Projektbereich B
Discussion Paper No. B-392

Aggregating Money Demand in Europe with a Divisia Index

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November 1996

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Abstract: *Proponents of an aggregation theoretic approach to money demand argue that simple-sum measures do not capture the theoretical notion of money. This is especially true for broad monetary aggregates, which include components held for savings motives that are only imperfect substitutes for transactions media. Simple-sum monetary aggregates thus are not consistent with microeconomic theory. Monetary aggregation in Europe using indices for monetary services seems attractive because these indices can account for the imperfect substitutability between different currencies. In this paper the aggregation theoretic framework is applied to money holdings of European residents and the resulting index is compared to simple-sum M3.*

Keywords: *Divisia index, money demand, European Monetary Union*

JEL Classification: *E41, C43*

The ratification of the Maastricht Treaty and the agreement on the constitution of the European Central Bank have given rise to a number of papers investigating the demand for money in Europe. European money demand is particularly important given the prospects for a common currency. Most of these papers, however, use conventional simple-sum aggregates to measure the quantity of money in the European Union.[1]

Since the European Central Bank will presumably target a wide monetary aggregate, the question arises whether a simple-sum aggregate of M3 is the most appropriate measure for the quantity of money held in Europe. Proponents of an aggregation theoretic approach to money demand argue that simple-sum measures are not consistent with microeconomic theory because the simple addition of components is justified only when all components are perfect substitutes for each other (see Barnett, 1980). This condition is clearly violated for broad monetary aggregates, which include components held for savings motives that are only imperfect substitutes for transactions media. Simple-sum monetary aggregates are therefore likely to give an incorrect expression of the stock of money in the economy.

This consideration is taken into account by Fase and Winder (1994) who compute European Divisia monetary indices for 10 countries in the European Union (leaving out Luxembourg and Greece). Using the Divisia index, they find that European money demand is fairly stable. A similar result is obtained by Monticelli and Papi (1996). They construct a currency equivalent index (CEI) proposed by Rotemberg, Driscoll, and Poterba (1991)[2] and conclude that a stable long-run relationship between a European index of monetary services, income and a measure of opportunity costs exists.

Both papers use two alternative methods to construct the European indices, the direct and the indirect method. The indirect method computes an index for each country individually and then constructs the European aggregate by taking the average of the national indices. The direct method adds up components with an equal degree of liquidity across countries and then constructs the European index, using weighted averages of national interest rates to compute the user cost.[3] Neither approach is completely satisfactory as both are inconsistent with ag-

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[1] See, e.g., Kremers and Lane (1990), Artis, Bladen-Howell, and Zhang (1993), Cassard, Lane, and Masson (1994) or Monticelli (1996).

[2] The main difference between the Divisia index and currency equivalent index is that the Divisia index measures expenditures on monetary services in the current period, whereas the currency equivalent index equals the present discounted value of the expenditure on monetary services.

[3] Fase and Winder (1994) compute as many as 13 different Divisia indices, using 2 different weighting schemes to obtain the aggregate interest rate, 4 exchange rates, and the direct and the indirect method of computation.

gregation theory. Aggregation by simply averaging national Divisia indices is incompatible with the index theoretic approach. The same applies for the direct approach because the simple addition of monetary assets across countries requires them to be perfect substitutes, which is obviously not the case at the moment. The computation of a European Divisia index, involving aggregation over different national moneys, should also be consistent with the aggregation theoretic framework.[4]

The organization of the paper is as follows: the first section presents the definition of the Divisia index. Section 2 derives a consistent European Divisia index, and in Section 3 the European Divisia index and a simple-sum measure of European money are compared with respect to their empirical performance.

1 The Divisia Monetary Index

Money essentially performs three different economic functions: it is a medium of transactions, a store of value and a unit of account. The medium of transactions function is crucial for distinguishing money from other financial assets. Recently, monetary theory has also stressed the store of value function of money (see Thornton and Yue, 1992) since money will be of better use in transactions if it maintains its value over time. With respect to the store of value function, however, other assets like savings or time deposits are superior to money as they earn interest and are thus better protected against inflation. On the other hand, they are less liquid and cannot directly be used in transactions.

The Divisia index for monetary services makes an attempt to separate the transactions function of money from the other functions that money performs. Instead of measuring the stock of money held in the economy, the Divisia index assesses the utility the consumer derives from holding a portfolio of different monetary assets. Money is regarded as a consumer durable, yielding a flow of monetary services.[5] These services are performed by different monetary assets to a different degree and are proportional to the stock of monetary assets held. If the consumer's utility function is weakly separable in consumption and monetary assets, the Divisia aggregate can be regarded as a single economic good.[6] In contrast, official

[4] Marquez (1987) tackles this problem by applying the Divisia approach to money demand in an open economy. But since his focus is on the holding decision of residents, only residents' holdings of foreign currency are included.

[5] The difficulty with this analogy is that money is only of use if it is spent. While a consumption good yields its services as a flow during its lifetime the stock of money is gone once it performs its services.

[6] Weak separability means that the marginal rate of substitution between current period monetary assets is independent of the other decision variables in the model. In aggregation theory the utility function is the exact

aggregates cannot be regarded as a single good in an economic sense for which a stable demand function exists since they fail to measure the economic concept of money (Barnett, 1980). The growth rate of the Divisia index is defined as

$$\log Q_t - \log Q_{t-1} = \sum_{i=1}^{N} s_{it}^{*}(\log m_{it} - \log m_{i,t-1}),$$

$$s_{it}^{*} = \frac{1}{2}(s_{it} + s_{i,t-1}).$$

Q_t denotes the quantity of the index, m_{it} is the real quantity of a monetary asset *i* held in period *t* and the s_{it} are the expenditure shares for the respective monetary asset. The expenditure shares are computed as

$$s_{it} = \frac{\pi_{it} m_{it}}{\sum_{k=1}^{N} \pi_{kt} m_{kt}},$$

where π_{it} is the user cost for the monetary services of asset *i*. From a utility maximizing framework, Barnett (1980) derives the one period nominal user cost π_{it}

$$\pi_{it} = p_t^{*} \frac{R_t - r_{it}}{1 + R_t},$$

with p_t^{*} as the true cost of living price index and r_{it} as the own rate of return on the monetary asset m_{it}. R_t is the return on a benchmark asset that does not provide liquidity services and is only used to transfer wealth between periods. Under the assumption that the portfolio is in equilibrium and the consumer maximizes his utility, the monetary services of an asset can be measured by the user cost of the respective asset. The user cost expresses the discounted value of the interest foregone by holding one unit of that asset and measures the opportunity cost – at the margin – of the monetary services provided by asset *i*.[7]

The Divisia index attempts to measure the amount of money held for transactions purposes. Interest yield is not considered a monetary service since it reflects the return on investment. So the monetary quantity index excludes the portion of assets that are held for investment purposes.

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aggregate. However, estimating the aggregator function can be difficult. Alternatively, index numbers can be used. While the aggregator function depends on quantities and unknown parameters, indices depend on prices and quantities and on the assumption of maximizing behavior of the representative agent (Barnett, 1980). The Divisia index provides a second order approximation to an arbitrary unknown aggregator function (Diewert, 1976).

[7] It is far from clear what the Divisia index includes when measuring transactions services because the interest rate yield is assumed to reflect all other functions that money performs. See Fisher, Hudson, and Pradhan (1993) for a discussion.

2 European Monetary Aggregation

The Divisia approach focuses on the aggregation of different goods and does not consider the aggregation over different individuals. Instead, the concept of a representative consumer is applied. This concept simply supposes that the behavior of the representative consumer reflects the average behavior of the population and is generally used in demand theory to avoid the problems arising from aggregation over different individuals (see Phlips, 1974, p. 100). Though the assumption of a representative agent is very restrictive, it is maintained in the analysis of simple-sum aggregates as well. In addition, simple-sum aggregates assume perfect substitutability of all monetary assets.

To derive a European monetary aggregate, a representative European consumer is assumed to hold a diversified portfolio of European currencies with different degrees of liquidity.[8] Following Barnett (1980), the user cost of monetary services is derived from the budget restriction of a representative European consumer.

$$\begin{aligned} w_s L_s + \sum_{j=1}^{M}\sum_{i=1}^{N}\frac{(1+r_{ij,s-1})M_{ij,s-1}}{e_{j,s-1}} + (1+R_{s-1})A_{s-1} - \sum_{j=1}^{M}\sum_{i=1}^{N}\frac{M_{ij,s-1}d_{j,s-1}}{e_{j,s-1}} \\ = \sum_{k=1}^{K}\sum_{j=1}^{M}\frac{p_{kj,s}}{e_{j,d}}x_{kj,s} + \sum_{j=1}^{M}\sum_{i=1}^{N}\frac{M_{ij,s}}{e_{j,s}} + A_s \end{aligned} \tag{1}$$

The left hand side of eq. (1) describes the endowment of the consumer at the beginning of the period. In period *s*, the representative individual is endowed with labor income $w_s L_s$ (with w_s as the wage rate and L_s as the number of hours of labor supplied) and with nominal monetary balances $M_{ij,s-1}$ and bond holdings A_{s-1} carried over from the last period. At the beginning of each period, interest R_{s-1} is paid on bond holdings and $r_{ij,s-1}$ on the holdings of monetary asset $M_{ij,s-1}$. The exchange rate of country *j*, e_j, is the current market rate relative to a weighted currency basket like the ECU.[9] It is assumed that bonds, denominated in different currencies, are perfect substitutes for the representative agent. So only the bond with the

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[8] In fact, this says nothing about the substitutability of different national money. Indeed, failure of the representative consumer to react in his portfolio composition to exchange rate changes indicates that different money are not close substitutes.

[9] In the literature, different choices have been made for the exchange rate. As the budget constraint gives the consumer's wealth in each period, current market exchange rates seem appropriate for the conversion of nominal variables into a common currency.

highest yield, adjusted for the expected depreciation $\delta^e_{j,s}$, is used for the intertemporal transfer of wealth.[10]

$$1+R_s=\max(1+R_{j,s}-\delta^e_{j,s})$$

The last term in the first line of equation (1) is the capital loss or gain on money holdings due to exchange rate changes, where $\delta_{j,s-1}$ is the depreciation of currency *j* against the currency basket between period *s-1* and period *s*.

$$\delta_{j,s-1}=\frac{e_{j,s}-e_{j,s-1}}{e_{j,s-1}}$$

On the right hand side of equation (1), the allocation of the consumer's budget on consumption, money holdings and bond holdings is shown. As the representative individual consumes *K* different goods whose prices are denominated in national currencies, prices have to be converted into a common currency.

The consumer is assumed to maximize utility over time subject to his budget constraint. For a finite planning horizon up to *T* periods ahead, the intertemporal budget constraint is

$$\begin{aligned}\sum_{s=t}^{t+T}\sum_{k+1}^{K}\sum_{j=1}^{M}\frac{p_{kj,s}}{e_{j,s}\rho_s}x_{kj,s}+\sum_{s=t}^{t+T}\sum_{j=1}^{M}\sum_{i=1}^{N}\left(\frac{1}{\rho_s}-\frac{(1+r_{ij,s})-\delta_{j,s}}{\rho_{s+1}}\right)\frac{M_{ij,s}}{e_{j,s}}\\+\sum_{j=1}^{M}\sum_{i=1}^{N}\frac{(1+r_{ij,t+T})}{\rho_{t+T+1}}\frac{M_{ij,t+T}}{e_{j,t+T}}+\frac{A_{t+T}}{\rho_{t+T}}\\=\sum_{s=t}^{t+T}\frac{w_sL_s}{\rho_s}+\sum_{j=1}^{M}\sum_{i=1}^{N}(1+r_{ij,t-1})M_{ij,t-1}+(1+R_{t-1})A_{t-1}.\end{aligned}\tag{2}$$

The first term on the left hand side of eq. (2) is the discounted value of goods consumption. The discount factor, ρ_s, is defined as

$$\rho_s=\begin{cases}\prod_{u=t}^{s-1}(1+R_u) & \text{for } t+1\le s\le t+T\\ 1 & \text{for } s=t\end{cases}.$$

The second term in eq. (2) is the discounted value of expenditure on monetary services. The one period real user cost for the monetary asset *i* denominated in currency *j*, M_{ij}, is

$$\pi_{ij,t}=\frac{R_t-r_{ij,t}+\delta_{j,t}}{1+R_t}.$$

[10] Since interest and exchange rates are not known with certainty, an adjustment for risk should be made (see Barnett and Liu, 1995). Risk could be captured by the covariance between the interest rates and consumption in the next period. This aspect, however, is neglected here.

The main difference between this equation and the user cost in the single country case is the term $\delta_{j,t}$, which reflects the capital gain or loss due to exchange rate fluctuations.[11] A capital gain caused by an appreciation of the exchange rate is treated like the interest yield on a monetary asset. For a European Divisia index the expenditure shares therefore are

$$s_{ij,t} = \frac{(R_t - r_{ij,t} + \delta_{j,t}) m_{ij,t} / e_{j,t}}{\sum_{k=1}^{N} \sum_{l=1}^{M} (R_t - r_{kl,t} + \delta_{l,t}) m_{kl,t} / e_{l,t}},$$

with $m_{ij,t} = M_{ij,t}/p_t^*$ denoting real monetary balances, deflated by the true cost of living price index. Though national currencies have different user costs, the representative consumer wants to hold all of them since they are imperfect substitutes. If they were perfect substitutes he would only want to hold the currency with the highest appreciation gains.

Construction of the Index

Aggregation theory requires that the assets over which aggregation takes place form a weakly separable group. This restriction can be tested, but more generally aggregation is performed over the components of the official aggregates. Following Fase and Winder (1994) and Monticelli and Papi (1996), aggregation is performed over two different groups of monetary assets; money and quasi money as defined in the *International Financial Statistics* of the International Monetary Fund.[12]

The choice of the benchmark asset is difficult. Conceptually, the reference asset does not offer any transactions services and is only used for the transfer of wealth between periods. In practice, such an asset is almost impossible to find, as even long term bonds are traded on secondary markets and thus not completely illiquid. Moreover, in order to be comparable to monetary assets, the benchmark asset should be capital-certain and its yield should not include a risk premium (see Fisher, Hudson, and Pradhan, 1993). As benchmark yield the return on government bonds is used.

Another problem is negative user costs. In theory, the benchmark yield is the maximum expected holding period yield in the economy (Barnett, Fisher, and Serletis, 1992). Any asset yielding liquidity services must therefore earn less interest than the benchmark asset. In reality, however, interest rates on time deposits are often higher than long-term rates and user costs become negative. The respective asset would enter with a negative weight into the monetary services

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[11] However, one has to keep in mind that the definition of R_t is related to European bonds. The same applies for the true cost of living price index, p_t^* which is defined over the prices of European consumption goods.
[12] Unless otherwise indicated, all data are from International Monetary Fund's *International Financial Statistics*.

index, which makes no sense. To avoid negative user costs, two types of adjustments are possible. First, the user costs can be augmented by their minimum value. This approach can be viewed as augmenting the benchmark rate by a "liquidity premium" since data on the theoretically correct – i.e. completely illiquid – benchmark yield are difficult to obtain. However, this method is arbitrary and depends on the particular sample period. Second, the asset yielding the highest return in that period could be taken as benchmark asset. The drawback is that some assets are considered money in one period and as not yielding monetary services in another. Only results for the index obtained with the second method are presented here.[13] It is assumed that M1 earns no interest. For the interest rate on quasi money the money market rate is used.[14]

In the following, the European Divisia index is constructed and compared to a broad, simple-sum monetary aggregate. The countries investigated are Germany, France, the Netherlands, Belgium and Austria. These five countries are likely candidates for a core monetary union. A currency union without Germany and France is not conceivable since the two countries are the driving forces behind European Unification. The Netherlands, being the only country for which the narrow exchange rate targets apply at the moment, have close economic relations with Germany as well as with France. Belgium is a potential candidate for the European Monetary Union due to its geographical position between Germany, France and the Netherlands. Finally, Austria is included because it maintains an almost fixed exchange rate with Germany for over 20 years. Data are quarterly from 1973:1 to 1994:4.

Fig. 1 shows the annual growth rate of the Divisia index and simple-sum M3 for the five countries. As it is common with national indices, Divisia money shows a slightly lower average growth rate and a higher standard deviation than M3. Fig. 2 shows the price dual together with the aggregated government bond yield. Confirming what is known from national Divisia studies, the price dual bears no close relation to the aggregated interest rate.[15] At the beginning of the sample period the price dual shows large oscillations due to frequent exchange rate changes after the breakdown of the Bretton-Woods-System. Since 1983 exchange rates became more stable with the "hardening" of the European Monetary System and the price dual is dominated by interest rate movements.

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[13] Which of these two adjustments for negative user costs are used makes no qualitative difference for the empirical results. To avoid taking logarithms of zero, a very small constant of less than a basis point was further added to the user costs, see Anderson, Jones and Nesmith (1996).
[14] A deposit rate would have been preferable but was not available for all countries over the sample period.
[15] See, e.g., Fisher, Hudson, and Pradhan (1993).

Specification of Money Demand

In general, the performance of a Divisia index is assessed by estimating a demand function for Divisia money and comparing it to the money demand function for a simple-sum aggregate. Money demand functions generally include real income and an interest rate as explanatory variables. Barnett (1996) conjectures that these variables are not consistent with demand theory. Since the Divisia index is derived from a utility maximization framework, the demand for Divisia money should be modeled according to demand theory as the second stage of the budget allocation where the agent allocates his expenditure among consumption and monetary services. National income does not correspond to the representative agent's income as it appears in the budget constraint. Gross domestic product (GDP) contains components such as investment that do not appear in the budget constraint. On the other hand, expenditure on monetary services is part of the households expenditure but not included in GDP. The scale variable that is consistent with demand theory therefore is expenditure on consumption plus expenditure on monetary services.[16]

Similar considerations apply to the opportunity cost variable used in money demand estimation. It serves no purpose to include the interest rate on component assets since movements in these rates should have no effect on the aggregate.[17] Instead, the correct price for monetary services is the price dual to the Divisia index.

Though these variables are consistent with demand theory, they are less relevant for central bank policy. From a policy maker's perspective, a measure of money is useful only in so far as it conveys information about the behavior of objective variables, such as prices and output (Pill and Pradhan, 1994). Therefore, the demand for Divisia money is often modeled like conventional money demand equations.

Two different money demand systems for Divisia money are estimated here: the first one uses expenditure on consumption and monetary services as the income variable and the Divisia price dual as opportunity cost (*DIVISIA 1*). The second uses GDP and the government bond yield as explanatory variables (*DIVISIA 2*). These estimations are compared to a conventional simple-sum money demand function. The simple-sum European money stock com-

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[16] Consumption data are from the OECD. For the Netherlands, data from 1973:1 to 1976:4 were estimated by a regression of private consumption expenditure on GDP for 1977:1 to 1994:4. Data were converted to 1990 prices for France (1980 prices) and Germany (1991 prices). As for Germany pre-unification data are seasonally adjusted and post-unification data not, these were adjusted by regressing on 3 seasonal dummies and a constant.

[17] See e.g. Monticelli and Papi (1996).

prises the same components as the Divisia index: narrow money and quasi-money, converted with current exchange rates and expressed in a weighted currency.[18] The money demand systems are estimated in real terms because absence of money illusion is assumed. The European price index used to deflate the simple-sum and the Divisia aggregates is obtained by aggregating national consumer price indices with GDP weights based on current exchange rates. The income variable is real GDP, also converted into a weighted currency. Except for the government bond yield, all variables are in logarithms.

3 Empirical Results

Before the model is specified, the time series are tested for their order of integration. The results of the unit root tests in Table 1 indicate that all variables are integrated of order one. For the estimation the Johansen cointegration approach (Johansen, 1988) is used, which estimates the long-run relation and the dynamic adjustment in form of a vector error correction model (VECM).

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-k} + \mu + \phi D_t + \varepsilon_t$$

X is a *p* dimensional vector of endogenous variables, including the real monetary aggregate, income and opportunity cost. μ denotes the intercept and *D* a matrix of dummies, consisting of four seasonal dummies and a dummy for German unification that takes the value of one in the third quarter of 1990 onwards and is zero elsewhere.[19] The error term ε is independently normally distributed, Δ means first differences.

Since the variables in *X* are *I(1)*, their first differences are stationary. If the variables in X_t are cointegrated, a stationary linear combination ΠX_{t-k} of the elements in X_t exists. The hypothesis that a cointegrating vector exists can be formulated with respect to the rank *r* of the matrix Π. For the analysis of the long run relationships the matrix Π can be factored as

$$\Pi = \alpha\beta',$$

with α and β as two *pxr* matrices. The columns of β are the cointegrating vectors, the columns of α the error correction terms.

To determine the number of lags to include in the VECM, a unrestricted VAR in first differences is estimated, considering lags from 1 to 4. The Akaike criterion suggests a lag

[18] The weighted exchange rate is constructed by using GDP weights, converted with purchasing power parities from the OECD (1990).

length of 1, i.e. $k = 2$. Table 2 shows multivariate and univariate test statistics for the residuals.For the *DIVISIA 2* system, however, the residual tests pointed to a misspecification of the model with $k = 2$, so that the lag length was increased, until the residuals pass the tests for autocorrelation and normality.[20]

Table 3 shows the λ_{max} statistic and the trace statistic for the determination of the number of cointegrating relations. For each Divisia system as well as for the simple-sum M3 system one single cointegrating vector exists. Parameter values for the long-run relations are shown in Table 4. Only for the second Divisia system an income elasticity of unity cannot be rejected with a likelihood ratio test statistic of 3.05, compared to a critical value of 3.84 ($\chi^2(1)$). The income elasticity is significantly below unity for the *DIVISIA 1* system (test statistic 9.07), and slightly – but also significantly – above unity for simple-sum M3 (test statistic 4.20). The elasticity with respect to the price dual is much higher for the Divisia aggregate than the interest rate elasticity for simple-sum M3. Nevertheless, if the Divisia aggregate is regressed on GDP and the government bond yield, results are almost identical to those obtained with M3.

The last line of Table 4 gives the error correction term. For both Divisia systems the error correction term implies a reasonable speed of adjustment towards equilibrium and is significant, though only on the 10 % level for the *DIVISIA 1* system involving the variables of the demand theory. For simple-sum M3, however, the error correction term is much lower and insignificant, casting doubt on the stability of the estimated relation.

Testing for Aggregation Errors

Exact aggregation over goods requires weak separability of monetary assets in the agent's utility function. If these restrictions are satisfied, the aggregate behaves like a single economic good. Then the demand for monetary assets depends only on the first moment of the index, and higher moments contain no information. Consequently, if the higher moments of the components of the index contain information on the demand for monetary assets, an aggregation error is present.

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[19] Unfortunately, any dummy that does not add to zero changes the marginal distribution of the λ_{max} and the trace statistic. Since the dummy for German unification is an impulse dummy, the impact on the marginal distribution can be expected to be negligible.

[20] Equality of the long run parameters obtained by the Engle Granger procedure with those of the Johansen procedure cannot be rejected on the 5 % level of significance for *DIVISIA 2* and M3 with a test statistic of 2.34

The second moments of the Divisia index can be derived from stochastic index number theory (see Barnett and Serletis, 1990; Barnett, Jones, and Nesmith, 1996). The Divisia quantity variance is defined as

$$\text{VAR}\, Q_t = \sum_{i=1}^{N} \bar{s}_{it} (Dm_{it} - DQ_t)^2 ,$$

with D denoting the log difference of the respective variable. The Divisia user cost variance is

$$\text{VAR}\, P_t = \sum_{i=1}^{N} \bar{s}_{it} (D\pi_{it} - D\Pi_t)^2 ,$$

the Divisia price-quantity covariance is

$$\text{COV}\, QP_t = \sum_{i=1}^{N} \bar{s}_{it} (Dm_{it} - DQ_t)(D\pi_{it} - D\Pi_t) ,$$

and the Divisia share variance is

$$\text{VAR}\, S_t = \sum_{i=1}^{N} \bar{s}_{it} (Ds_{it} - DS_t)^2 .$$

Since the share variance can be written as $\text{VAR}\, S_t = \text{VAR}\, Q_t + \text{VAR}\, P_t + 2\,\text{COV}\, QP_t$, one of the second moments has to be excluded from the regression. The share variance was excluded because it is dominated by the user cost variance. Because the second moments are stationary (see Table 5), they are included to model the short-run dynamic adjustment and do not enter the long-run relationship.

For *DIVISIA 1* none of the second moments is significant in the money demand equation, thus indicating that the demand system is well specified. However, even insignificant Divisia second moments do not necessarily mean that aggregation introduces no error, as higher moments than the variance could have an influence.

For the *DIVISIA 2* and M3 system, the price-quantity covariance is significant at the 5 % level a t-value of 2.102 and 2.603, respectively. This may indicate that the substitution effects between monetary assets are not captured correctly. The negative mean (-0.0036) of the covariance between quantity and price also suggests substitution effects (Barnett, Jones, Nesmith, 1996). This is remarkable since other studies generally fail to find currency substitution between European currencies.

An aggregation error therefore seems to be present in M3, but also, though to a lesser extent, in the Divisia aggregates.

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and 0.96, compared to a critical value of 5.99 ($\chi2(2)$). For *DIVISIA 1* the test statistic of 6.63 is slightly above

4 Conclusion

The advantage of the Divisia index over simple-sum aggregates lies in its micro-economic foundation. While the Divisia approach regards money as a durable consumption good yielding a flow of services, simple-sum measures treat money as a component of wealth in a simple accounting procedure.

Monetary aggregation in Europe using indices for monetary services seems attractive because these indices can account for financial innovation that has proceeded at quite different paces in the European countries. The main benefit of the Divisia index can be expected during the transition to monetary union, as the index can take account of increased exchange rate stability. With completely fixed exchange rates, the European Divisia index equals the conventional Divisia index as exchange rate depreciation will vanish. Moreover, if a common currency is introduced, monetary assets of the same degree of liquidity become indistinguishable for the consumer and can be aggregated across countries by simple summation.

Another appealing feature of the Divisia index is that it can cope better with financial innovation. The move to a currency union will involve increased liberalization and competition in the banking sector and will presumably lead to new financial products in those countries where markets are still regulated. As payment systems still differ among the European countries, the Divisia index may give a more appropriate indication of liquidity in Europe until a completely integrated financial market has developed (Spencer, 1995).

With respect to the European Monetary Union the question arises if the European Central Bank should monitor a Divisia aggregate, as e.g., Gaab and Mullineux (1995) and Spencer (1995) propose. A Divisia index of European monetary services may provide additional insight into money demand during the period of transition to monetary union. Moreover, the empirical results suggest that the demand for a Divisia monetary aggregate for five European countries is performs better than simple-sum M3, regardless if real GDP and the government bond yield or expenditure on consumption and monetary services and the price dual are used as explanatory variables. Nevertheless, the empirical differences are small and more research is warranted to reach a definite conclusion.

If the European Central Bank is to use a Divisia aggregate as a target variable, it has to be controllable. This question has not been investigated here. Stein (1994) warns that the controllability of a Divisia aggregate is impeded as it is influenced by interest rate changes.

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the 5 % level.

Krämer (1996) finds for Germany that M3 is easier to control than a Divisia measure. Therefore, while a Divisia aggregate as an indicator may give a more appropriate picture of the monetary conditions in the transition to European Monetary Union, the European Central Bank should not use the Divisia index as a target variable until its controllability is established.

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Tables and Figures: EG5

Table 1. Unit Root Tests

Variable	ADF-level	ADF 1. diff.	Regression		Conclusion
DIVR	-2.65	-4.24	T	C	unit root
M3R	-2.67	-3.83	T	C	unit root
EXPR	-3.16	-5.43	T	C	unit root
GDPR	-2.96	-4.11	T	C	unit root
DIVP	-1.70	-5.41	C	N	unit root
GBY	-2.26	-3.62	C	N	unit root

Notes: DIVR denotes real Divisia money, M3R real simple-sum money, EXPR real expenditure on consumption and monetary services, GDPR real gross domestic product, DIVP the price dual to the Divisia index and GBY the government bond yield. T, C, and N indicate the specification of the test, with T meaning the inclusion of a trend and a constant, C the inclusion of a constant only and N without trend and constant. All tests include four lags. Critical values are -3.46 for the tests including a trend and a constant, -2.90 for the tests with a constant only and -1.95 for the tests without trend and constant (MacKinnon, 1991).

Table 2. Residuals

	DIVISIA 1 $k = 5$			*DIVISIA 2* $k = 2$			*M3* $k = 2$		
Ljung-Box	142.98			164.94			152.46		
LM (1)	5.72			11.98			3.84		
LM (4)	18.25			12.77			4.28		
Normality	9.09			12.41			7.38		
	DIVR	*EXPR*	*DIVP*	*DIVR*	*GDPR*	*GBY*	*M3R*	*GDPR*	*GBY*
ARCH	7.78	4.37	1.60	4.16	1.27	4.75	1.96	1.83	4.27
NORM	2.47	3.98	3.35	5.12	3.44	4.36	4.12	2.20	3.27

Notes: The upper panel shows multivariate, the lower panel univariate statistics, k is the order of the VECM.. The Ljung-Box is a test for residual autocorrelation of the first 20 lags. The critical values for the 5% level are 163.117 ($\chi^2(135)$) for *DIVISIA 1*, and 202.51 ($\chi^2(171)$) for *DIVISIA 2* and *M3*. LM(1) and LM(4) are Lagrange multiplier tests for first and fourth order autocorrelation, the critical value for the 5% level is 16.919 ($\chi^2(9)$). Normality is the multivariate version of the Shenton-Bowman test, NORM is the univariate Shenton-Bowman test for normality of the residuals (see Hansen and Juselius, 1995). The multivariate test is distributed as $\chi^2(6)$, the critical value for the 5% level is 12.592. The univariate test is distributed as $\chi^2(2)$ with a critical value of 5.99. ARCH is a test for autoregressive conditional heteroscedasticity of order k and is distributed as $\chi^2(k)$.

Table 3. Test for Cointegration

H0	*DIVISIA 1*		*DIVISIA 2*		*M3*	
	λ_{max}	Trace	λ_{max}	Trace	λ_{max}	Trace
$r \leq 0$	17.51	26.43	21.59	29.43	20.40	28.82
$r \leq 1$	8.17	8.93	7.83	7.84	8.41	8.42
$r \leq 2$	0.76	0.76	0.01	0.01	0.01	0.01

Notes: Critical values for the 90 % significance level are 13.39 ($r \leq 0$), 10.60 ($r \leq 1$), and 2.71 ($r \leq 2$) for the λ_{max}-statistic, and 26.70 ($r \leq 0$), 13.31 ($r \leq 1$), and 2.71 ($r \leq 2$) for the trace statistic. The sample period is 1973:1 to 1994:4. All regressions include a dummy for German Unification and seasonal dummies. The constant is unrestricted. *DIVISIA 1* includes the real Divisia money, real expenditure on consumption and monetary services, and the price dual, *DIVISIA 2* real Divisia money, real GDP and the government bond yield. M3 is a conventional money demand system with real simple-sum M3, real GDP, and the government bond yield.

Table 4. Long-Run Estimates and Error Correction Parameters

	DIVISIA 1	*DIVISIA 2*	*M3*
DIVR / M3R	1.000	1.000	1.000
EXPR / GDPR	0.629	0.922	1.061
DIVP / GBY	-0.288	-0.018	-0.012
a *(t-value)*	-0.130 (-1.851)	-0.207 (-3.453)	-0.076 (-1.127)

Notes: The upper panel gives the parameter estimates for the cointegrating vector, α is the error correction term for the money demand equation. T-values in parenthesis.

Table 5. Unit Root Tests

Variable	*ADF-level*	*Regression*	*Conclusion*
VARQ	-3.69	C	stationary
VARP	-3.95	C	stationary
COVQP	-3.57	C	stationary

Notes: VARQ is the Divisia quantity variance, VARP the Divisia price variance, and COVQP the covariance between prices and quantities.

Fig. 1. Annual growth rates for Divisia and M3

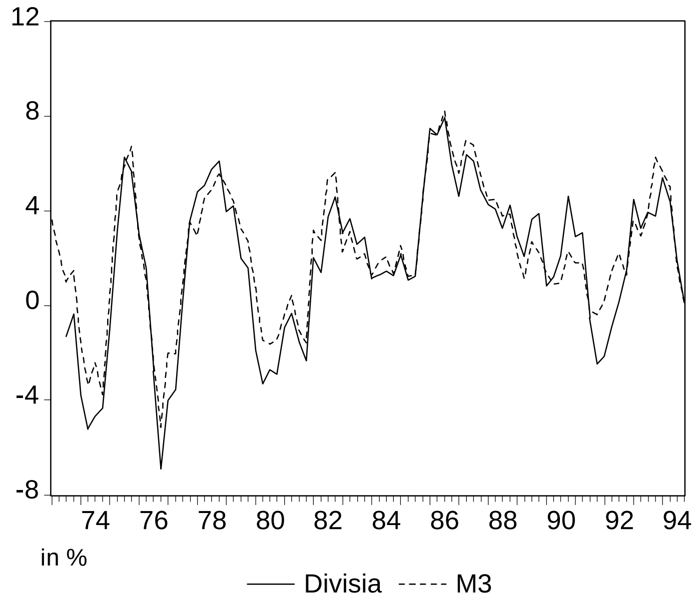

Fig. 2. Divisia Price Index and Government Bond Yield