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INSTITUTE OF SOCIAL SCIENCES

COMPARISON OF SIMPLE SUM AND DIVISIA MONETARY AGGREGATES USING PANEL DATA ANALYSIS

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Abstract

It is well documented that financial innovation has led to poor performance of simple sum method of monetary aggregation destabilizing the historical relationship between monetary aggregates and ultimate target variables like rate of growth and rate of unemployment during the liberalization period of 1980s. This thesis tries to emphasize the superiority of an alternative method of aggregation over the simple sum method, namely Divisia monetary aggregates, taking advantage of two testing methodologies, one of which is the system estimation (Seemingly Unrelated Regression (SUR)) using *time series data* and the other is the *panel data* analysis for United States, United Kingdom, Euro Area and Japan for the period between 1980Q1 and 1993Q3. After estimating the parameters of the system through SUR method, I have proceeded with the panel procedure and investigated the order of stationarity of the panel data set through several panel unit root tests and performed advanced panel cointegration tests to check the existence of a long run link between the Divisia monetary aggregates and income and interest rates in a simple Keynesian money demand function. Findings revealed that there exists a long run link between Divisia monetary aggregates, income (measured by real GDP) and interest rates and the relationship between these three variables is relatively robust when compared to the link between simple sum monetary aggregates, income and interest rates.

To my beautiful aunt, Hülya Keskinel whom I always feel her hands on my shoulder and always looks at me through the stars.

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Introduction

It is highly difficult to deny the direct relationship between the money supply and key macroeconomic variables such as output and inflation. In this context, the issue of monetary aggregates has been studied in the literature and the possible casual link between money and real variables has been examined by empirical studies supported by the theoretical framework. From the monetarist perspective, money affects inflation and does not affect output and unemployment in the long run even if the short term effect of money on these real variables is considerable. Monetarists recommended a fixed target growth rate for base money in order to achieve price stability on which many central banks base their monetary policy. Price stability is important because a rising price level-inflation imposes substantial economic costs on society. Some of these costs are increased uncertainty about the outcome of business decisions and profitability, adverse effects on the cost of capital caused by the interaction of inflation with the tax system and reduced effectiveness of the price and market systems. Achieving price stability and hence obtaining the desired long run results of this policy through a fixed target rate for base money requires two conditions: one is the necessity for a stable money demand so that the impact of monetary policy will be predictable and the other one is the need for a stable money multiplier meaning that the changes in broad money supply might be forecasted by the changes in monetary base. The stability of money demand functions is important due to the fact that it reflects the predictive ability for future economic activity. Therefore, any uncertainty affecting the choice of a money supply indicator for predicting future economic performance of a country also affects the estimation of money demand models.

The general view of the early 1970s was that there exist a considerable linkage between broad monetary aggregates and the real variables such as output and unemployment. Therefore, major industrial countries adopted some form of monetary growth target as a guide or intermediate objective of monetary policy. Friedman (1982a) and Dennis (1982), in their studies, mentioned about the major reasons behind the switch to monetary targeting. These reasons were the acceleration of inflation in the early 1970s and hence the difficulty in interest rate targeting, the expectation that small and open economies could conduct their own monetary policy independently and finally the dissatisfaction with the fine-tuning policies which rely on the fact that money supply should be demand-determined. In this respect, in 1975, the Federal Reserve began to report annual target growth ranges for M1, M2, M3 and the bank credit and after 1977, the target was defined as " maintain long run growth of monetary and credit aggregates… so as to promote effectively the goals of maximum employment, stable prices and moderate long term interest rates". Also the Federal Open Market Committee under the Chairman Paul Volcker adopted a policy based on monitoring non-borrowed reserves so as to control the growth of M1 and M2 and thereby reduce inflation. However, after the second oil crisis of 1979, monetary targeting procedures became subjects of considerable debate not only in the United States but also in other countries and the close relationship between the monetary aggregates and the targeted real variables was questioned due to the deregulation of financial markets, the financial innovation, the competition between financial intermediaries, the rapid development of new information and the liberalization attempts in terms of free capital flows and the introduction of flexible exchange rates. These developments seen in the early 1980s certainly affected the definition of money, the money supply process and the stability of demand for money. For instance, in 1982, the Federal Reserve Board argued that it would be convenient to pay less attention to M1 and focus on broader monetary aggregates. Moreover, Hendry (1995) argued that the instability in M1 demand forced Bank of Canada (BOC) to abandon M1 as a target variable. In the early 1980s, the United Kingdom also gave less weight to its sterling M3 target.

Not only the above mentioned developments in the early 1980s resulted in the instability of the demand for money, but also the aggregation method used for the components of monetary aggregates supplied by many central banks has caused induced instability of money demand and supply conditions. The aggregation method mentioned here is simply the simple sum method. This procedure has been criticized due to the fact that this method of aggregation weighs each component equally. In other words, this procedure treats all included assets equally in terms of "moneyness" ("money substitutes", "near money", "secondary liquidity" etc.) and the excluded variables as the ones providing no monetary services. This fact paves the way for new monetary aggregates one of which is the famous

Divisia monetary aggregates which allow for a weighted aggregate of components in order to measure the flow of monetary services.

In this thesis, I basically aim to show the performance of Divisia monetary aggregates calculated for the advanced countries (the Unites States, the United Kingdom, Euro Area and Japan) over their simple sum counterparts covering a period between 1980 Q1 and 1993 Q3. Within this framework, I try to answer the following two questions:

- Is there any evidence that Divisia monetary aggregates of the relevant countries perform well when compared to their simple sum counterparts?
- Does there exist a significant long run link between the Divisia monetary aggregates, income and interest rates in a simple Keynesian money demand function?

In the first chapter of this thesis, I will argue for the concept of monetary aggregation and the theoretical background of the monetary aggregation. The second chapter mentions about the formulation of new monetary aggregates including Divisia monetary aggregates and currency equivalent indexes. The third chapter touches upon the historical performance of monetary aggregates in the relevant developed countries while the forth chapter explains the methodology of the econometric tests and methods (SUR method (using time series data) and unit root and cointegration tests, and Fully Modified Ordinary Least Squares estimation (using panel data)) and reveals the empirical findings regarding the results of these tests considering the previous studies on the comparison of simple sum and Divisia monetary aggregates. The final chapter is devoted to the conclusion of this thesis.

1. Monetary Aggregation

The monetary assets held by consumers, firms and other economic decision makers play a significant role in macroeconomics. These economic units hold these aggregate quantities for the purposes of transaction, speculation and contingencies. Monetary aggregates published by central banks in aggregate forms like M1, M2, M3 or L are generally the sums of the amounts of monetary assets in dollar or in other currencies. The content of these aggregates vary from one country to another. In this context, it would be convenient to discuss the monetary aggregates of United States (U.S), United Kingdom (U.K), Euro Area (E.A) and Japan, which are constructed by summation procedure:

United States:

M1 = Currency and Travellers' Checks + Demand Deposits Held by Consumers + Demand Deposits Held by Businesses + Other Checkable Deposits + Super NOW Accounts Held at Commercial Banks + Super NOW Accounts Held at Thrifts

M2 = M1 + Money Market Mutual Fund Shares + Money Market Deposit Accounts at Commercial Banks + Money Market Deposit Accounts at Thrifts + Savings Deposits at Commercial Banks + Savings Deposits at Savings and Loans (S&Ls) + Savings Deposits at Mutual Savings Banks

(MSBs) + Savings Deposits at Credit Unions + Small-Time Deposits and Retail RPs at Commercial Banks + Small Time Deposits at S&Ls and MSBs and Retail RPs at Thrifts + Small Time Deposits at Credit Unions

M3 = M2 + Large Time Deposits at Commercial Banks + Large Time Deposits at Thrifts + Institutional Money Market Funds + RPs at Commercial Banks and Thrifts + Eurodollars

L = M3 + Savings Bonds + Short-term Treasury Securities + Bankers' Acceptances + Commercial Paper.

United Kingdom:

M2 = notes and coins held by the U.K non-bank and non-building societies of private sector + the sterling retail deposits with the U.K banks and building societies + the cash component of M4.

M4 = notes and coin held by the U.K private sector other than monetary financial institutions + sterling deposits at Monetary Financial Institutions (MFIs) in the U.K + certificates of deposit and other paper issued by MFIs of not more than 5 years original maturity.

Japan:

M2 = cash currency in circulation plus deposits deposited at Domestic Banks etc.

M2 +CDs[1] = M1 + private and public deposits less demand deposits with financial institutions surveyed + certificates of deposit including those of

[1] M2+CDs is also described as the sum of quasi-money (time deposits held at Bank of Japan, All Banks, Shinkin Banks, the Norinchukin Bank and the Shoko Chukin Bank) and certificates of deposit (CDs), which are introduced in 1979 and whose interest rates are market determined.

private corporations, individuals and the public with the financial institutions surveyed.

M3 = Cash Currency in Circulation + Deposits deposited at Depository Institutions.

L = M3 + pecuniary trusts + investment trusts + bank debentures + straight bonds issued by banks + commercial paper issued by financial institutions + government bonds + foreign bonds.

Euro Area:

M1 = Currency in circulation + overnight deposits

M2 = M1 + Deposits with an agreed maturity up to 2 years + Deposits redeemable at a period of notice up to 3 months

M3= M2 + Repurchase agreements + Money market fund (MMF) shares/units + Debt securities up to 2 years

The monetary quantity aggregates supplied by these central banks are the simple unweighted sums of the component quantities. These aggregates are constructed by the summation procedure in which a weight of unity is assigned to each monetary asset and the owners of these assets regard these assets as perfect substitutes. Fisher and Fleissig (1997) argue that the simple sum aggregation procedure might be useful for policymakers under the condition that interest rates do not fluctuate very much. However, significant fluctuations in interest rates reveal some doubts in terms of the appropriateness of simple sum aggregation method. Besides that, economic agents hold a portfolio of monetary assets, which have different opportunity costs. Therefore, it would be inconvenient to consider that the simple sum aggregation procedure captures the true dynamics of the asset demand theory.

As the number of financial assets treated as money increased substantially, the idea of treating these assets as perfect substitutes would be inconvenient. Since some financial assets have more “moneyness” than others, they deserve larger weights. In this context, it would be useful to demonstrate the first attempts at constructing an alternative to simple sum aggregate.

1.1. The Origins of Monetary Aggregation

Economic deals with two distinct aggregation problems, one of which is aggregation across heterogeneous agents and the other is aggregation of the various goods purchased by a single agent. This thesis focuses on the latter, examining the aggregation of monetary assets held by a single representative agent.

In the literature, there have been many studies discussing the microfoundations of money[2]. However, prior to Barnett (1978, 1980, 1981); Hutt (1963), Chetty (1969), and Friedman and Schwarz (1970) had applied either microeconomic aggregation theory or index number methods to monetary assets.

Hutt (1963) suggested the index known as the currency equivalent (CE) index of which the theoretical framework and the formulation developed by Rotemberg *et. al* (1995). He also explains two forms of money which are pure money and hybrid money and his aggregation consists of the

[2] Among others, see Pesek and Saving (1967), Samuelson (1968), Niehans (1978) and Fama (1980).

combination of these two units so as to provide a future flow of monetary services. He argues that money should produce monetary services and attributes the difference between money and other assets to the value of money influenced by the demand of the monetary services provided by these monetary assets. However, his study actually lacks robust empirical support and is not based on a sound theoretical framework.

As for the study by Chetty (1969), he extended the portfolio of the monetary aggregates meaning that he added savings-type deposits to currency and demand deposits and estimated the substitutability between non-medium of exchange assets and the pure medium-of-exchange assets. For instance, using time series data for the United States covering a period between 1945 and 1966, Chetty finds that time deposits and savings and loan shares are good substitutes for money. He also defines an adjusted money stock based on the estimates obtained from the degree of substitution between monetary assets. One of the problems regarding Chetty's approach is that the parametric tests used in his study are sensitive to specification errors.

The idea that the aggregation methods should keep the information contained in the elasticities of substitution and should not make strong a priori assumptions regarding these elasticities causes Friedman and Schwarz (1970) to deal with the problems regarding the proper definition of money. First of all, they form four monetary aggregates (currency, currency, demand deposits, time deposits, mutual savings bank deposits, savings and loan shares[3]) through simple sum procedure. After constructing these four aggregates by simple summation of monetary asset, they offer a definition for the quantity of money as the weighted sum of the aggregate value of all assets and in the procedure they follow, all the weights are either zero or unity. Furthermore, a weight of unity is attached to assets having the largest quantity of "moneyness" per dollar of aggregate value. Actually, the major problem with this procedure is not only the way of assigning weights but also the potential instability in the weights assigned to individual assets.

The assessments made by the authors above mentioned could not touch upon the fact that even weighted aggregates might produce perfect substitutability unless the aggregation procedure is non-linear (Barnett *et al.* 1992). Nonetheless, monetary authorities have widely used simple sum monetary aggregates due to their availability. Goldfeld (1976) also mentioned about the poor performance of money demand functions employing simple sum aggregates. Since the common problem with forming weighted monetary aggregates and employing appropriate definitions of monetary aggregates for money demand functions was the lack of a robust theoretical background, Barnett (1978) started to focus on the microeconomic foundations of the monetary aggregation[4] and built the theoretical framework of the new monetary aggregates. Before proceeding with the formulation of the new monetary aggregates, it would be better to consider the theoretical framework of these new monetary aggregates.

[3] Friedman and Schwarz (1970) constructed 4 aggregates, one of which is the sum of the first two assets and the others are formed by adding one more asset to the added sums so as to reach the remaining three aggregates.
[4] Microeconomic foundations of monetary aggregations can be illustrated in models of profit maximizing firms and financial intermediaries (Barnett, 1987).

1.2. Theoretical Framework of Monetary Aggregation

Microeconomic theory is necessary for monetary aggregation in order to express various monetary aggregates as a single aggregate. The general conditions which are sufficient for the aggregation of a group of economic variables are listed by Anderson *et. al*. (1997a). These conditions include:

1. The existence of a theoretical aggregator function defined over a group of variables (in other words, the existence of a sub-function that can be factored from the economic agent's decision problem);
2. Efficient allocation of resources over the group of variables;
3. No quantity rationing within the group variables;
4. Given that the underlying data have been aggregated previously across consumers, the existence of a representative agent.

These conditions permit the theoretical aggregation of a group of variables. However, these conditions do not allow the nature of the aggregates to be analyzed with the microeconomic theory. Anderson *et. al* (1997a) also specify some conditions in order to present strong linkages between monetary aggregation and microeconomic theory by focusing on the aggregation of monetary assets held by a representative consumer since assuming the existence of a representative agent is one of the methods of developing aggregate demand functions depending upon the microeconomic decision. These specific conditions include:

1. The weak separability assumption which implies the existence of a theoretical aggregator function defined over current period monetary assets;

2. The utility maximization which leads to the efficient allocation of resources over the weakly separable group;

3. Disregarding the quantity rationing.

In this context, the theoretical framework of monetary aggregation is based on solving the intertemporal decision problem of the representative consumer using weak separability assumption and a theoretical aggregator function which will be explained in the following sections:

1.2.1. Consumer Choice Problem

The existence of a representative consumer is important in developing aggregate demand functions, which are consistent with microeconomic decision rules. Besides that, it has been common practice in the literature to use a representative consumer while solving for optimal maximization[5]. This representative consumer faces the problem of maximizing its utility subject to a budget constraint and the equilibrium level of price and quantity is reached through first order conditions.

Monetary assets have taken place in utility functions since Walras (1954). Arrow and Hahn (1971) argue that given the positive value of money in general equilibrium, there exists a derived utility function including money[6]. Therefore, any model that does not contain money in the utility function but creates a motive for holding money in equilibrium is tantamount to a model

[5] The stochastic method of aggregation does not employ a representative agent. Among others, some examples are Theil (1971), Barnett (1979, 1981) and Selvanathan (1991).

[6] Fisher (1979) derives a production function that contains money balances. Feenstra (1986) introduces specific utility functions implied by several popular models of money demand. Duffie (1990) presents a review of general-equilibrium models in which money has positive value.

that includes money in the utility function. In this context, the generality in modelling does not disappear depending upon adding money component to the utility function.

The consumer's choice problem starts with the assumption that the representative consumer maximizes intertemporal utility over a finite planning horizon of T periods[7]. The consumer's intertemporal utility function in any period, t, is

$U\ (m_t, m_{t+1},..., m_{t+T};\ z_t, z_{t+1},\ldots, z_{t+T};\ l_t, l_{t+1},\ldots, l_{t+T};\ A_{t+T})$,

where, for all s contained in {t, t+1,….,t+T}, m_s is a vector of real stocks of n monetary assets, z_s is a vector of quantities of h non-monetary goods and services, l_s is the desired number of hours of leisure, and A_{t+T} is the real stock of a benchmark financial asset, held only in the final period, at date t+T.

The representative consumer reoptimizes in each period, choosing the values of $(m_t,\ m_{t+1},\ldots,\ m_{t+T};\ z_t,\ z_{t+1},\ldots,\ z_{t+T};\ l_t,\ l_{t+1},\ldots,\ l_{t+T};\ A_{t+T})$ that maximize the intertemporal utility function subject to a set of T+1 multiperiod budget constraints. This set of multiperiod budget constraints for s found in {t, t+1,….,t+T} is:

$$\sum_{i=1}^{n} p_{is} z_{is} = w_s L_s + \sum_{i=1}^{n}\left[(1+r_{i,s-1})p^*_{s-1} m_{i,s-1} - p^*_s m_{i,s}\right] + \left[(1+R_{s-1})p^*_{s-1} A_{s-1} - p^*_s A_s\right]$$

Where p^*_s is a true cost of living index, p_s is a vector of prices for the h non-monetary goods and services, r_s is a vector of nominal yields on the n monetary assets, R_s is the nominal yield on the benchmark asset, w_s is the

[7] This model assumes perfect certainty and that all agents are price takers.

wage rate, A_s is the real quantity of a benchmark asset that is included in the utility function only in the final period, t+T and L_s is the number of hours of labor supply.

The consumer has leisure time, l_s, during each period as, $l_s = H - L_s$ where H denotes the total number of hours in a period. In the above representation, the real value of assets carried over from the previous planning period is

$$\sum_{i=1}^{n}(1+r_{i,t-1})m_{i,t-1}+(1+r_{t-1})A_{t-1}$$

and the real value of the consumer's provisions for the following planning periods is

$$\sum_{i=1}^{n}(1+r_{i,t+T})m_{i,t+T}+(1+R_{t+T})A_{t+T}$$

The model also assumes that:

1. There exists a true cost-of-living index, p^*_s, as in Barnett (1987).

2. The utility function, U(.), contains all the services provided to the representative consumer by monetary assets, except for the intertemporal transfer of wealth.

3. Each period's budget constraint includes the benchmark asset, A_s. However, only the final period utility function contains it. The reason is that the benchmark asset is used to transfer wealth from one period to another during all periods, except the final period. The consumer stores all wealth in the form of the benchmark asset and transfers it to the next period until the final period. In this sense, the benchmark asset provides no monetary services to the consumer until the final period.

Before proceeding with the consumer's choice problem, it is possible to simplify notation. Assume that the vector m_t= (m_{1t},…,m_{nt}) includes all current-period monetary assets, and the vector x_t= (m_{t+1},..,m_{t+T}; z_t, z_{t+1},…, z_{t+T}; l_t, l_{t+1},…, l_{t+T}; A_{t+T}) contains all other decision variables in the utility function. Moreover, assume that the vectors m^*_t= (m^*_{1t},…,m^*_{nt}) and x^*_t= (m^*_{t+1},…,m^*_{t+T}; z^*_t, z^*_{t+1},..., z^*_{t+T}; l^*_t, l^*_{t+1},…,l^*_{t+T}; A^*_{t+T}) show the solutions to the consumer's maximization problem. The utility function can be simplified to U(m_t, x_t). By solving for the first order conditions of this model it is possible to obtain the marginal rate of substitution between current period monetary assets m_{it} and m_{jt} and the marginal rate. Evaluated at the optimum, the first order condition is:

$$\frac{\left.\dfrac{\partial U(m_t,x_t)}{\partial m_{it}}\right|_{\substack{x_t = x^*_t \\ m_t = m^*_t}}}{\left.\dfrac{\partial U(m_t,x_t)}{\partial m_{jt}}\right|_{\substack{x_t = x^*_t \\ m_t = m^*_t}}} = \frac{p^*_t \dfrac{R_t - r_{it}}{1+R_t}}{p^*_t \dfrac{R_t - r_{jt}}{1+R_t}}$$

By solving for the first-order conditions of this model, it is possible to obtain the marginal rate of substitution between current period monetary assets m_{it} and the current period non-monetary good z_{kt}. Evaluated at the optimum, the first order condition is:

$$\frac{\left.\dfrac{\partial U(m_t,x_t)}{\partial m_{it}}\right|_{\substack{x_t = x^*_t \\ m_t = m^*_t}}}{\left.\dfrac{\partial U(m_t,x_t)}{\partial z_{kt}}\right|_{\substack{x_t = x^*_t \\ m_t = m^*_t}}} = \frac{p^*_t \dfrac{R_t - r_{it}}{1+R_t}}{p_{kt}}$$

With this derivation, the reason for using a representative consumer becomes clear. At the optimum, the first-order conditions (marginal rate of substitution) are equal to the relative prices of goods. Thus, the "price" or opportunity cost of the current period monetary asset, m_{it}, is

$$\pi_{it} = p*_t \frac{R_t - r_{it}}{1 + R_t}$$

This formula has been referred by the monetary aggregation literature as the "user cost" of a monetary asset. It is calculated as the discounted value of the interest foregone by holding a dollar's worth of the i^{th} asset. Furthermore, r_i is the nominal holding-period yield on the i^{th} asset and R is the nominal holding period yield on an alternative asset (the "benchmark asset") and finally $p*_t$ is the true cost of living index (Barnett, Fisher and Serletis, 1992). As I mentioned before, the benchmark asset provides no liquidity or other monetary services for the consumer until the final period. While each period's budget constraint has the benchmark asset, the utility function only has the benchmark asset at the final period implying that the wealth is transferred to each period during all periods except the final period. Before introducing the formulation of new monetary aggregates, it would be appropriate to mention about another crucial assumption that the microeconomic theory of monetary aggregation employs, which is the weak separability assumption.

1.2.2. Weak Separability Assumption and Aggregator Functions

Another important assumption employed by the microeconomic theory of monetary aggregation is weak separability assumption. Weak separability assumption of the utility function is an important assumption in terms of formulating the consumer problem as a two-stage budgeting problem. Goldman and Uzawa (1964) argue that the marginal rates of substitution among the variables of the weakly separable group are independent of the quantities of decision variables *outside* the group. By holding the assumption of weak separability, the utility function includes a category sub-utility function defined over the current period monetary assets implying that the decisions made for the current period monetary assets are independent of all the decisions about non-monetary assets and the other period's monetary assets. The weak separable utility function has the following form:

$U\,(u(m_t), m_{t+1},..., m_{t+T};\ z_t, z_{t+1},\ldots, z_{t+T};\ l_t, l_{t+1},\ldots, l_{t+T};\ A_{t+T})$, which might be expressed as $U\,(u(m_t), x_t)$. It should be noted that only the current period monetary assets are included in this sub-utility function. In absence of weak separability, changes in the relative prices of other assets (x_t), which does not change the aggregate's overall price index, would imply different levels of demand for the aggregate as a whole. However, this is against the notion of a stable money demand. In this context, weak separability assumption is a necessary condition for a group of assets to be considered as a monetary aggregate.

The weak separability of the current period monetary assets, m_t, means the marginal rates of substitution between current period monetary assets becomes:

$$\frac{\partial u(m_t) / \partial m_{it}}{\partial u(m_t) / \partial m_{jt}}$$

and, when evaluated at the optimum, equals:

$$\frac{\dfrac{\partial U(m_t)}{\partial m_{it}} \Big| m_t = m^*_t}{\dfrac{\partial U(m_t)}{\partial m_{jt}} \Big| m_t = m^*_t} = \frac{\pi_{it}}{\pi_{jt}}$$

This result shows that the vector of current period monetary assets, m^*_t, which solves the intertemporal utility maximization of the representative consumer, is the same vector that solves the following choice problem (Barnett, 1980, 1981, 1987):

$$\underset{m=(m_1,\ldots,m_n)}{Max} \quad u(m)$$

subject to $\sum_{i=1}^{n} m_{it}\pi_{it} = y_t$, where $y_t = \sum_{i=1}^{n} m^*_{it}\pi_{it}$

is the optimal total expenditure on monetary assets implied by the solution to the agent's intertemporal decision problem. As previously noted, the consumer choice problem is formulated as a two-staging budgeting problem. In the first stage, while the consumer chooses the optimal expenditure, y_t, on the current monetary assets and other optimal quantities on other components included in the utility function, in the second stage, he chooses the optimal quantities of the individual current period monetary assets, m^*_t, subject to the optimal total expenditure on current period monetary assets, y_t, chosen at the first stage.

In this problem, if u(.) is homogeneous of degree one, then it is a monetary quantity aggregator function. The consumer thinks that the monetary quantity aggregate, $M_t = u\ (m^*_t)$, is the optimum quantity of a single good, which is termed as the current period monetary services. This implies that given the market prices and the consumer budget constraint, the first stage decision can be perceived as the simultaneous choice of the optimal quantities of current period monetary services, and all other decision variables.[8] The linear homogeneity assumption allows the total value of transactions services to be related to the partial derivative of each asset in the aggregator function and thus to equilibrium prices. Besides, the linear homogeneity means that the aggregate and each of its components will grow at the same rate.[9]

1.3. Statistical Index Numbers

Aggregator functions (utility functions for consumers, production functions for firms) form the basis for aggregation theory. However, in the empirical research, it is almost impossible not only to specify the functional forms of these aggregator functions but also to know the parameters of the model. For instance, functional quantity aggregators, like u (.) above, depend upon the quantities of the component goods and upon unknown parameters. Estimates of these unknown parameters depend upon the specified model, the data, and the estimator. Functional quantity aggregators cannot depend

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[8] Anderson *et. al.* (1997a) demonstrate this characteristic formally.

[9] This property is useful in the derivation of the Divisia index from the transactions services function and is proved by Fisher *et. al.* (1993).

upon prices and the definition of a functional quantity aggregator does not derive from the maximizing behaviour of economic agents.

On the other hand, unlike aggregator functions, statistical index numbers do not depend on unknown parameters. Instead, they depend on maximizing behaviour of economic agents leading us to conclude that an exact statistical index number (exactness in terms of capturing the dynamics of the aggregator function) might track the aggregator function, evaluated at optimum, without error (Anderson *et. al*. 1997a).

The linkage between aggregation theory and statistical index number theory was first examined by Erwin Diewert (1976) by combining economic properties with statistical indices. As stated above, the issue of exactness of statistical index numbers has been elaborated in a way that using a number of well-known statistical indices is regarded as the same as using a specific functional form to describe the unknown aggregator function. Here, the absence of a true functional form for aggregator function leads to use an index number for a functional form that might provide second order approximation to the unknown aggregator function. This index number is regarded by Diewert as superlative. In this context, monetary aggregation can rely on statistical index numbers possessing the characteristics of exactness and flexibility in terms of functional forms.

There are two distinct types of statistical index numbers depending on their treatment of prices and quantities used. While chained statistical index numbers employ prices and quantities of adjacent periods like, p_{it} and p_{it+1}, fixed base statistical index numbers use prices and quantities of a current and a fixed base period like, p_{it} and p_{i0}. Diewert (1978) emphasizes the advantages of chained superlative price index numbers over the fixed base superlative price index numbers. One of these advantages is related to the movement of the centre of the second order approximation. For a chained superlative index, this movement means that the remainder term in the approximation relates to the changes between successive periods. For a fixed base superlative index, this movement implies that the remainder term in the approximation relates to the changes from the base period to the current period. Usually changes in prices and quantities between consecutive periods are smaller than changes in prices and quantities between a fixed base period and the current period. Hence, as Diewert (1978) argues, a chained index number will be more likely to provide a better approximation to the unknown aggregator function than a fixed base index number.

The key role played by the statistical index numbers in the analysis of microeconomic theory of monetary aggregation is pointed out through the link between aggregation theory and statistical index numbers. The slowly developing literature has been put together by Barnett (1978) whose theoretical contribution will be summarized in the next section. His study is regarded as establishing the relationship between monetary aggregation and statistical index numbers after Diewert (1976) unified the two fields of study.

1.4. Barnett's Contribution

Once the linkage between monetary aggregation and statistical index numbers was established, Barnett (1978) added the missing part of the theory of monetary aggregation. His derivation of "user cost" completes the needed "price" for monetary assets.[10] He also addressed the questions as to which set of assets the weights should be applied to and how the weights should be derived by taking advantage of statistical index number, consumer demand and aggregation theory (Mullineux, 1996:3).

Barnett (1978) emphasizes the importance and the need for attaching a price (user cost) to each monetary asset in the process of aggregation. His derivation employs a rigorous Fisherine intertemporal consumption expenditure allocation model for discrete time. His main assumptions are:

1. Time period t is defined to be the time interval, $[t, t+1)$, closed on the left and open on the right.

2. Consumption of goods can proceed continuously throughout any time interval, though the model uses only the total of that consumption for any time period.

3. Stocks of monetary assets and bonds are constant during each period and can only change at the end of an interval.

4. Interest on bonds and on monetary assets is paid at the end of each period.

5. Interest rates, prices, and wage rates remain constant within the interior of each period, but can change discretely at the boundaries of periods.

[10] However, credit is given to Donovan (1977) who is the first to reach such a user cost imputation through general economic reasoning without employing a model.

Therefore, capital gains (or losses) resulting from changes in market bond yields can take place only at the boundaries of periods. In this respect, consumers are assumed to sell and to buy all bond holdings at the end of each period.

6. Labor supply is exogenously determined, and labor supplies during all periods of the consumer's planning horizon are blockwise weakly separable from all other variables in the consumer's utility function.

As with all goods and services, the changes in the price of monetary services will affect both the demand for and supply of monetary services and other non-monetary goods and services. In addition to substitution and income effects, there are wealth effects associated with monetary assets. Monetary wealth is measured by the discounted present value of the representative consumer's expected expenditure on monetary services and Barnett (1978, 1987) incorporates the multi-period budget constraints for the intertemporal decision into a single budget constraint. The following multi-period budget constraint,

$$\sum_{i=1}^{n} p_{is} z_{is} = w_s L_s + \sum_{i=1}^{n} \left[(1+r_{i,s-1}) p^*_{s-1} m_{i,s-1} - p^*_s m_{i,s} \right] + \left[(1+R_{s-1}) p^*_{s-1} A_{s-1} - p^*_s A_s \right]$$

turns out to be a single budget constraint with monetary assets being included therein through the following term:

$$V_t = \sum_{s=t}^{T} \sum_{i=1}^{n} \left[\frac{p^*_s}{\rho_s} - \frac{p^*_s (1 + r_{is})}{\rho_s + 1} \right] m_{is}$$

$$= \sum_{s=t}^{T} \sum_{i=1}^{n} \pi_{is} m_{is},$$

where the discount factor and the discounted nominal user costs are $\rho_s = \begin{cases} 1, & \text{s=t} \\ \prod_{u=1}^{s-1}(1+R_u), & \text{t+1} \le \text{s} \le \text{t+T} \end{cases}$ and π_{is}, respectively.

Letting T go infinity and evaluating V_t at the optimum, yields the following:

$$V_t = \sum_{s=t}^{\infty}\sum_{i=1}^{n}\pi_{is}m^*_{is} = \sum_{s=t}^{\infty} y_s$$

where y_s is the discounted expected optimal total expenditures on monetary assets in period s. V_t might be regarded as the discounted present value of all current and future expenditures on monetary services. The consumer maximizes its utility conditional upon the single wealth constraint and the user cost of m_{is} can be modified to show that current period user cost equals

$$\pi_{it} = p^*_t \frac{R_t - r_{it}}{1+R_t}$$

Now it is possible to summarize the aggregation procedure using the statistical index number theory. Assuming that q_t and p_t are the vector of quantities consumed of the goods (monetary assets) and the vector of goods' prices respectively, a chained statistical index number is a function f(p_t, q_t, p_{t-1}, q_{t-1}) of current and lagged quantities and prices. Seeking a statistical price index means looking for a function f, such as f(p_t, q_t, p_{t-1}, q_{t-1}), that will represent the correct price aggregate P(p_t) between periods t and t-1. In this respect, seeking a statistical quantity index means looking for a function f such as f(p_t, q_t, p_{t-1}, q_{t-1}), that will represent the correct quantity aggregate Q(q_t) between periods t and t-1. The function f contains both prices and quantities whereas P contains only prices and Q contains only quantities.

However, P and Q also contain unknown parameters whereas f does not. Thus, economic aggregation underlies the properties of aggregates like P and Q, and statistical index number theory provides estimators of these unknown exact economic aggregates. This is the reason monetary aggregation uses the non-parametric approach of the statistical index number theory to determine the monetary aggregates (Barnett 1984).

After I establish the relationship between monetary aggregation and the statistical index number theory, it would be convenient to identify the statistical index numbers that can be employed for monetary aggregation. In the next section, the formulation and characteristics of these monetary aggregates are introduced.

2. The Formulation of New Monetary Aggregates

Statistical index numbers possess characteristics that monetary aggregation theory relies on while building new monetary aggregates. As stated previously, aggregation theory needs statistical index numbers whose foundations are laid by Irving Fisher (1922). He actually describes the statistical properties of statistical indices and provides a set of test so as to assess the quality of the statistical index. These statistical properties are classified as good and bad properties. While the weak factor reversal test and the circulatory test[11] are the well known good properties, the bias and freakishness are the bad ones. The bad properties are attached to only one index, which is simple sum. Referring to the simple sum index, Fisher

[11] Weak factor reversal test argues that the price times quantity of an index for an aggregated good must equal actual expenditure on the component goods, whereas the circulatory test establishes the path independence of the index.

(1927) argues that simple arithmetic average produces one of the very worst of index numbers.

Fisher believes that the satisfactory statistical properties are well incorporated to index numbers so that these statistical indices are known as Fisher Ideal Index, which is the geometric mean of two weighted averages. One other index that carries several good characteristics has been improved by Törnqvist (1936). This index has been termed as the Divisia index by the advocates of the new monetary aggregation literature. Theil (1967) demonstrates that the Divisia price and quantity indexes are naturally produced as the aggregation formulas in information theory. Thus, usually the Divisia index used for the formulation of one of the new monetary aggregates is known as the Törnqvist-Theil monetary services index. One closely related formulation of the Divisia index is the CE Index. The following sections introduce the formulation of these indices while discussing their characteristics.

2.1. Divisia Monetary Aggregates

Divisia index which carries important statistical properties was originated by Francois Divisia (1925). The idea behind the construction of this index was to measure the flow of monetary services provided by the financial assets.

Divisia index differs from the simple sum index in such a way that the former assigns weights to each of its components according to the extent that they provide monetary services, whereas the latter attaches the same weight to each component. Besides that, the calculation of user costs matters in order to assign weights for the components of Divisia monetary aggregates and the individual monetary services obtained from asset components of Divisia are proxied by these user costs. In contrast, simple-sum aggregates are constructed by simply adding the dollar amounts of the component assets whose weights are treated equally. Among two versions of Divisia Index, both discrete and continuous, this thesis will examine the properties of the discrete time version due to the panel data analysis of the empirical section.

The discrete time Divisia index for period t is D_t,

$$\frac{D_t}{D_{t-1}} = \prod_{i=1}^{n} (m_{it} / m_{i,t-1})^{(1/2)(s_{it}+s_{i,t-1})}$$

where m_{it} is the holding (quantity) of monetary asset i at time t,

$s_{it} = \pi_{it} m_{it} / \sum_i \pi_{it} m_{it}$

π_{it} is the user cost (price) of asset i at time t,

Taking logarithms of each side, we obtain

$$\ln D_t - \ln D_{t-1} = \sum_{i=1}^{n} s*_{it} (\ln m_{it} - \ln m_{i,t-1})$$

where $s*_{it} = 1/2(s_{it} - s_{i,t-1})$

This formulation shows that the Divisia index is a weighted sum of its components' growth rates, where the weight for each component is the expenditure on that component as a proportion of the total expenditure on the aggregate as a whole. Thus, the Divisia index is in accordance with the microeconomic theory of optimization.

2.2. Currency Equivalent Index

Another new monetary aggregate, which is closely related to Divisia index is the Currency Equivalent (CE) index whose theoretical origins were established by Hutt (1963) and Rotemberg (1991). However, the theoretical framework of the CE index has been introduced by Rotemberg *et. al.* (1995). The CE index is the total stock of currency required to provide the same amount of transactions services that is provided by all monetary assets. In other words, the CE index is a time-varying weighted average of the stocks of all monetary assets, where weights are the ratio of each asset's user cost to a benchmark "zero liquidity" asset, i.e. currency.

While the CE index is a weighted average of the levels of monetary assets, the Divisia index is a weighted average of growth rates of monetary assets. In this sense, the CE index is derived within the same theoretical framework as the Divisia index. The formulation of the CE index that is described by Rotemberg *et. al.* (1995) is

$$CE_t = p^* \sum_{i=1}^{n} ((r_{b,t} - r_{i,t}) / r_{b,t}) m_{i,t}$$

where p^* is a true cost-of-living index, r_{bt} is the return on the benchmark asset, r_{it} is the return on the monetary asset i, and m_{it} is the quantity of monetary asset held at time *t*.

Under static expectations CE equals the discounted present value of expenditures on liquidity services, where those expenditures can be measured employing the Divisia index (Barnett, 1991). The total expenditures in period t equal $\sum (r_{b,t} - r_{i,t}) m_{i,t}$ which denotes the total amount of interest foregone by holding monetary assets rather than the benchmark asset. Assuming static expectations, the present value of these expenditures equals their level divided by the rate of return on the benchmark asset. This actually constitutes the CE aggregate.

After emphasizing the difference between simple sum and other new monetary aggregates (both Divisia and CE index), it would be better to have a look at the historical performance of monetary aggregates in developed countries such as U.S, U.K, Euro Area and Japan.

3. Historical Performance of Monetary Aggregates in Developed Countries

The monetarist view that inflation can only be reduced by slowing down the rate of growth of the money supply had an important effect on the course of monetary policy conducted in the U.S and in the U.K during the early 1980s. For instance, the U.K government elected into office in 1979, as part of its medium term financial strategy, sought to reduce progressively the rate of monetary growth in order to achieve the objective of permanently reducing the rate of inflation. Besides that, the recessions experienced in the U.S and U.K economies in 1981-82 and 1980-81, respectively supported the view that inflation can not be reduced without incurring the output-employment costs. The Thatcher government in the U.K (in the period of 1979-85) and the Fed in the U.S (in the period of 1979-81) were under the significant influence of monetarism. However, unexpected decline in velocity, which resulted in the recessions mentioned above, caused the constant growth rate monetary rule advocated by Friedman to be completely discredited. In addition to the decline in velocity seen in the early 1980s, the financial innovation started to destabilize the stable relationships between the monetary aggregates chosen for targeting and the ultimate target variables.

Not only Barnett (1980) presented plausible explanations for the problems with the targeted monetary variables, but also Goodhart (1984) suggested that the act of targeting in terms of restricting the growth of a particular monetary aggregate would lead to circumventive innovation and that the stable historical relationship between the monetary aggregate and the target variable would be destabilized as a result. Therefore, in such an environment, it would be insensible to construct a monetary aggregate by simply summing monetary components. The next subsections will mention about the historical performance of monetary policies of the countries of interest in terms of the comparison of simple sum and Divisia monetary aggregates.

3. 1. United States:

The microfoundations approach has its origins in the United States. It is not surprising to note that several studies have concluded in favour of the Divisia indices over the simple-sum monetary aggregates that the Federal Reserve use (Barnett 1980, Barnett *et. al.* 1984, Serletis 1988, Chrystal and MacDonald 1994, Belongia 1996b, Fisher 1996 and Fisher *et. al.* 1998). Moreover, Rotemberg *et. al.* (1995) presented evidence from another monetary aggregate, the CE index. On the other hand, despite the theoretical and empirical superiority of these indices to their simple sum counterparts, economists generally have preferred to continue using the official simple sum measures reported by central banks. By the end of 1980s, this led two troublesome effects. The first one was that many studies relating money to economic activity started to signal that money had no effect. The second was that Federal Reserve and most of the primary central banks were forced to deal with the velocity problem. The misleading pattern of the simple sum indices was acknowledged when the Fed Chairman Alan Greenspan announced on July 1993 that the Fed would abandon money in favour of targeting the ex ante real interest rate.

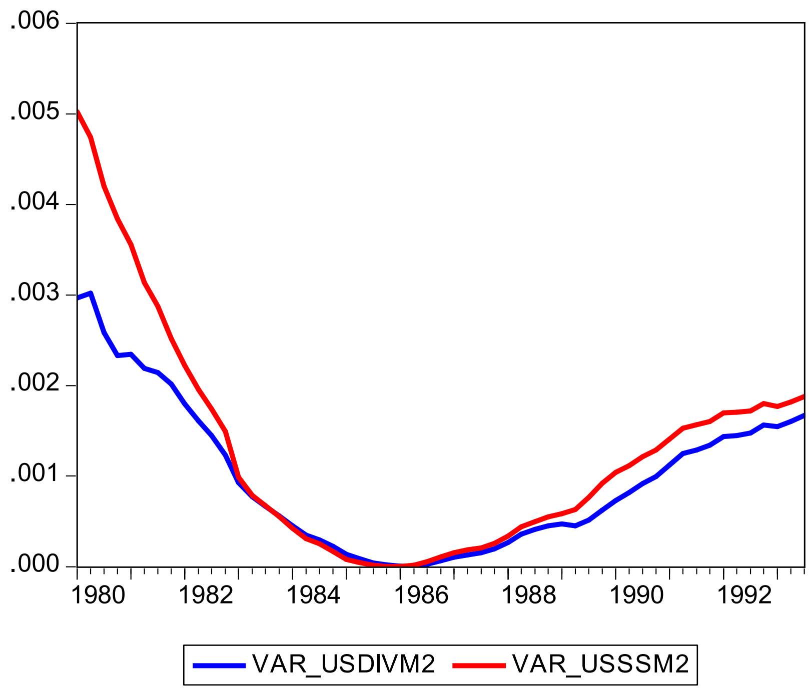

Fig. 1. Variance of Simple Sum and Divisia M2 in U.S

Figure 1 illustrates the variation of the levels of Divisia M2 and its simple sum counterpart for the case of U.S covering a quarterly period between 1980 and 1993. Even though the variation pattern of simple sum M2 and Divisia resembles, two aggregates differ greatly in high inflation years in the early 1980s such that the variation of the former is greater in these years in comparison to the variation of the latter, meaning that this high inflation period was well captured by the Divisia M2.

3.2. United Kingdom:

The last three decades have seen the most substantial evolution in the financial and monetary sectors in the U.K like many industrial countries. As Ford and Mullineux (1996) argue, the competition between commercial banks and building societies has been the driving force of the financial innovations. The new products offered included payment of interest on checking accounts as well as new types of checking accounts for which there had to be no minimum balance. Moreover, the computer revolution has added automated machines (ATMs) and electronic funds transfer at the point of sale (EFTPOs) into banking industry services and hence has substantially affected the demand for cash and their role upon the economy, particularly through the monetary services provided by bank cheque accounts.

The effects of these developments have been considered by several studies and the Divisia indices seem to perform better than their simple-sum counterparts (Ford *et. al.* 1992, Fisher *et. al.* 1993, Mullineux 1994, Spencer 1994, Ford and Mullineux 1996). For instance, Ford and Mullineux (1996), as previously stated, mentioned about the effects of two innovations (implicit interest effect and computer revolution effect) on the construction of a Divisia index of monetary services.

Like the Federal Reserve, Bank of England (BoE) has taken an active interest on the calculation of Divisia monetary indices, publishing a series in its Quarterly Bulletin based on the components of the simple sum aggregate M4 whose composition is examined under the first section of Monetary Aggregation. The Bank not only considered the demand for Divisia money (by both the private sector and the corporate sectors separately and collectively) but also the policy information content of a particular Divisia monetary aggregates.

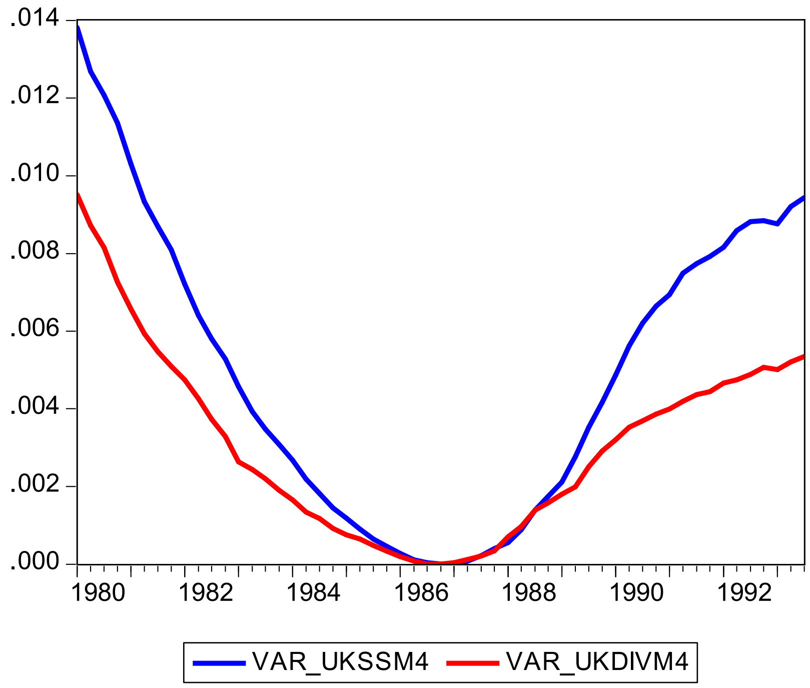

Fig. 2. Variance of Simple Sum and Divisia M4 in the U.K

The time profiles for the variation of both simple sum and Divisia monetary aggregates are illustrated in Figure 2. As can be seen, they again exhibit a similar pattern as in the case for the U.S. However, the volatility measured by the variance of each aggregate indicates that the variance of simple sum M4 is seen at high levels when compared to the variance of its Divisia counterpart.

Between the periods from 1977 and 1985, the existence of an implicit net tax rate of interest on non-interest bearing accounts made the two indices to diverge. However, this rate has been decreasing in the 1990s, as banks have started to raise charges to cover the costs of providing money transmission services.

3.3. Euro Area:

Many studies in the literature regarding the properties of money indicators in the euro area have focused so far on simple sum monetary aggregates (see Coenen and Vega, 1999, Brand and Cassola, 2000, Calza, Gerdesmeier and Levy, 2001, and Stracca, 2001). However, the study by Stracca (2001) in which the time series Divisia index data has been used in this thesis, analyzes the properties of a Divisia-weighted monetary aggregate in the euro area and aims at constructing a Divisia monetary aggregate based on the short term financial instruments included in the euro area monetary aggregate M3[12]. His study makes use of euro area data covering a quarterly period between 1980 and 2000, aggregated prior to 1999 based on the

[12] Among others, the studies by Fase (2000), Spencer (1995) and Drake, Mullineux and Agung (1997) have suggested constructing a Divisia monetary aggregate for the euro area.

irrevocable exchange rates of December 31, 1998 on which the conversion rates between the 11 participating national currencies and the euro are established.

In order to construct historical Divisia aggregates for the euro area, it is necessary to discuss alternative aggregation schemes since monetary components of different countries have to be used. However, these aggregation schemes may differ in terms of assumptions about the representative agent. These assumptions are explained under three titles in the study by Reimers (2001) which are the assumption of one representative agent, assumption of representative national agents and the assumptions regarding the exchange rates. This thesis takes the third assumption into consideration.

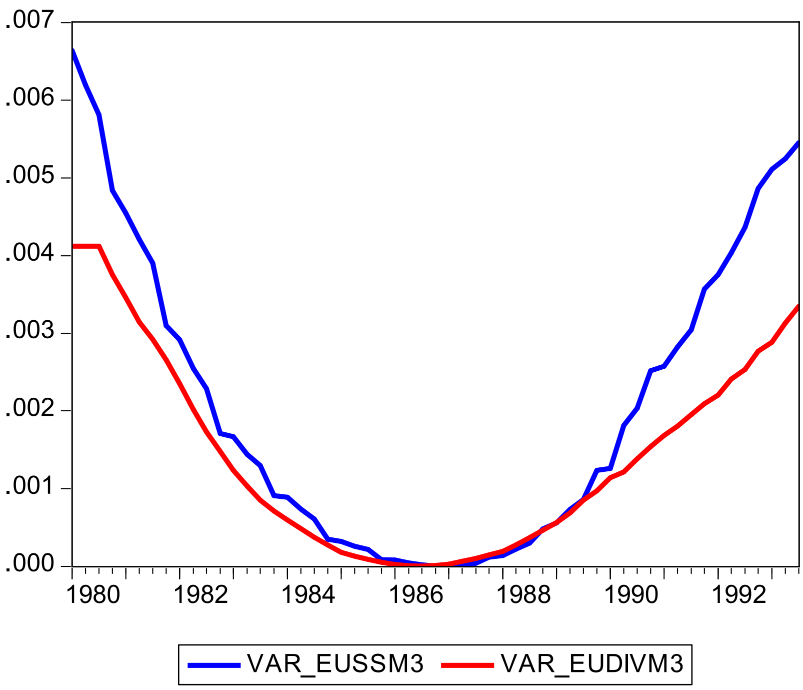

Fig. 3. Variance of Simple Sum and Divisia M3 for Euro Area

In Figure 3, the historical performance of two monetary aggregates (simple sum and Divisia) is illustrated through the variance thereof. Despite the fact that the time profile of the level of these two series has the similar upward trend, the simple sum index has much more volatility than its Divisia counterpart as indicated in the variation patterns of these two aggregates, especially at the beginning of the 1980s.

3.4. Japan

The deregulation efforts in Japan started in the 1980s (Hirayama and Kasuya, 1996). The main changes were the introduction of deposits with unregulated interest rates, and the issue of certificates of deposits. After this first wave of financial innovations, money market certificates (MMCs) were offered by commercial banks in 1985. Finally, interest rates on all time deposits were fully deregulated in 1993. These changes were reflected in empirical studies of money demand. Yoshida and Rasche (1990) present evidence for a structural break for broad money in 1985, following on the introduction of the MMCs. On the other hand, McKenzie (1992) shows that a structural shift has taken place in 1980, as the financial deregulation has started. Hirayama and Kasuya (1996) argue that the Divisia indices do not have characteristics to outperform the simple-sum monetary aggregates depending on their empirical results. On the other hand, Chrystal and MacDonald (1994) provide some support for Divisia indices. These controversial findings mean that it is important to consider weighted monetary aggregates for Japan with different techniques to search for a better explanation which will be given in the empirical part of this thesis.

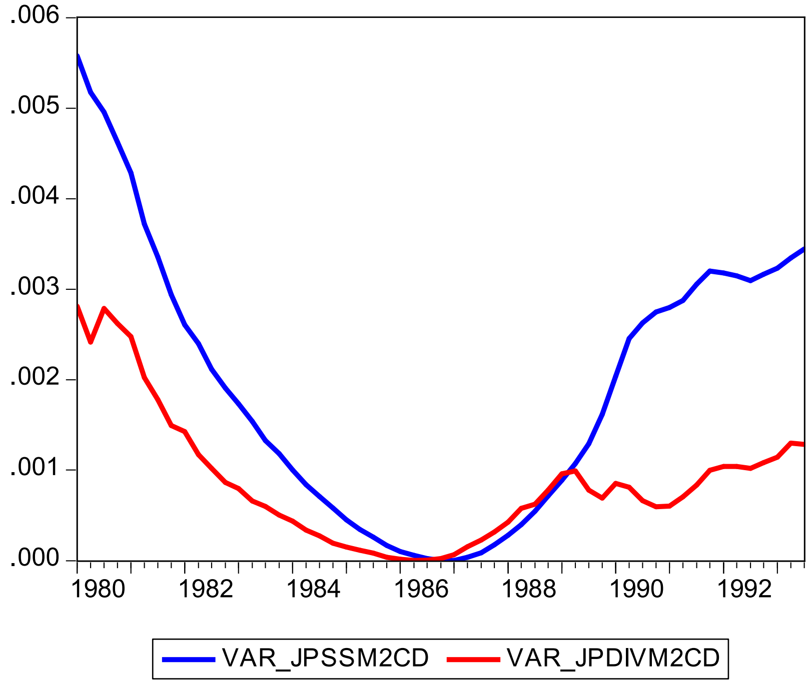

Fig. 4. Variance of Simple Sum and Divisia M2+CD for Japan

Figure 4 illustrates the variation pattern of the simple sum and its Divisia counterpart. The volatility pattern seen in simple sum M2+CD is similar to one seen in the previous country cases (high volatility until the late 1980s followed by a stability period and then again high volatility up to 1993). However, the variation in Divisia monetary aggregates of M2+CD lose some momentum in the late 1980s and from the beginning of the 1990s, the trend returns to its previous course.

4. Econometric Methodology and Empirical Results for Developed Countries

This section includes the methods employed in this thesis and the empirical assessment of the monetary aggregates (both simple sum and Divisia) of the developed countries (United States, United Kingdom, Euro Area and Japan). After presenting the relevant econometric methods used in this thesis and focusing on several studies that have tested the empirical validity of the new monetary aggregates, I have evaluated the empirical results of the tests applied in this thesis for these four developed countries.

4.1. Econometric Methodology

Since macroeconomists generally deal with time series data in their empirical study, the problem of non-stationarity arises because some financial time series are not stationary in their levels and many time series are mostly represented by first differences. In order to avoid the spurious regression problems resulted from these non-stationary series, it would be convenient to observe the linear combinations of such non-stationary series so as to check whether these combinations somehow reveal stationarity. In this context, unit root tests are applied in order to check whether the variables of interest reveal non-stationarity and then cointegration test is employed after detecting the existence of non-stationarity of the each time series.

Since the power of the individual or univariate unit root tests is restricted due to the short data span of the macroeconomic time series, it would be appropriate to construct a panel of time series and cross section dimension so as to allow for high degrees of freedom and higher efficiency and hence increase the power (Bai and Ng 2004a). In this thesis, I have dealt with a panel data from a group of countries and used econometric tools such as panel unit root tests, panel cointegration tests and panel Fully Modified Ordinary Least Squares (FMOLS) estimation which will be discussed in the following sub-sections.

Before analyzing the relevant panel data, I have estimated the system equations through the Seemingly Unrelated Regression (SUR) not only for accounting for heteroskedasticity and contemporaneous correlation in the errors across equations, but also for supporting the tests on panel data with SUR analysis.

4.1.1. Seemingly Unrelated Regression (SUR) Analysis

The seemingly unrelated regression (SUR) method, also known as the multivariate regression, or Zellner's method, estimates the parameters of the system, taking account of the heteroskedasticity and contemporaneous correlation in the errors across equations. The estimates of the cross-equation covariance matrix are based upon parameter estimates of the unweighted system.

The model analyzed by Zellner (1962) considers involved m regression equations, ($Y_t = A(\beta)' X_t + U_t$ where a=1, 2, …., m) that seem unrelated (so the term seemingly unrelated regression is used) and allows dependent variables to depend on different sets of independent variables. Moon and Perron (2006) mention about two motivations for use of SUR. The first one is to obtain new estimates that are asymptotically more efficient than usual least squares estimates. The second one is to impose and/or test restrictions that involve parameters in different equations.

If the SUR model is written in a form of a multivariate regression with parameter restrictions, we obtain the following:

$$Y_t = A(\beta)' X_t + U_t$$

where $X_t = \left[x'_{1t}, x'_{2t}, ..., x'_{NT}\right]'$ and $A(\beta) = diag(\beta_1, ...\beta_N)$ is a block diagonal coefficient matrix.

When the non-constant regressors in X_t is integrated nonstationary variables but the errors in U_t is stationary, the above model is said to be a seemingly cointegration regression model. Moon and Perron (2004) argues that for efficient estimation of β, an estimator of the long run variance of U_t, should be used in the feasible Generalized Least Squares (GLS).

4.1.2. Panel Unit Root Tests

Three types of panel unit root tests have been employed in this thesis in order to verify that all the variables have the same integrated order in levels. The first two tests, termed as the first generation unit root tests, include the tests of Levin, Lin and Chu (2002) and Im, Peseran and Shin (2003). The last one, termed as the second generation unit root test, includes the test of Peseran (2007). The first generation unit root tests are constructed according to the assumption that the individual time series in the panel are cross-sectionally independent, whereas the second generation unit root tests disregard the cross-sectional independence.

4.1.2.1. Levin, Lin and Chu (2002) Test (LLC Test)

Levin, Lin and Chu (2002) – hereafter LLC – presenting a generalization of Quah's model[13], allows for heterogeneous individual deterministic effects and heterogeneously serially correlated error term structure assuming homogenous first order partial autoregressive parameters and imposing a cross-equation restriction on the coefficients of these parameters under the null hypothesis that Ho: $\rho_i = \rho = 0$ against the alternative Ho: $\rho_i = \rho < 0$ for all *i* meaning that LLC assumes homogenous autoregressive coefficients between individuals.

The structure of LLC might be expressed as follows:

$\Delta y_{it} = \rho y_{it-1} + \alpha_{0i} + \alpha_{1i} t + \varepsilon_{it}$, i = 1,2,….N , t = 1,2,…..T

where a time trend (α_{1i} t), which is the source of the heterogeneity in the model, and individual effects (α_{0i}) are included. In this equation, the coefficient of the lagged dependent variable is restricted to be homogenous across all units in the panel.

When the disturbances are identically and independently distributed (i.i.d) and there are no individual-specific fixed effects, the panel unit root t-statistic converges to the standard normal distribution when the number of time series observations (T) and the number of groups or individuals (N) go to infinity. The existence of fixed effects, time trends or serial correlation in

[13] In the case of a large size of N and T, Quah (1990, 1994) derives the asymptotic standard normality of the Dickey Fuller unit root test statistic for a model with i.i.d disturbances and no heterogeneity across groups. However, the random field approach used in the model is insufficient for more general model specifications such that this approach is unable to incorporate the individual fixed effects and serial correlation in disturbances.

disturbances paves the way for adjusting the t-statistic obtained from Monte Carlo simulation (Levin and Lin 1992).

4.1.2.2. Im, Peseran and Shin (2003) tests

Using the likelihood procedure, Im, Peseran and Shin (2003) – hereafter IPS – suggest a new unit root testing procedure for panels in which they propose a new test statistic (t-bar statistic) based on the mean of Augmented Dickey Fuller statistics computed for each cross section units in the panel. IPS test allows for residual serial correlation and heterogeneity of error variances across groups. The model takes the following form:

$$\Delta y_{it} = \alpha_{0i} + \rho\, y_{it-1} + \sum_{j=1}^{p_i} \varphi_{ij} \Delta y_{it-j} + \varepsilon_{it}, \; i = 1,2,\ldots N, \; t = 1,2,\ldots T$$

The null hypothesis Ho: $\rho_i = 0$ (for all i) is tested against the alternative:

$$H_a = \begin{cases} \rho_i < 0 \; for \; i = 1,\ldots N_1 \\ \rho_i = 0 \; for \; i = i = N_1 + 1,\ldots N \end{cases} \quad \text{with } 0 \leq N_1 \leq N$$

Baltagi (2005), focusing on the main advantages of IPS test, argues that this test might be used for unbalanced panels and permits different lag values in ADF tests that are calculated for every horizontal sections.

4.1.2.3. Peseran (2007) CIPS Test

Unlike the first generation unit root tests mentioned above, the second generation tests, one of which is CIPS test used in this thesis rejects the cross sectional independence hypothesis. Peseran (2007) proposes an alternative to the standard panel unit root tests such that standard augmented Dickey-Fuller (ADF) regressions for the individual series are augmented with the cross section averages of the lagged levels and the first differences of the individual series. In the case of serially correlated error terms in addition to the cross-section dependence, the average of the cross sectionally ADF t-statistics give the CIPS t-statistics.

4.1.3. Panel Cointegration Tests

Three panel cointegration tests have been applied in this thesis after checking whether the variables of interest are non-stationary and have the same integration levels. These panel cointegration techniques applied here include Pedroni (1999), Westerlund (2007), and Westerlund and Edgerton (2007) tests.

4.1.3.1. Pedroni (1999, 2004) Test

Pedroni (1999, 2004), extending the cointegration approach developed by Engle and Granger (1987), proposes several tests for cointegration that allow for heterogeneous intercepts and trend coefficients across cross-sections. Under the null hypothesis of no cointegration (ρ_i = 0), the residuals obtained from the regression of the dependent variable y_{it} on the explanatory variables x_{it} and a deterministic trend t are tested in order to check whether they are integrated of order one, I(1). For each cross section, the following auxiliary regression is run:

$$e_{it} = \rho_i e_{it}-1 + \sum_{j=1}^{p_i} \Psi_{ij} \Delta e_{it-j} + \upsilon_{it}$$

There are two alternative hypotheses, one of which is the homogenous alternative ($\rho = \rho_i$ < 1 for all i) termed as the panel statistics test and the other of which is the heterogeneous alternative (ρ_i < 1 for all i) termed as the group statistics test[14].

4.1.3.2. Westerlund (2007) ECM Panel Cointegration Tests

Westerlund (2007) proposes a panel cointegration test – ECM test – with null hypothesis of no cointegration. ECM tests are based on structural rather than residual dynamics so that there is no common factor restriction. There are four test statistics two of which are panel statistics which are based on pooling the error correction information along the cross sections and the rest two of which are group statistics which do not exploit the error correction information. The panel statistics (P_τ and P_α) and the group statistics (G_α and G_τ) are estimated as follows:

$$G_\tau = \frac{1}{N}\sum_{i=1}^{N}\frac{\hat{\alpha}_i}{SE(\hat{\alpha}_i)} \quad , \quad G_\alpha = \frac{1}{N}\sum_{i=1}^{N}\frac{T\hat{\alpha}_i}{\hat{\alpha}_i(1)} \qquad i = 1,\ldots N \;\; t=1,\ldots T$$

$$P_\tau = \frac{\hat{\alpha}}{SE(\hat{\alpha})} \quad , \quad P_\alpha = T\hat{\alpha} \qquad i = 1,\ldots N \;\; t=1,\ldots T$$

where $\hat{\alpha}$ is the error correction estimator and the $\hat{\alpha}_i(1)$ is the semi-parametric kernel estimator of α (1).

4.1.3.3. Westerlund and Edgerton (2007) Panel Cointegration Tests

The final cointegration test[15] used in this thesis is the one by Westerlund and Edgerton (2007) who propose a bootstrap test of the null hypothesis of

[14] These tests are regarded as the first generation panel cointegration tests.
[15] The bootstrap cointegration test developed by Westerlund and Edgerton (2007) and the previously discussed ECM test are termed as the second generation panel cointegration tests.

cointegration in the panel data. The test is based on the Lagrange multiplier test of McCoskey and Kao (1998)[16] and might handle the dependency within and between the cross sectional units. This Lagrange multiplier test is very sensitive to serial correlation even if the residuals are cross sectionally independent leading the asymptotic critical values obtained from this test to be deceptive in small samples. Therefore, Westerlund and Edgerton (2007) recommend using bootstrap critical values.

4.1.4. Panel Fully Modified OLS Estimation

This thesis has utilized the methodologically sound Fully Modified Ordinary Least Squares (FMOLS) procedure developed by Pedroni (1999b, 2001) due to the fact that OLS estimator is biased and inconsistent when applied to cointegrated panels. FMOLS estimation not only generates consistent estimates of the variables of interest but also checks for endogeneity of the regressors and serial correlation. In this context, after employing cointegration tests which signal a long run link between the pooled variables, I have proceeded with panel FMOLS estimation in order to have consistent estimates of the relevant panel variables in the cointegrated money demand equation.

Pedroni (1999b) argues that even in case of very small number of group or individuals (N) and number of observations (T), the bias of the group mean FMOLS estimator is very small meaning that small sample properties of the estimator and t-statistic behave very well. He also argues that this result is

[16] The asymptotic test of McKoskey and Kao (1998) is not equipped to deal with the cross sectional dependence and therefore some bootstrap techniques are applied in order to increase the test performance.

valid for panels with heterogeneous serial correlation dynamics, individual-specific effects and endogenous regressors.

The group mean panel FMOLS provides t-statistic to test a common value for cointegrating vector under the null hypothesis that values of the cointegrating vector are common versus the alternative that those values need not to be common. The FMOLS group mean estimator is derived by averaging the value of individual FMOLS estimates.

4.2. Empirical Results

Before giving the results of the econometric techniques employed in this thesis, it would be better to examine the other studies focusing on the comparison of simple sum monetary aggregates with their Divisia counterparts despite the fact that this thesis has partially mentioned about the literature of interest concerning four developed country cases.

There have been many studies in the literature comparing the simple sum and Divisia monetary aggregates. For instance, Marquez (1985), in his study covering a quarterly period between 1974 and 1982 for U.S, removes the assumption of perfect substitution and touches upon the currency substitution by using Divisia monetary aggregates. Belongia and Chrystal (1991) utilize tests for weak separability for the monetary aggregates of the U.K and find that a Divisia measure of sterling M4 might be preferred to the aggregates currently targeted. Cynse (2000) also suggest the use of Divisia monetary aggregates in order to measure welfare losses resulted from interest rate fluctuations and inflation. Furthermore, the study by Oda and Okina (2001) illustrates the Divisia index for Japan (consisting of base money, short-term government bonds and BoJ bills sold) such that the exchange between base money and short term government bonds causes a quantative monetary easing since these two components are different in terms of moneyness. Acharya and Kamaiah (2001), in their study for the Indian case, establish the superiority of Divisia index using two different periods, one for annual and the other for monthly. Another study by Reimers (2001) examines the historical Divisia aggregates for euro area using cointegrated VEC model and single-equation techniques and argues that Divisia monetary aggregates include smaller exchange rate affects so that they might well present the historical money development in euro area. Dahalan (2004) also investigated different measures of monetary assets, namely M1, DM1 and M2, DM2 and found a long run link between all measures of monetary aggregates with inflation using dynamic error correction models for the alternative measures of monetary aggregates. Besides that, one of the most recent studies testing the forecasting performance of Divisia monetary aggregates is by Binner *et.al* (2009) who argues that both Divisia M2 and M3 have direct effects on aggregate demand for the period between 1980 and 2005 and also between 1991 and 2005 and focuses on the potential ability for predicting euro area inflation.

It should also be noted that this thesis refers to the conventional money demand framework (Keynesian) while testing the empirical validity of the microfoundations approach. As is well-known, the conventional money demand framework is the real money balances function, expressed as

$$M^D/P = f(Y, r)$$

where M^D/P is the real quantity of money demanded, Y is the real income and r is the nominal interest rate. However, microfoundations approach expresses the nominal quantity of money demanded (M^D) as the flow of monetary services received from the monetary assets in the portfolio of an economic agent. This is achieved through accounting for the effects of different opportunity costs of monetary assets. Keynesian money demand function uses the simple sum monetary aggregates for M^D whereas the microfoundations approach replaces M^D with Divisia monetary aggregates.

In this thesis, the first part of the empirical analysis includes the SUR method in which the estimates of each system equation are revealed. After that, I employed panel unit root tests (classified as first generation (Levin *et. al* (2002); Im *et. al* (2003)) and second generation (Pesaran (2007)) unit root tests for 4 variables[17] (Divisia index, simple sum index, real GDP and 10-year government bond yields) 4 advanced countries, which are U.S, U.K, E.A and Japan with a quarterly time period between 1980Q1 and 1993Q3. After I detected the existence of non-stationarity at the same integration order, I proceeded with panel cointegration tests with the same classification as in the panel unit root tests and employed first generation (Pedroni (2004)) and second generation (Westerlund (2007) and Westerlund and Edgerton (2007)) panel cointegration tests in order to check whether there is a long rung link between the variables of interest. As the final part of the empirical study, I kindly demonstrated the results of individual and panel FMOLS (Fully Modified Ordinary Least Squares) in order to estimate the

[17] Details for all the variables and their characteristics will be presented in the Appendix.

coefficients obtained from the panel cointegration test and also to test the robustness of the long run relationship. In this respect, I utilize two equations to see the effect of real GDP (Y) and government bond yields (R) on the Divisia index (DIV) and compare this index with its simple sum (SS) counterpart. These two equations are presented in the following:

$$\log (DIV_t) = \alpha_0 + \alpha_1 \log (Y_t) + \alpha_2 R_t$$

$$\log (SS_t) = \alpha_0 + \alpha_1 \log (Y_t) + \alpha_2 R_t$$

By taking into account these two equations, I applied the relevant panel unit root and cointegration tests. Before giving the results of those tests, it would be convenient to apply the SUR method so as to take account of the correlation of the error terms across equations. Since I wanted to test the superiority of Divisia monetary aggregates over its simple sum counterpart, I applied each regression (both iterative and two-step GLS) based on two dependent variables, both of which are simple sum and Divisia monetary aggregates. Table 1 and Table 2 demonstrated below gives the results of two-step GLS method for simple sum and Divisia.

Table 1: Two-step GLS - Dependent Variable SS

Two Step GLS				
System: SUR				
Sample: 1980Q1-1993Q3				
Dependent Variable: SS				
	Coefficient	**Std. Error**	**t-Statistic**	**Prob.**
C(1)	- 8.1405	0.6251	- 13.0226	0.0000
C(2)	8.5352	0.3806	22.4280	0.0000

C(3)	- 0.9241	0.3962	- 2.3324	0.0206
C(4)	- 15.3386	1.3849	- 11.0754	0.0000
C(5)	4.4019	0.2572	17.1137	0.0000
C(6)	- 0.9865	1.9470	- 0.5067	0.6129
C(7)	- 8.1274	0.5013	- 16.2142	0.0000
C(8)	3.0511	0.1056	28.8917	0.0000
C(9)	- 1.3077	0.4997	- 2.6171	0.0095
C(10)	- 4.2882	0.1172	- 36.5764	0.0000
C(11)	1.9455	0.0230	84.6262	0.0000
C(12)	- 0.5304	0.1716	- 3.0906	0.0023

Equation: LUSM2 = C(1) + C(2)*LUSGDP + C(3)*USR			
R-squared	0.961078	**Mean dep. var**	5.126495
Adjusted R-squared	0.959581	**S.D. dep. var**	0.265385
S.E. of regression	0.053354	**Sum sq. resid**	0.148027
Durbin-Watson stat	0.109347		
Equation: LUKM4 = C(4) + C(5)*LUKGDP+C(6)*UKR			
R-squared	0.929616	**Mean dep. var**	5.468773
Adjusted R-squared	0.926909	**S.D. dep. var**	0.520515
S.E. of regression	0.140723	**Sum sq. resid**	1.029753
Durbin-Watson stat	0.850093		
Equation: LEUM3 = C(7) + C(8)*LEUGDP+C(9)*EUR			
R-squared	0.963014	**Mean dep. var**	5.204183
Adjusted R-squared	0.961591	**S.D. dep. var**	0.338741
S.E. of regression	0.066387	**Sum sq. resid**	0.229175
Durbin-Watson stat	0.124089		
Equation: LJPM2CD = C(10) + C(11)*LJPGDP+C(12)*JPR			

R-squared	0.993912	**Mean dep. var**	5.154224
Adjusted R-squared	0.993678	**S.D. dep. var**	0.324745
S.E. of regression	0.025821	**Sum sq. resid**	0.034671
Durbin-Watson stat	0.571349		

Two step GLS estimation in which the simple sum aggregates (SS) is regarded as dependent variable reveals high R^2 values for each cross section equation. Since it is a rule for the SUR method that the number of explanatory variables in each cross-section equation should be the same, the explanatory variables in four equations indicated in the above table are in common. Table 1 also shows statistically significant coefficients for all variables except the one for the interest rate of the United Kingdom. The signs of the coefficients are also consistent with the expectations such that the coefficients for income are positive, whereas the ones for interest rate are negative.

Table 2: Two-step GLS - Dependent Variable DIV

Two Step GLS				
System: SUR				
Sample: 1980Q1-1993Q3				
Dependent Variable: DIV				
	Coefficient	**Std. Error**	**t-Statistic**	**Prob.**
C(1)	- 6.2109	0.4283	- 14.5002	0.0000
C(2)	7.1899	0.2592	27.7348	0.0000
C(3)	- 1.3348	0.2851	- 4.6819	0.0000
C(4)	- 10.2449	0.8895	- 11.5175	0.0000
C(5)	3.4035	0.1671	20.3686	0.0000
C(6)	- 1.9715	1.2085	- 1.6313	0.1043

C(7)	- 4.9965	0.4044	- 12.3548	0.0000
C(8)	2.3410	0.0847	27.6488	0.0000
C(9)	- 2.4140	0.4097	- 5.8926	0.0000
C(10)	- 3.3983	0.1842	- 18.4529	0.0000
C(11)	1.1919	0.0360	33.1494	0.0000
C(12)	- 2.0681	0.2773	- 7.4569	0.0000

Equation: LUSDM2 = C(1) + C(2)*LUSGDP + C(3)*USR			
R-squared	0.980415	**Mean dep. var**	4.910764
Adjusted R-squared	0.979662	**S.D. dep. var**	0.231525
S.E. of regression	0.033018	**Sum sq. resid**	0.056689
Durbin-Watson stat	0.195741		
Equation: LUKDM4 = C(4) + C(5)*LUKGDP+C(6)*UKR			
R-squared	0.943396	**Mean dep. var**	5.714976
Adjusted R-squared	0.941219	**S.D. dep. var**	0.412546
S.E. of regression	0.100021	**Sum sq. resid**	0.520218
Durbin-Watson stat	1.031164		
Equation: LEUDM3 = C(7) + C(8)*LEUGDP+C(9)*EUR			
R-squared	0.968506	**Mean dep. var**	5.077414
Adjusted R-squared	0.967295	**S.D. dep. var**	0.280491
S.E. of regression	0.050726	**Sum sq. resid**	0.133801
Durbin-Watson stat	0.110508		
Equation: LJPDM2CD = C(10) + C(11)*LJPGDP+C(12)*JPR			
R-squared	0.968481	**Mean dep. var**	2.276999
Adjusted R-squared	0.967268	**S.D. dep. var**	0.218239
S.E. of regression	0.039484	**Sum sq. resid**	0.081065
Durbin-Watson stat	0.323831		

Like the findings in Table 1, the two-step GLS estimation in which the dependent variable is Divisia monetary aggregates (DIV) again indicates high R^2 values and significant, both theoretically and statistically. One similarity between the findings obtained from these two estimations is that the coefficient of interest rate for the United Kingdom. This is also insignificant at 5% significance level.

The next step for estimating the system equations for two different dependent variables (in this case SS and DIV) is to iterate the process so as to minimize the error terms for each equation. In this context, another estimation procedure, namely the Iterative GLS estimation has been performed. The findings from this estimation are demonstrated in Table 3 and 4 in the following:

Table 3: Iterative GLS - Dependent Variable SS

Iterative GLS				
System: SUR				
Sample: 1980Q1-1993Q3				
Dependent Variable: SS				
	Coefficient	**Std. Error**	**t-Statistic**	**Prob.**
C(1)	- 8.0011	0.6211	- 12.8821	0.0000
C(2)	8.4478	0.3787	22.3071	0.0000
C(3)	- 0.9513	0.3874	- 2.4558	0.0149
C(4)	- 15.3297	1.3319	- 11.5099	0.0000
C(5)	4.3939	0.2484	17.6918	0.0000
C(6)	- 0.7113	1.8581	- 0.3828	0.7023
C(7)	- 7.7782	0.4952	- 15.7069	0.0000

C(8)	2.9774	0.1049	28.3959	0.0000
C(9)	- 1.5232	0.4847	- 3.1425	0.0019
C(10)	- 4.3124	0.1180	- 36.5327	0.0000
C(11)	1.9488	0.0233	83.7927	0.0000
C(12)	- 0.3989	0.1655	- 2.4098	0.0168

Equation: LUSM2 = C(1) + C(2)*LUSGDP + C(3)*USR			
R-squared	0.960599	**Mean dep. var**	5.126495
Adjusted R-squared	0.959084	**S.D. dep. var**	0.265385
S.E. of regression	0.053681	**Sum sq. resid**	0.149848
Durbin-Watson stat	0.10663		
Equation: LUKM4 = C(4) + C(5)*LUKGDP+C(6)*UKR			
R-squared	0.929251	**Mean dep. var**	5.468773
Adjusted R-squared	0.92653	**S.D. dep. var**	0.520515
S.E. of regression	0.141087	**Sum sq. resid**	1.03509
Durbin-Watson stat	0.840982		
Equation: LEUM3 = C(7) + C(8)*LEUGDP+C(9)*EUR			
R-squared	0.961781	**Mean dep. var**	5.204183
Adjusted R-squared	0.960311	**S.D. dep. var**	0.338741
S.E. of regression	0.067484	**Sum sq. resid**	0.236814
Durbin-Watson stat	0.121489		
Equation: LJPM2CD = C(10) + C(11)*LJPGDP+C(12)*JPR			
R-squared	0.99368	**Mean dep. var**	5.154224
Adjusted R-squared	0.993437	**S.D. dep. var**	0.324745
S.E. of regression	0.026308	**Sum sq. resid**	0.035989
Durbin-Watson stat	0.549208		

Table 3 indicates the results for the iterative GLS estimation in which SS is chosen as a dependent variable. As in the previous estimation method, which is the two-step GLS, all the coefficients except the one for the interest rate of the United Kingdom are statistically significant with the meaningful signs for each coefficients and high R^2 values.

Table 4: Iterative GLS - Dependent Variable DIV

Iterative GLS				
System: SUR				
Sample: 1980Q1-1993Q3				
Dependent Variable: DIV				
	Coefficient	**Std. Error**	**t-Statistic**	**Prob.**
C(1)	- 5.9423	0.4138	- 14.3587	0.0000
C(2)	7.0257	0.2512	27.9659	0.0000
C(3)	- 1.4551	0.2710	- 5.3699	0.0000
C(4)	- 9.9431	0.8542	- 11.6406	0.0000
C(5)	3.3432	0.1613	20.7311	0.0000
C(6)	- 2.1186	1.1460	- 1.8487	0.0659
C(7)	- 4.6180	0.3954	- 11.6787	0.0000
C(8)	2.2625	0.0834	27.1384	0.0000
C(9)	- 2.7015	0.3936	- 6.8641	0.0000
C(10)	- 3.3943	0.1834	- 18.5102	0.0000
C(11)	1.1920	0.0359	33.2393	0.0000
C(12)	- 2.1430	0.2724	- 7.8665	0.0000

Equation: LUSDM2 = C(1) + C(2)*LUSGDP + C(3)*USR			
R-squared	0.979646	**Mean dep. var**	4.910764
Adjusted R-squared	0.978863	**S.D. dep. var**	0.231525
S.E. of regression	0.03366	**Sum sq. resid**	0.058916
Durbin-Watson stat	0.190472		
Equation: LUKDM4 = C(4) + C(5)*LUKGDP+C(6)*UKR			
R-squared	0.942989	**Mean dep. var**	5.714976
Adjusted R-squared	0.940797	**S.D. dep. var**	0.412546
S.E. of regression	0.10038	**Sum sq. resid**	0.523954
Durbin-Watson stat	0.992172		
Equation: LEUDM3 = C(7) + C(8)*LEUGDP+C(9)*EUR			
R-squared	0.966756	**Mean dep. var**	5.077414
Adjusted R-squared	0.965477	**S.D. dep. var**	0.280491
S.E. of regression	0.052116	**Sum sq. resid**	0.141237
Durbin-Watson stat	0.11306		
Equation: LJPDM2CD = C(10) + C(11)*LJPGDP+C(12)*JPR			
R-squared	0.968449	**Mean dep. var**	2.276999
Adjusted R-squared	0.967235	**S.D. dep. var**	0.218239
S.E. of regression	0.039503	**Sum sq. resid**	0.081147
Durbin-Watson stat	0.332016		

It would also be better to evaluate the results in Table 4 shown in above. The results of the iterative GLS estimation where the variable DIV is taken as a dependent variable indicate that the similarity between all these four estimations is that almost all coefficients are statistically significant and the values of R^2 for each equation are high. On the other hand, the only difference seen from the results of the latest estimation (see Table 4) is that the significance degree of the interest rate coefficient for the UK increases such that we reject the null of insignificance at 10 percent significance level for the case of the UK.

Mixing different types of data, namely combining the temporal change and cross-sectional differences, might lead to the violation of the standard least squares assumption of error independence. The “solution" to that problem might be the specification of an error components model. Avery (1977) argues that the regression error is supposed to be composed of three components, which are time component, cross-section component and observation component. Since the single equation error component procedures can not be used in order to achieve efficient estimates from a system of equations (as in the case in this thesis) unless error terms between equations are assumed to be zero, it would be convenient to develop a method for jointly estimating a series of equations, each with correlated error terms across equations. The residual correlations between two set of equations, one for SS and the other for DIV, are displayed in the following tables:

Table 5: Residual Correlation Matrix – SS

	LUSM2	**LUKM4**	**LEUM3**	**LJPM2CD**
LUSM2	1.0000	0.2279	0.6621	0.6016
LUKM4	0.2279	1.0000	0.4113	0.0364
LEUM3	0.6621	0.4113	1.0000	0.3686
LJPM2CD	0.6016	0.0364	0.3686	1.0000

Table 6: Residual Correlation Matrix – DIV

	LUSDM2	LUKDM4	LEUDM3	LJPDM2CD
LUSDM2	1.0000	0.4356	0.6675	0.0701
LUKDM4	0.4356	1.0000	0.4396	-0.4759
LEUDM3	0.6675	0.4396	1.0000	-0.0977
LJPDM2CD	0.0701	-0.4759	-0.0977	1.0000

Each entry in Table 5 represents an equation for the relationship between the simple sum monetary aggregates, income and interest rate for 4 groups of countries, whereas each entry in Table 6 represents an equation for the relationship between Divisia monetary aggregates and the same two explanatory variables again for 4 groups of countries. When each table is thoroughly examined, it is found that the correlations of residuals obtained from the estimations where the Divisia monetary aggregates are regressed on two explanatory variables are generally higher in comparison to the ones obtained from the estimations in which the Simple Sum monetary aggregates are regressed on the same independent variables. In this context, one might argue that the random shock affecting the dependent variable in one country could also affect the one in the other country, and this effect is much more powerful in terms of the relationship between Divisia monetary aggregates and other variables of interest.

Final part in the SUR analysis is to apply restriction for two sets of equations; one is for the coefficients of constant terms, income and interest rate in the SS case and the other is for the coefficients of constant terms, income and interest rate in the DIV case. The following two tables give the results for Wald Coefficient Test for two sets of equations.

Table 7: Wald Coefficient Test - SS

Wald Test:			
System: SUR			
Test Statistic	**Value**	**df**	**Probability**
Chi-square	881.1	3	0.0000
Ho Summary:			
Restriction (= 0)		**Value**	**Std. Err.**
C(1) - C(4)		7.1981	1.4713
C(2) - C(5)		4.1333	0.4395
C(3) - C(6)		0.0624	1.9622

Table 8: Wald Coefficient Test – DIV

Wald Test:			
System: SUR			
Test Statistic	**Value**	**df**	**Probability**
Chi-square	1047.3	3	0.0000
Ho Summary:			
Restriction (= 0)		**Value**	**Std. Err.**
C(1) - C(4)		4.0340	0.8987
C(2) - C(5)		3.7864	0.2751
C(3) - C(6)		0.6367	1.1824

The number of restrictions to be applied for each set of equations might be extended, however in this thesis; three restrictions are applied for each set: one is testing whether the estimated constant term in the SS equation including the U.S is equal to the one in the SS equation including the U.K; the second is testing whether the estimated income coefficient of the U.S in SS equation is equal to the one of the U.K in SS equation, and the third is testing whether the estimated interest rate coefficient of the U.S in SS equation is equal to the one of the U.K in SS equation. The same procedure is applied for all Divisia equations. In both cases, all these three restrictions are statistically untrue (low p-values) so that unrestricted estimates do not satisfy restrictions.

In order to support the results obtained from the SUR analysis, the rest of the empirical part is devoted to panel data analysis, which is composed of panel unit root and cointegration tests followed by FM-OLS estimation procedure. The following table presents the results of both first generation and second generation unit root tests.

Table 9: Panel Unit Root Tests in Levels[18]

		1st Generation		2nd Generation
VARIABLE	CASE	Common U.Root	Individual U.Root	
		LLC	IPS	Pesaran CIPS
DIV	Drift	-4.811*(0.000)	-1.559 (0.060)	-1.924
	Drift and Trend	5.169 (0.999)	7.065 (0.999)	-2.171
SS	Drift	-5.835*(0.000)	-3.151* (0.000)	-1.114
	Drift and Trend	2.079 (0.981)	1.859 (0.969)	-1.300
Y	Drift	-1.028 (0.152)	1.242 (0.893)	-2.529*
	Drift and Trend	1.597 (0.945)	1.998 (0.977)	-2.187
R	Drift	0.732 (0.768)	0.699 (0.758)	-2.688*
	Drift and Trend	-0.638 (0.262)	-1.743* (0.041)	-3.231*

When the results of panel unit root test results are examined, it is seen that the 1st generation unit root tests of LLC and IPS indicate only 4 significant cases out of 16 cases for all variables. The 2nd generation test results fail to detect unit root in the variable in Y (only for the drift case) and the variable R (for both cases). In the light of these two testing methodologies and their results, I generally argue that DIV, SS, Y and R reveal nonstationarity at 5 percent significance level. These results pave the way to apply panel cointegration tests to see the long run link between the relevant variables and employ FM-OLS estimation thereafter as to estimate the coefficients from panel cointegration tests.

[18] All tests use Schwarz Information Criteria for lag selection (lag is determined to be 8 for all cases). In the 1st Generation tests, the values in brackets are p-values. For the case with drift, critical values for Pesaran CIPS test are -2.55, -2.33 and -2.21 for significance levels 1%, 5% and 10% respectively. For the case with drift and trend, critical values are -3.06, -2.84 and -2.73 for significance levels 1%, 5% and 10% respectively. (*) denotes significance at 5%.

Table 10: 1st Generation Panel Cointegration Test: Dependent Variable DIV[19]

Pedroni (1999, 2004)	Constant	Constant and Trend
Homogenous Alternative		
Panel v-statistic	1.852703**	10.76151*
Panel rho-statistic	-5.019873*	-1.012851
Panel PP-statistic	-4.752096*	-1.283587
Panel ADF-statistic	-0.346365	2.689388*
Panel v-statistic – weighted	1.433902	3.873133*
Panel rho-statistic – weighted	-1.730807**	0.633870
Panel PP-statistic – weighted	-2.552838*	0.530509
Panel ADF-statistic – weighted	0.181419	2.411571*
Heterogeneous Alternative		
Group rho-statistic	-1.242111	0.743255
Group PP-statistic	-2.486645*	1.208634
Group ADF-statistic	0.772100	4.132263*

[19] (*) denotes significance at 5% significance and (**) denotes 10% significance level. The level of integrated order is tested under the null hypothesis of no cointegration.

Table 11: 1st Generation Panel Cointegration Test: Dependent Variable SS[20]

Pedroni (1999, 2004)	Intercept	Intercept and Trend
Homogenous Alternative		
Panel v-statistic	1.224059	16.68909*
Panel rho-statistic	-3.714385*	0.168507
Panel PP-statistic	-3.666449*	-0.342664
Panel ADF-statistic	-1.422684	2.905144*
Panel v-statistic – weighted	1.421803	5.819771*
Panel rho-statistic – weighted	-1.685856**	1.264295
Panel PP-statistic – weighted	-2.588567*	0.792065
Panel ADF-statistic – weighted	-0.367227	3.167387*
Heterogeneous Alternative		
Group rho-statistic	-1.007332	-0.095547
Group PP-statistic	-2.539394*	-0.486173
Group ADF-statistic	-0.007755	1.608223

The results of 1st generation panel cointegration test are demonstrated in Table 10 and Table 11 where the variables DIV and SS are regarded as dependent variables respectively. Table 10 signals the long run link between DIV, Y and R for 6 cases out of 11 cases with intercept and 5 cases out of 11 cases with intercept and trend[21]. On the other hand, Table 11 show the existence of long run relationship between SS, Y and R for 5 cases out of 11 cases with intercept and 4 cases out of 11 cases with intercept and trend.

[20] (*) denotes significance at 5% significance and (**) denotes 10% significance level. The level of integrated order is tested under the null hypothesis of no cointegration.

[21] Here we mention about all the test statistics regardless of classifying between homogenous and heterogeneous alternatives.

From the perspective of the superiority of Divisia index over simple sum index, I might infer from the results that the link between DIV, Y and R is more robust than the one between SS, Y and R.

Table 12: 2nd Generation Panel Cointegration Tests: Dependent Variable DIV[22]

Westerlund (2007)		
Test	**Constant**	**Constant and Trend**
G_τ	2.024	2.952
$G\alpha$	0.277	-3.436*
P_τ	-2.408*	0.756
P_α	-8.712*	-8.202*
Westerlund and Edgerton (2007)		
Constant	lm statistic	1.543*
	bootst p-val	0.732*
	asymp p-val	0.061
Constant and Trend	lm statistic	8.796
	bootst p-val	0.002
	asymp p-val	0.000

[22] For Westerlund (2007), the critical value for all test statistics is -1.645 at 5% significance level. As for the Westerlund and Edgerton (2007), the test is conducted under the null hypothesis of cointegration. For Westerlund (2007), (*) denotes significance at 5% whereas for Westerlund and Edgerton, (*) signals the existence of cointegration.

Table 13: 2nd Generation Panel Cointegration Tests: Dependent Variable SS[23]

Westerlund (2007)		
Test	**Constant**	**Constant and Trend**
G_τ	0.628	5.431
$G\alpha$	0.579	0.135
P_τ	-1.644	3.585
P_α	-3.574*	0.527
Westerlund and Edgerton (2007)		
Constant	lm statistic	1.771*
	bootst p-val	0.707*
	asymp p-val	0.038
Constant and Trend	lm statistic	9.548
	bootst p-val	0.000
	asymp p-val	0.000

The tables above (Table 12 and Table 13) indicate the results of the 2nd generation panel cointegration tests again considering DIV and SS as dependent variables respectively. Westerlund and Edgerton (2007) almost reveal the same result for both SS and DIV meaning that the constant case has an insignificant lm statistic with high bootstrapping p-values and fail to reject the null of cointegration. However, Westerlund (2007) detects 4 significant cases for DIV and only 1 case for SS with both constant, and constant and trend included. As in the Pedroni (1999, 2004), the latter

[23] For Westerlund (2007), the critical value for all test statistics is -1.645 at 5% significance level. As for the Westerlund and Edgerton (2007), the test is conducted under the null hypothesis of cointegration. For Westerlund (2007), (*) denotes significance at 5% whereas for Westerlund and Edgerton, (*) signals the existence of cointegration.

captures more sound long run link between DIV, Y and R when compared the link between SS and the relevant other variables.

Table 14: FM-OLS Estimation Results for Coefficient Estimation[24]

		Y	R
DIV			
	United States	1.60* (5.40)	-0.82* (-3.04)
	United Kingdom	3.51* (9.18)	-1.11 (-1.02)
	Euro Area	2.45* (8.75)	-1.60* (-3.15)
	Japan	1.17* (2.24)	-2.66* (-5.84)
	Panel Group	**2.18* (12.78)**	**-1.55* (-6.53)**
SS		**Y**	**R**
	United States	1.86* (4.61)	-0.49 (-1.49)
	United Kingdom	4.37* (7.52)	-1.60 (-0.77)
	Euro Area	2.45* (8.75)	-1.60* (-3.15)
	Japan	1.93* (21.12)	-0.87* (-5.05)
	Panel Group	**2.65* (21.00)**	**-1.14* (-5.23)**

Finally, I conducted FM-OLS estimation in order to allow for the coefficient estimation in cointegrated panels. I can say that for the first case where the variable DIV is chosen to be dependent, I have significant FM-OLS coefficients for all variables except R for the case of United Kingdom. As for the second case with SS regarded as dependent, again for all variables, the FM-OLS coefficients are significant at 5% significance level except R for the case of United Kingdom. The signs of these coefficients are also consistent with our a priori expectations meaning that demand for money is

[24] The values in brackets are t-values. Lag 4 is determined to be the maximum lag length based on SIC. (*) denotes significance at 5% percent.

positively proportional to real GDP (Y) whereas, inversely proportional to the interest rate (R).

5. Conclusion

As previously noted, price stability is critical due to the fact that a rising price level imposes substantial economic costs on society. Achieving price stability and the desired long run results of this policy through a fixed target rate for base money possibly come true under two conditions, one of which is the stable demand and the other is a stable money multiplier. During the periods in which the inflation remains at low levels, the linkage between monetary aggregates, which are generally published by central banks as the simple unweighted sums of the component quantities, and real economic variables is remarkable. However, the structure of the stable money demand is broken in high inflation periods as in the case seen in the early 1980s. In this context, a major shortcoming of Simple Sum monetary aggregates is that they are unable to react to financial innovation and assume a stable money demand function. On the other hand, the alternative Divisia monetary aggregates well adjust for financial innovation due to the weights constructed for these aggregates.

This thesis tries to compare the traditional simple sum monetary aggregates and Divisia monetary aggregates for 4 advanced countries, namely U.S, U.K, E.A and Japan. For the sake of this famous comparison, I basically estimate the system equations through the Seemingly Unrelated Regression (SUR) method using time series data and then employ both unit root and cointegration tests followed by FMOLS estimation using panel data. In this sense, this thesis is the one that empirically evaluates the time series and panel data separately but makes inferences based on two sets of data. Previous studies in the literature have used different types of estimation procedures in order to see whether Divisia monetary aggregates are superior to their simple sum counterpart. While some use cointegrated VEC model and single equation techniques (see Reimers 2001), some use dynamic error correction models (see Dahalan 2004) using panel data. Among others, this study not only combines both panel and time series data, but also supports the empirical results obtained from the panel unit root and cointegration tests by the system equation estimates.

Before proceeding with the panel data analysis, both two-step and iterative GLS estimation methods are applied based on two dependent variables, both of which are simple sum and Divisia monetary aggregates. The former reveals significant coefficients for all variables except the one for the interest rate of the U. K. Among four estimations (two of them are for two-step GLS, the remaining two is for iterative GLS), the iterative GLS in which the variable DIV is taken as dependent variable signals a high degree of significance for the U.K case. Another finding regarding the residual correlations between two set of equations with different dependent variables is that the residual correlations obtained from the estimations where the variable DIV is regressed on two explanatory variables are generally higher in comparison to the ones obtained from the estimations in which the variable SS is regressed on the same independent variables indicating that the effect of a change in the Divisia index on real variables is higher when compared to the effect of a change in the simple sum aggregates on real variables.

The panel unit root part classified as the 1st and 2nd generation tests demonstrates that all the variables (DIV, SS, Y and R) exhibit non-stationary characteristics that therefore lead me to resort to cointegration tests with 1st and 2nd generation tests included.

The panel cointegration part also support our expectations that especially based on the test of Westerlund (2007), I empirically find a long run link between DIV, Y and R which is relatively robust compared to the link between SS, Y and R. The results obtained from the SUR analysis also support that finding. Following the panel cointegration tests, I employ FM-OLS estimation technique for coefficient estimation and obtain consistent results with appropriate sign and meanings for coefficients (The sign is OK for the case of U.K, but I have insignificant coefficient for this country in both cases).

Despite the statistical significant long run link between Divisia and other real variables, the time period used in this thesis is short, namely only 55 observations due to the unavailability of monthly data for some countries. Therefore, it would be convenient to evaluate the empirical results considering this short time horizon even though I have tried to turn it into an advantage by applying a time series analysis based on the SUR method. Clearly, a longer dataset containing more than currently available time period with different structures would be useful.

The principle objective of this thesis was to compare the performance of Divisia monetary aggregates in some developed countries with the standard simple sum aggregates in the context of a simple Keynesian money demand function, which inherently incorporates inflation through the interest rate mechanism. The point here is that whether the adoption of inflation targeting has diminished economic performance in countries that have adopted it (such as United Kingdom, Canada, Sweden and Australia) relative to performance of other industrial countries (such as the United States, Japan, Germany, France and the Netherlands) and affects inflation expectations. Incorporating these inflation expectations into a more sophisticated formulation, namely a Divisia index, might be useful in terms of properly estimating future inflation not only in inflation targeting countries, but also in non-inflation targeting countries.

The research area might be extended regarding the issue of comparison of Simple Sum and Divisia Monetary Aggregates and perhaps some other countries (e.g. emerging countries) might be considered to see whether the Divisia index actually beats its simple sum counterpart.

Appendix: The Data

The countries I cover in this thesis are U.S, U.K, E.A and Japan and the variables are Divisia Index (DIV), Simple Sum Index (SS), real GDP (Y) and 10-year government bond yields (R). I have balanced panel covering a quarterly period between 1980Q1 and 1993Q3. All the variables are seasonally adjusted and expressed in their logarithmic forms except the variable R. The SS data for all countries are collected from the Reuters data.

On the other hand, the DIV data for U.S are collected from Federal Reserve Bank of St. Louis and the other DIV data for U.K are from Bank of England. As for the DIV data of E.A and Japan, these are not collected from ECB or BoJ but from authors who construct these indices for their study. I get Euro-Divisia index from Livio Stracca providing the available Divisia data for the period between 1980 and 2008 (see Stracca (2001)). As for the Japan Divisia data, these are also obtained from Kenjiro Hirayama (co-author of the study which is included in the edited book by Mullineux (1996)) again providing a quarterly Divisia index for the period between 1967 and 1993. GDP data of all countries and the 10-year bond yields for Japan are also collected from Reuters data (all the GDP data are deflated by the corresponding GDP deflators again collected from Reuters data). Bond yields for U.S, E.A and U.K are collected from FED, ECB and BoE.

As for the composition of Divisia monetary aggregates, I use 4 different Divisia monetary aggregates for 4 countries and use their simple sum counterparts. Divisia Monetary Aggregates for U.S, U.K, E.A and Japan are M2, M4, M3 and M2+CD respectively.

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