrate utility theoretic models of money demand which indicate that the appropriate scale variable is total expenditure, the gross domestic product.

period 1960.1-1996.4. As **Belongia (1996)** argues it is important to examine the existence of general trends or specific episodes in which divergent behaviors of simple-sum and Divisia measures indicate. Furthermore, these behaviors might signal the reasons for inconsistent estimates of real money balances.

The M1 data is plotted in Figure.1 with GM1 as the growth rate of the Divisia aggregate and GSSM1 as the growth rate of the simple-sum monetary aggregate. Till 1980, we don't observe too much of a difference between these two series due probably to the relatively stable structure of the U.S. financial markets which is compatible with **Belongia (1996)**.<sup>5</sup> Simple-sum M1 grows at a faster rate than the Divisia aggregate for 1983-1987 period and 1992-1995 period, a pattern demonstrating the reason for inaccurate predictions of higher inflation. Beside, the simple-sum M1 and Divisia M1 tend to diverge from each other especially after the 1990s, implying that the qualitative inference on the thrust of monetary policy rely on the index weights in the recessionary periods.

Figure.2 includes the plot of simple-sum M2 against the Divisia M2. It is not hard to realize that the studies using M2 found almost no evidence of a stable long-run relationship, depending on its volatile nature. Furthermore, this non-stationary structure points out that the quantitative and qualitative inferences drawn by using simple-sum M2 are rather misleading.

On the other hand, the general pattern of the Divisia M2 is rather consistent with the U.S. economy. The recessions of 1981-82 and 1990-91 are captured in the growth rates as well as the smooth trend that we observe after the 1990s. In this respect, the Divisia aggregates perform much better than the simple-sum aggregates in reflecting the dynamics incorporated in the economic activity. Nevertheless, a stable long-run money demand function relies on the effects of different economic variables and their respective outcomes. Hence, we need to employ the standard econometric procedures for evidence of empirical support.

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<sup>5</sup> **Belongia (1996)** uses the Divisia aggregates calculated by **Thornton and Yue (1992)**.

Figure.1: Growth rates of simple-sum M1 and Divisia M1

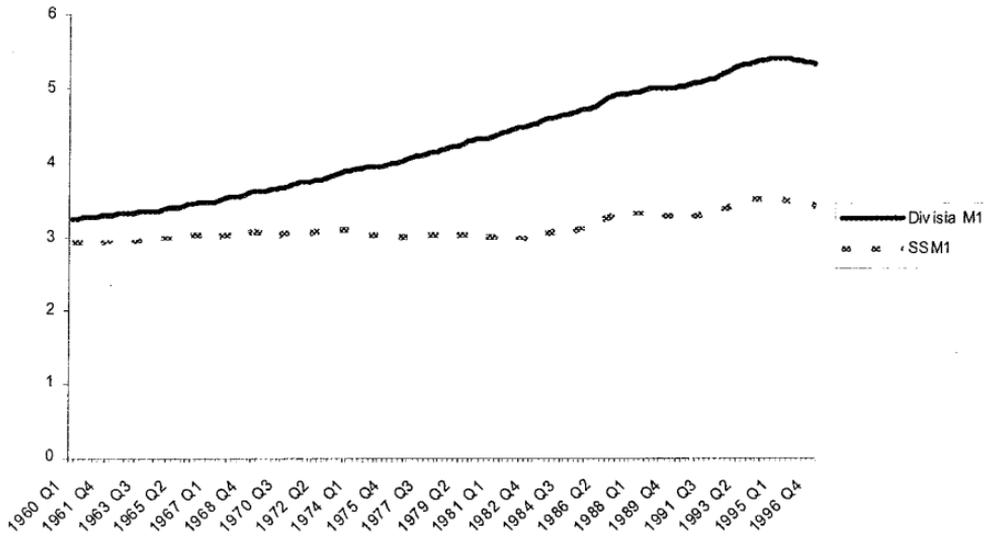
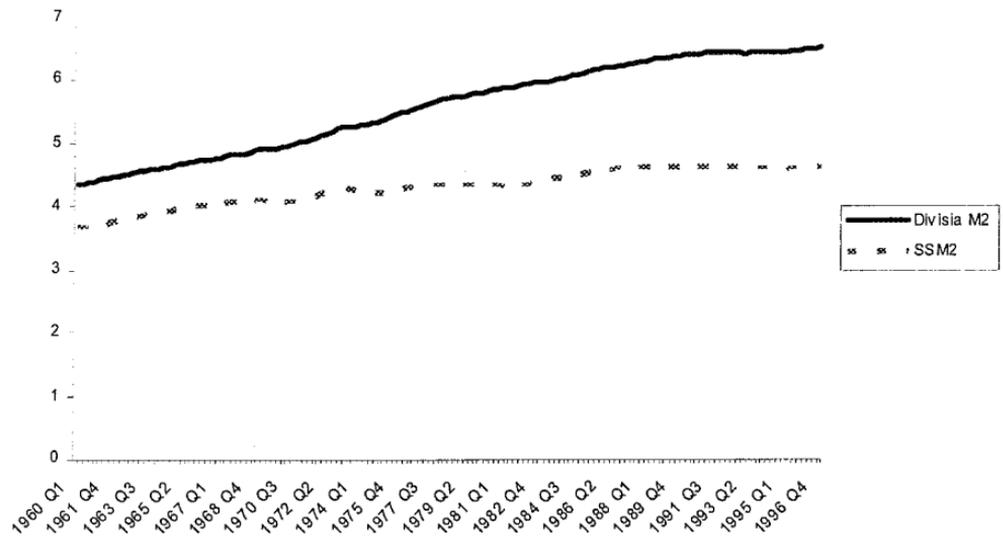


Figure.2: Growth rates of simple-sum M2 and Divisia M2



## 4.2 Empirical results

The first step of empirical analysis is to test whether the series in question are non-stationary or not. Beside, it is important to distinguish between the sources of non-stationarity of time series as a unit root process and the presence of a deterministic trend.

There have been three widely used tests in the literature, namely the three statistics of Dickey-Fuller (**Fuller (1976)**, **Dickey and Fuller (1979,1981)**) (ADF)  $\tau\tau$ ,  $\tau\mu$ ,  $\Phi_3$ , the three **Phillips-Perron (1988) (PP)** statistics of  $Z(\tau\alpha^*)$ ,  $Z(\tau\alpha^-)$ ,  $Z(\Phi_3)$ , test and the LM test of **Kwiatkowski et al. (1992) (KPSS)**. We use Akaike's criterion to determine the appropriate lag length and Box-Pierce  $Q$  to guarantee that the chosen lag length leads to white noise errors in test regressions. The results are in Table.1a and Table.1b. The numbers in the parentheses are the critical values at 5 % significance level. All the variables except the interest rate are in their natural logarithm form.

Table .1a- ADF Unit root tests-Levels

Variable	$\tau\mu$	$\tau\tau$	$\Phi_3$
Divisia M1	-1.31 (-2.86)	-2.32 (-3.41)	2.75 (6.25)
Divisia M2	-2.53 (-2.86)	-2.64 (-3.41)	4.54 (6.25)
GDP	-2.67 (-2.86)	-2.78 (-3.41)	6.52 (6.25)
T-Bill rate	-2.34 (-2.86)	-2.19 (-3.41)	2.72 (6.25)

Table.1b- PP Unit root tests-Levels

Variable	$Z(\tau\alpha^*)$	$Z(\tau\alpha^-)$	$\Phi_3$
Divisia M1	-0.32 (-2.86)	-1.52 (-3.41)	1.22 (6.25)
Divisia M2	-2.96 (-2.86)	-1.97 (-3.41)	4.62 (6.25)
GDP	-1.93 (-2.86)	-1.70 (-3.41)	2.87 (6.25)
T-Bill rate	-2.52 (-2.86)	-2.52 (-3.41)	3.26 (6.25)

The results of Table.1a and Table.1b show that we fail to reject the null hypothesis of non-stationarity of our series except two cases. First, in the ADF test, we accept the null of a unit root but we reject the null of a unit root and deterministic time trend for the GDP series. Hence, this outcome does not contradict our testing strategy. Second, in the Phillips-Perron test, we reject the null of a unit root for Divisia M2 but we fail to reject the null of a unit root and a deterministic trend. This outcome, however, shows that Divisia M2 series might be a deterministic trend, rather than being nonstationary. However, we follow the results of the ADF test due to its wide acceptance and conclude that our series are nonstationary at levels.

Table .2a- ADF Unit root tests-Differences

Variable	$\tau\mu$	$\tau\tau$	$\Phi_3$
Divisia M1	-3.66 (-2.86)	-3.61 (-3.41)	6.71 (6.25)
Divisia M2	-4.63 (-2.86)	-4.82 (-3.41)	11.63 (6.25)
GDP	-8.72 (-2.86)	-9.05 (-3.41)	40.99 (6.25)
T-Bill rate	-6.86 (-2.86)	-15.88 (-3.41)	23.82 (6.25)

Table .2b- PP and KPSS Unit root tests-Differences

Variable	Z ( $\alpha^*$ )	Z ( $\alpha^*$ )	$\Phi_3$	LM
Divisia M1	-4.83 (-2.86)	-4.77 (-3.41)	11.56 (6.25)	0.125 (0.146)
Divisia M2	-4.59 (-2.86)	-4.91 (-3.41)	12.07 (6.25)	0.145 (0.146)
GDP	-8.98 (-2.86)	-9.17 (-3.41)	42.07 (6.25)	0.135 (0.146)
T-Bill rate	-14.78 (-2.86)	-14.75 (-3.41)	108.63 (6.25)	0.031 (0.146)

As Table.2a and Table.2b emphasize, all of our series have a unit root and no deterministic trend except the GDP. We reject the null of non-stationarity using ADF and PP and fail to reject the null of stationarity in case of KPSS at 5 % significance level. Overall, these results show that our series have a unit root and no deterministic trend except the GDP in case of the

Dickey-Fuller test. Thus, we consider both cases of no deterministic trend and a deterministic trend in the cointegration analysis.

Next, we employ tests for cointegration suggested by **Engle and Granger(1987)(ADF) and Johansen and Juselius(1990)(JJ). Haug (1993)** compares the power and size of distortions of these tests in a Monte Carlo study and finds that the ADF and JJ maximum eigenvalue tests have the least size distortions.

To determine the appropriate lag length for the residuals from the OLS regression for ADF test and the vector error-correction process in Johansen and Juselius's procedure, we employ the Akaike criterion and check all the residuals for white noise with the Box-Pierce  $Q$  statistic. The results are in Table.3a and Table.3b. The numbers in the brackets are the critical values at 5 % significance level.

**Table.3a-ADF Cointegration tests**

Model	ADF -No trend	ADF-With trend
log(Div M1), log (GDP), log(T-bill)	-3.04 (-2.86)	-3.04 (-3.41)
log(Div M2), log (GDP), log(T-bill)	-2.31 (-2.86)	-2.52 (-3.41)

**Table.3b-JJ Cointegration tests**

Model	Null	Max. eig. Test	Trace Test
log(Div M1),	$r \leq 2$	1.48 (3.96)	1.48 (3.96)
log (GDP),	$r \leq 1$	5.01 (14.03)	6.50 (15.20)
log(T-bill)	$r \leq 0$	32.27 (20.78)	38.76 (29.51)
log(Div M2),	$r \leq 2$	0.04 (3.96)	0.04 (3.96)
log (GDP),	$r \leq 1$	9.01 (14.03)	9.05 (15.20)
log(T-bill)	$r \leq 0$	10.46 (20.78)	19.51 (29.51)

The cointegration results are rather mixed in supporting the superiority of the Divisia aggregates. ADF procedure results in non-stationary residuals in three cases out of the four at 5 % significance level. Hence, we fail to reject the null of no cointegration. On the other hand, we need to compare these results with JJ test results. In case of Divisia M1, we have one cointegrating vector at 5 % significance level whereas in case of Divisia M2 the

null of no cointegrating vector cannot be rejected at 5 % significance level. Thus, we end up with one cointegrating vector for Divisia M1. This finding shows that using a weighted monetary aggregate we can show the existence of a long-run relationship in the framework of a money-demand function for the US data. This is very important in underlining the contribution of the Divisia monetary aggregates to the monetary economics literature.

## 5. Conclusion

This study tried to incorporate the essentials of two specifications trying to explain the dynamics of a stable long-run relationship between real money balances and interest rate and GDP. It is possible to argue that there is one cointegrating vector among these variables, the evidence is rather limited but very satisfactory. Using Divisia M1 appears to be the correct specification while analyzing the money demand function.

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