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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 study tries to emphasize the superiority of an alternative method of aggregation over the simple sum method, namely Divisia monetary aggregates, employing panel data analysis for United States, United Kingdom, Euro Area and Japan for the period between 1980Q1 and 1993Q3. After investigating the order of stationarity of the panel data set through several panel unit root tests, we perform 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.

Key Words: *Divisia, Simple Sum, Monetary Aggregation, Panel Cointegration*

JEL Classification: C23, E41

1. INTRODUCTION

The main reason why monetary aggregates in an economy draw so much attention is that the amount of money is very important as it affects real variables such as output and unemployment. Monetarists argue that monetary growth affects inflation and has no impact on output and unemployment in the long run. They also recommend a fixed target growth rate for base money (notes and coins (i.e. cash) in circulation excluding bank-created money) to achieve price stability (zero or low inflation). In order to obtain the desired long run results of this policy action, there are two conditions to be achieved. One is the necessity for a stable money demand so that the impact of monetary policy will be predictable and the other is the need for a stable money multiplier meaning that changes in broad money supply might be predicted through changes in monetary base.

The general view of the early 1970s was that there existed a considerable linkage between broad monetary aggregates and the real variables such as output and unemployment. This fact led many countries to adopt monetary aggregates as intermediate targets. For instance 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 the rate which will "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". Moreover, the Federal Open Market Committee under 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. Actually this policy was abandoned in 1982 and the close relationship between monetary aggregates and the targeted real variables was questioned due to several factors. These included deregulation of financial markets causing major financial innovation and leading to the surging level of competition between financial intermediaries, the rapid development of new information and liberalization attempts in terms of free capital flows with the regime shift to flexible exchange rates. These issues observed in the early 1980s led to questions about the definition of money, the money supply process and the stability of demand for money.

Not only the financial innovation of the early 1980s resulted in the instability of the demand for money, but also the aggregation methods used for the components of monetary aggregates supplied by many central banks has caused induced instability of money demand and supply conditions. The main aggregation method used has been the simple sum method. This procedure has been criticized heavily as it weighs each component of a monetary aggregate equally. In other words, this procedure assumes that all included assets are equal in terms of "moneyness" ("money substitutes", "near money", "secondary liquidity" etc.) and the excluded variables are the ones that provide no monetary services. This flaw of simple sum monetary aggregation paves the way for the development and employment of new monetary aggregates, one of which is the famous Divisia monetary aggregate which allows for a weighted aggregate of the growth rates of components in order to measure the flow of monetary services.

In this study, we basically aim to measure the performance of Divisia monetary aggregates calculated for the advanced economies of U.S., U.K., Japan and the Euro Zone against their simple sum counterparts for the period between 1980 Q1 and 1993 Q3. Within this analysis, we try to answer two questions:

- Is there any evidence that Divisia monetary aggregates of the relevant economies 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 part of our study, we will focus on the concept of monetary aggregation and the theoretical background of monetary aggregation considering the previous literature on the comparison of simple sum and Divisia monetary aggregates. The second part briefly explains the methodology used in our analysis, namely the panel unit root and cointegration tests. Finally, the last part includes the empirical findings regarding the results of both panel unit root and panel cointegration tests with some interpretations.

2. MONETARY AGGREGATION

The monetary quantity aggregates supplied by many central banks are the simple unweighted sums of the component quantities. In fact, the simple sum aggregation might be useful for policymakers when the interest rate fluctuations are negligible. However in the case of significant fluctuations in interest rates; some doubts arise regarding the usefulness of simple sum aggregation method (Fisher and Fleissig, 1997: 459). The usefulness of aggregation methods is naturally dependent on the assumptions regarding the elasticities of substitution of monetary assets. Simple sum aggregation in which only two assets (currency and demand deposits) are considered as money treats these two assets as perfect substitutes.

As the number of financial assets regarded as money increase substantially, the idea of treating these assets as perfect substitutes would be inconvenient. Some financial assets also have more "moneyness" than others so that they deserve larger weights. In this context, it would be useful to demonstrate the first attempts at constructing an alternative to simple sum aggregate.

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 predict the parameters of the model. In this respect, aggregation theory needs statistical index numbers, the foundations of which are laid by Fisher (1922). He actually described the statistical properties of statistical indices and provides a set of tests so as to assess the quality of the statistical index. Moreover, 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, Jones and Nesmith, 1997: 40).

Fisher believed that the satisfactory statistical properties are well incorporated to index numbers so that these statistical indices are known as Fisher Ideal Index. Moreover, he studied a great number of indices and concluded that the simple sum index is the worst one to use. Another index which again carries important statistical properties is the Divisia Index originated by Divisia (1925). The idea behind the construction of this index was to measure the flow of monetary services provided by the financial assets.

The linkage between aggregation theory and statistical index number theory was first examined by Diewert (1976) by combining economic properties with statistical indices. The issue of exactness of statistical index numbers has been elaborated in such 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[1].

However, the simple sum method (adding the dollar amounts of assets) may misinterpret the amount of monetary services provided since the dollar amounts of various components might evolve over time so that they can represent different levels of “moneyness”. The need for each asset to be weighted in accordance with the degree of the moneyness it provided led to the construction of weighted monetary aggregates based on alternative theoretical considerations. Barnett (1978) not only considered the microeconomic foundations of the monetary aggregation but also developed theoretical framework for the new monetary aggregates adopting the idea that the necessary function of money is to fill the temporal gap between the sale of one item and the purchase of another. Before Barnett (1978, 1980); Hutt (1963), Chetty (1969) and Friedman and Schwarz (1970) mentioned the importance of the micro-foundations of money and studied the applications of either microeconomic aggregation theory or index number methods.

Hutt (1963) suggested the index known as the currency equivalent (CE) index of which the theoretical framework and the formulation have later been developed by Rotemberg *et. al* (1995). Huth also explains two forms of money which are pure money and hybrid money and his aggregation consists of the combination of these two units so as to provide a future flow of monetary services. 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. One of the problems regarding Chetty’s approach is that the parametric tests used in his study are sensitive to specification errors.

Friedman and Schwarz (1970) define the quantity of money as the weighted sum of the aggregate value of all assets and in their procedure, 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 the weights are assigned but also the potential instability in the weights assigned to individual assets.

Since the common problem with forming weighted monetary aggregates and employing these appropriate definitions of monetary aggregates for money demand functions was the lack of a robust theoretical background, Barnett (1978) focused on the microeconomic foundations of the monetary aggregation and built the theoretical framework of the new monetary aggregates. He 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).

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[1] 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.

Barnett started by assuming the existence of a representative agent to develop aggregate demand functions depending upon microeconomic decisions. So, he established a linkage between the monetary aggregation of monetary assets held by a price-taker representative consumer and the theoretical assumptions of microeconomic theory such as: (1) the weak separability assumption[2] 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 and (3) the non-existence of quantity rationing. This representative consumer maximizes its intertemporal utility over a finite planning time period:

$$u = U(c, L, x) \qquad (1)$$

$$\text{subject to} \quad q'c + \pi'x + \omega L = y \qquad (2)$$

In this utility function (1) subject to the budget constraint of (2), c is a vector of services of consumption goods, L is the leisure time and x is a vector of monetary assets which provide services. Moreover, in the budget constraint, q is a vector of the prices of c; π is a vector of monetary asset user costs; and ω is the shadow price of leisure. The i^{th} component of π is expressed by the following formula (Barnett, 1978):

$$\pi_{it} = p^*_t \frac{R_t - r_{jt}}{1 + R_t} \qquad (3)$$

This formula has been referred in 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[3]") and finally p* is the true cost of living index (Barnett, Fisher and Serletis, 1992: 2093).

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

[2] Weak separability assumption of the utility function is an important assumption in terms of formulating the consumer's choice 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.

[3] The benchmark asset is assumed to provide 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.

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.

There have been many studies in the literature comparing the simple sum and Divisia monetary aggregates. For instance, Marquez (1985), 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 UK 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 India, establish the superiority of Divisia index using two different periods, one for annual data and the other for monthly data. Another study by Reimers (2001) examines the historical Divisia aggregates for euro area using cointegrated vector error correction 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 investigates different measures of monetary assets, namely M1, DM1 and M2, DM2 and finds a long run link between all measures of monetary aggregates with inflation using dynamic error correction models for the alternative measures of monetary aggregates. 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.

3. THE METHODOLOGY AND EMPIRICAL FINDINGS OF THE STUDY

Since panel models make more information available leading to higher degrees of freedom and also diagnose the effects that can not be detected through either cross-section or time series data, the literature in economics has focused on the application of unit root and cointegration tests in panel of time series and cross section dimension in order to gain more statistical power.

In this study, we employ panel unit root tests (classifed as first generation (Levin *et al.* (2002); Im *et al.* (2003)) and second generation (Pesaran (2007)) unit root tests for our 4 variables[4] (Divisia index, simple sum index, real GDP and 10-year government bond yields) of 4 advanced economies, namely United States, United Kingdom, Euro Area and Japan with quarterly data between 1980Q1 and 1993Q3.

After we detect the existence of non-stationarity at the same integration order, we proceed with panel cointegration tests with the same classification as in the panel unit root tests and employ first generation (Pedroni (2004)) and second generation (Westerlund (2007) and Westerlund and

[4] Details for all the variables and their characteristics are in the Appendix.

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 our empirical study, we demonstrate the results of individual and panel fully modified ordinary least squares (FM-OLS) in order to obtain the coefficient estimates from the panel cointegration test. Moreover, we test the robustness of the long run relationship. In this respect, we utilize two equations to examine the effects of real GDP (Y) and government bond yields (R) on the Divisia index (DIV) and its simple sum (SS) counterpart. These two equations are:

$$\log (DIV_t) = \alpha_0 + \alpha_1 \log (Y_t) + \alpha_2 R_t \qquad (4)$$

$$\log (SS_t) = \alpha_0 + \alpha_1 \log (Y_t) + \alpha_2 R_t \qquad (5)$$

In Table 1 we have the results of panel unit root tests. For the 1st generation panel unit root tests of LLC and IPS the findings indicate only 4 significant cases out of 16 cases. The 2nd generation test results fail to detect unit root in variable Y (only for the drift case) and in variable R (for both cases). In the light of these two testing methodologies and the results, we could argue that DIV, SS, Y and R reveal nonstationarity at 5 per cent significance level. These results mean that we could apply panel cointegration tests to see the long run link between the relevant variables. Moreover, we should also employ FM-OLS tests thereafter to estimate the coefficients from panel cointegration tests to reach inferences on our findings.

Table 1: Panel Unit Root Tests in Levels

		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*

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 % levels, 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 % levels, respectively. (*) denotes significance at 5 % level.

The results of 1st generation panel cointegration test are demonstrated in Table 2 and Table 3 where the variables DIV and SS are regarded as dependent variables respectively. Table 2 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[5]. On the other hand, Table 2 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. From the perspective of the superiority of Divisia index over simple sum index, we 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 2: 1st Generation Panel Cointegration Test: Dependent Variable DIV

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*

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

Table 3: 1st Generation Panel Cointegration Test: Dependent Variable SS

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

[5] Here we show all the test results regardless of classifying between homogenous and heterogeneous alternatives.

See notes of Table 2.

Table 4 and Table 5 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 captures more sound long run link between DIV, Y and R when compared the link between SS and the relevant other variables.

Table 4: 2nd Generation Panel Cointegration Tests: Dependent Variable DIV

Westerlund (2007)		
Test	**Constant**	**Constant and Trend**
G_τ	2.024	2.952
Gα	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

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 5: 2nd Generation Panel Cointegration Tests: Dependent Variable SS

Westerlund (2007)		
Test	**Constant**	**Constant and Trend**
G_τ	0.628	5.431
Gα	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

See Notes of Table 4.

Finally, we conduct FM-OLS tests in order to allow for the coefficient estimation in cointegrated panels in Table 6. We can argue that for the first case where we normalize the coefficient on DIV, we 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 the normalized variable, the FM-OLS coefficients are significant at 5 % significance level again 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 positively proportional to real GDP (Y) whereas, inversely proportional to the interest rate (R). For the panel group, we obtain both significant and theoretically consistent results for both variables. However, the coefficient of income is rather smaller in DIV case compared to SS whereas the coefficient of interest rate is rather smaller in SS case compared to DIV case. Nevertheless, DIV performs at least as good as SS, if not better.

Table 6: FM-OLS Test Results for Coefficient Estimation

		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)**

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.

4. CONCLUSION

A major shortcoming of simple sum monetary aggregates is their inability to react to financial innovation and thus provide a stable money demand function. On the other hand, we employ a very promising alternative Divisia monetary aggregates which well adjust for financial innovation due to the weights constructed for these aggregates.

This study tries to compare the traditional simple sum monetary aggregates and Divisia monetary aggregates for 4 advanced economies of US, UK, Euro Zone and Japan. For the sake of this famous comparison, we basically apply both panel unit root and panel cointegration tests followed by FM-OLS coefficient estimation tests. The panel cointegration part supports our theoretical expectations, especially based on the powerful test of Westerlund (2007), we empirically find a long run link between DIV, Y and R which is relatively robust compared to the link between SS, Y and R. Hence, we show that for the financial innovation period of early 1980s into 1990s, Divisia performs at least as good as simple sum.

Appendix: The Data

The countries we cover in this study are US, UK, EU and Japan and the variables are Divisia Index (DIV), Simple Sum Index (SS), real GDP (Y) and 10-year government bond yields (R). We 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. On the other hand, the DIV data for US are collected from Federal Reserve Bank of St. Louis and the DIV data for UK are from Bank of England. As for the DIV data of EU and Japan, these are not collected from ECB or BoJ but from authors who construct these indices for their studies. We get Euro-Divisia index from Stracca (2001) and Japan Divisia data from Kenjiro Hirayama (co-author of the study which is included in the edited book by Mullineux (1996)). GDP data of all countries and the 10-year bond yields for Japan are also collected from Reuters (all the GDP data are deflated by the corresponding GDP deflators again collected from Reuters). Bond yields for US, EU and UK are collected from FED, ECB and BoE.

As for the composition of Divisia monetary aggregates, we use 4 different Divisia monetary aggregates for 4 countries and use their simple sum counterparts. Divisia Monetary Aggregates for US, UK, EU and Japan are M2, M4, M3 and M2+CD respectively.

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