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The Stability of European Money Demand: An Investigation of M3H

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Abstract: *The paper assesses the stability and predictive performance of a European money demand function as compared to national money demand functions. Two different groups of countries for a monetary union are considered. With respect to the explanatory accuracy, the national functions perform better than the aggregated function though the difference is barely significant. Examination of the residuals of the national money demand equations indicates that currency substitution is not the major cause for the stability of the aggregated money demand function.*

Key words: demand for money, European Monetary Union, cointegration

JEL classification: *E41, E52*

With the ratification of the Maastricht Treaty and the agreement on the constitution of the European Central Bank the interest in the demand for money has focused on a new question: what are the properties of a demand function for a European monetary aggregate? This issue is especially interesting for the future monetary authorities in the proposed European Monetary Union.

So far, a number of studies have investigated aggregated money demand functions for different groups of European countries.[1] These studies vary with respect to the estimation method, the monetary aggregate, and the sample period under consideration. Nevertheless, most conclude that a European money demand function possesses good economic and statistical properties and is more stable than most national functions.

Targeting a monetary aggregate has many advantages compared to other target variables for monetary policy. The Deutsche Bundesbank has had a positive experience with monetary targeting for over 20 years. Since the European Central Bank resembles the Bundesbank in its constitution and its instruments, it will presumably adopt the Bundesbank's strategy for monetary policy. In addition, monetary targets are easily verified by the public and will enhance the credibility of the European Central Bank that cannot rely on a reputation for price stability, like the Bundesbank, immediately after the transition to European Monetary Union.

Nevertheless, it is premature to advocate a particular monetary policy with a European monetary aggregate as intermediate target and the results for a European money demand function should be viewed with caution. Concerning the transition to monetary union, it is especially interesting to know what causes the superior performance of a European function. If it is due to currency substitution, a quick move to a monetary union would be advisable because increasing currency substitution would make monetary policy on the national level unfeasible. If, on the other hand, a stable European function is attained by a similar structure of money demand in the European countries there is no need to establish a monetary union. The European Monetary Union, though, could solve the problems of asymmetry in monetary policy formulation. Today, the Deutsche Bundesbank sets monetary policy according to domestic objectives and the other countries follow by fixing their exchange rate with Germany.

To reach a conclusion on these points, national and European functions that are estimated with the same data and methodology should be compared. Up to now, most studies estimate

[1] See e.g., Kremers and Lane (1990), Monticelli and Strauss-Kahn (1991), Artis, Bladen-Hovell, and Zhang (1993).

either national money demand functions or a European function, but do not compare aggregate and disaggregate functions in detail.[2]

The paper is organized as follows. Section II reviews the theory of money demand and outlines the empirical method. Section III presents the estimation results. Section IV assesses the stability and predictive quality of the aggregated and disaggregated functions. Finally, Section V draws conclusions for the future monetary policy in the European Monetary Union.

1
The Model

According to the theory of money demand, real income and the opportunity costs on alternative investments determine the demand for real balances. Money demand is estimated in real terms because absence of money illusion in the aggregate is assumed. Moreover, imposing a unitary price elasticity makes the identification problem less severe.[3] For simplicity, the model specification is the same for all countries.

Most economic time series are non-stationary, and the standard statistical methods do not apply. To deal with non-stationary time series, the theory of cointegration has been developed. It allows to separate between the cointegrating – that is, the long-run – relation and the short-run adjustment to this long-run relationship. Starting point is a vector autoregressive model (VAR) of order *k* (Johansen, 1988)

$$X_t = \Pi_1 X_{t-1} + \ldots + \Pi_k X_{t-k} + \mu + \phi D_t + \varepsilon_t \qquad (1)$$

where $X=(m,y,i)$ is a p dimensional vector of endogenous variables, including real money, income and interest rates, μ is the intercept, and D a matrix of dummies. The error term ε is independently normally distributed. It is convenient to express the VAR system in first differences, that is, as a vector error correction model (VECM).

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-k} + \mu + \phi D_t + \varepsilon_t \qquad (2)$$

$$\text{with} \quad \begin{aligned} \Gamma_i &= -1 + \Pi_1 + \ldots + \Pi_i \\ \Pi &= -1 + \Pi_1 + \ldots + \Pi_k \end{aligned}$$

[2] An exception is Artis, Bladen-Hovell and Zhang (1993). Though they compare national and aggregate money demand functions, this comparison is done without formal testing or assessment of the goodness of fit.

[3] The quantity of money held in the economy is determined by demand side and supply side factors, and *a priori* it is not clear that the demand for money function can be identified. The problem is avoided by assuming that the demand for money is independent of the price level. Since the central bank determines the nominal money supply, there is no supply function for real balances and therefore no identification problem, see Laidler (1993).

The first differences of X_t are stationary since the variables are *I(1)*. If the variables in X_t are cointegrated, a stationary linear combination ΠX_{t-k} of the elements in X_t exists. In this case, the regression is balanced, meaning that the order of integration on the left hand side of the system corresponds to the order of integration on the right hand side.

Two different groups of European countries are considered. The first group constitutes the smallest conceivable monetary union, comprising Germany, France, and the Netherlands. Germany and France are the driving forces in the European Unification process so that a monetary union without them is not imaginable. The Netherlands are a likely candidate for monetary union due to their geographic position and their close economic relations with Germany as well as with France. The second group includes four major European countries: Germany, France, Italy, and the United Kingdom. These countries accounted for nearly 80% of GDP in the European Union in 1994 and are chosen because quarterly income data are available over the whole sample period. Nevertheless, it is unlikely that these will be the countries entering into a monetary union in 1999. In the last year, none of them met the convergence criteria. Today, Italy with its extremely high government debt almost surely will fail to reach the required debt to GDP ratio of 60%. The United Kingdom has negotiated an opting out clause in the Maastricht Treaty, which makes her participation in the monetary union doubtful. On the other hand, from a political point of view a monetary union will be formed only if a sufficient number of countries are ready to participate. So the four major countries – as a proxy for the whole EU – may give an appropriate impression of money demand in a European Monetary Union.

The real money stock is defined as logarithm of M3H, deflated by the consumer price index. Income is the logarithm of real GDP. M3H denotes a harmonized definition of money, established by the Committee of Central Bank Governors, and includes comparable components in all countries. It relates to bank's liabilities with resident non-money-creating institutions and covers notes and coins, demand deposits, foreign currency deposits, and short term financial instruments, irrespective of their issuer. Since M3H comprises also time and savings deposits, the inclusion of an own interest rate and an interest rate on alternative investment opportunities seems appropriate. Including two interest rates, however, has consequences for the cointegrating relationships. Consider a system containing the four variables real money, real income, a long and a short interest rate: $X = (m, y, r^L, r^S)$. If the spread between the interest rates is stationary, two cointegrating vectors are obtained: one for money demand and one for the term structure of the interest rates. Without identifying restrictions, any linear combination of the cointegrating vectors is again a solution. To identify both cointegration vectors, at least one restriction on each vector has to be imposed. For the cointegrating vector representing the interest rate spread there is an overidentifying restriction: neither money nor income should enter. Moreover, if the expectations theory of the term structure holds, the coefficients on the interest rates should be equal with opposite signs.[4] For the money demand vector economic theory gives no plausible restrictions implying that only the sum of the interest rate elasticities is identified. If it is assumed that the expectations theory of the term structure holds, one interest rate can be excluded in the estimation and the sum of the long and short interest rate elasticity is obtained on the remaining interest rate coefficient.[5] This manipulation does not change the income or the interest rate elasticity because the regression always gives the sum of both interest rate elasticities, independently from the rate excluded. The interest rate used here is the government bond yield.

All data are quarterly and the model includes four centered seasonal dummies. The sample starts in the first quarter of 1973 because at that time the Bretton Woods System collapsed while the European countries tried to establish exchange rate stability with the „snake“. The sample end is dictated by data availability and falls on the last quarter of 1994.[6]

2 Empirical Results

First, money demand on the national level is investigated.[7] Before specifying the model, it is obligatory to investigate the time series properties of the variables. The unit root tests include two lags for the interest rate since they show no seasonal pattern, and four lags for the other variables. For most time series the Augmented Dickey-Fuller Test indicates that the time se-

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[4] See e.g., Campbell and Shiller (1987) for an empirical test of this hypothesis.

[5] See Hoffman and Rasche (1996), Hoffman, Rasche, and Tieslau (1995).

[6] Real GDP for Germany includes the new Länder from 1990:3 on and is from the Sachverständigenrat's annual report. Data on M3H were obtained from the national central banks. All other data are from the IMF's International Financial Statistics on CD-ROM. To get a common sample length for all countries, missing values for M3H have been taken from the broad monetary aggregate on IFS CD-ROM. This is for Italy before 1975:1 and for France before 1977:4. Since in the 1970's financial innovation and holdings of foreign currencies were insignificant, the differences between the harmonized and the IFS definition of broad money are negligible. For the Netherlands, GDP before 1986 was interpolated with data on industrial production.

[7] The estimation is performed with CATS in RATS.

ries are integrated of order one, *I(1)*.[8] The exceptions are real money in Italy and the British interest rate being trend stationary. However, in the case of Italy the result is not robust and changes if the number of lag is varied. Trend stationarity for an interest rate, however, makes theoretically no sense, as the rate of interest would have to rise by a fixed amount in all future periods. As for the British interest rate trend stationarity is caused by the constant rise of the government bond yield during the particular sample period, the variable is treated as a random walk. For France, the United Kindom, and the Netherlands the first differences of real money turn out to be non-stationary but this result changes if the Phillips-Perron test is used.[9] Therefore, these variables are treated as *I(1)*, too.

2.1
Results for National Money Demand

The Johansen procedure is based upon an unrestricted vector autoregressive model, and estimation and testing are contingent on the specification of the VAR. Before the model is estimated, a choice on the order of the VAR has to be made. For the determination of the lag order the Akaike Information Criterion (AIC) is used. The specifications considered for the VECM range from one to four lags.[10] For Germany and France, the AIC indicates the inclusion of two lags in the VECM, that is $k = 3$ in eq. (2). For the other countries, the VAR is estimated with a single lag. In the German equation a dummy variable for German Unification, taking the value of one in the third quarter of 1990, is included. The dummy enters only the short-run relation, assuming that the long-run money demand is not affected by the monetary union.[11]

TABLE 1 ABOUT HERE

First, the residuals are investigated to check if the model is correctly specified. Table 1 shows univariate and multivariate statistics for the residuals. Generally, the models seem to be well specified. For Italy, the United Kingdom, and the Netherlands the multivariate Shenton-

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8 In testing for a unit root the procedure suggested by Dolado, Jenkinson, and Sosvilla-Rivero (1990) is followed.

9 The nonparametric test by Phillips and Perron performs better than the Dickey-Fuller-Test if a positively correlated moving average process is considered (Phillips and Perron, 1988).

10 More than four lags were not considered because of the loss in degrees of freedom due to the estimation of too many parameters.

11 Unfortunately, almost any type of dummy variable changes the asymptotic distribution of the rank tests and the standard tables will not apply. As the results for German money demand do not differ markedly from the results for the other countries and from those of other studies, the effect of the German dummy on the asymptotic distribution seems to be negligible, and new tables were not computed.

Bowman test rejects the normality of the residuals. Including more lags does not solve this problem, so the specification with $k = 2$ is retained.

TABLE 2 ABOUT HERE

Table 2 presents the test statistics for the determination of the cointegration rank. Except for Italy, where no cointegrating vector is found at conventional levels of significance, for each country a single long-run relationship exists between money, income, and the interest rate.[12] Table 3 shows the estimates for the long-run parameters, normalized with respect to real money, and the adjustment coefficients for the money demand equation.

TABLE 3 ABOUT HERE

The estimates for the long run relation are quite similar across the countries and are in line with the results of other investigations.[13] For Germany, France, and the Netherlands the income elasticity exceeds unity, whereas for the United Kingdom the income elasticity of 0.3 is quite low. [14]. Except for Italy, the interest rate elasticity is negative, and the error correction term is significant. Nevertheless, it is low in absolute value, implying an adjustment towards equilibrium of only about 5 % per quarter.

2.2 Aggregate Specification

Next, an aggregate European money demand function is estimated. Though macroeconomic relationships are derived from assumptions about individual behavior and thus always imply aggregation over different individuals and different goods, little attention is paid to the theoretical justification for and the consequences of aggregation.

The first problem is the aggregation over different individuals. For a demand function to be independent of the distribution of explanatory variables over individual agents, one has to assume that all agents react identically to a change in these variables, that is, that a representative consumer exists.[15] Otherwise, a stable demand function exists only if the distribution of the explanatory variables remains constant over time. Valid aggregation thus requires *a priori*

[12] Though for Italy no stable long-run relationship could be found, the first eigenvector ís reported albeit it is not significant at the 90% level.

[13] See, e.g., the survey by Fase (1994).

[14] The results for the United Kindom and the Netherlands have to be regarded with some caution because normality of the residuals was rejected and the trace and the λ_{max} statistic may be biased.

[15] The assumption implies that all consumers allocate increases in income identically over their portfolios of monetary assets. In other words, preferences have to be quasihomothetic, leading to linear and parallel Engel-curves, see Gorman (1953) or Deaton and Muellbauer (1989).

knowledge of the distribution of the explanatory variables across the micro units. Neither assumption is appealing and generally fulfilled in practical applications.

Aggregation over commodities also involves special assumptions that are highly restrictive and unlikely to hold in practice. Simple summation of different goods is only valid if the goods are identical, that is, if they are perfect substitutes for the representative consumer. In other words, different commodities can be treated as one good only if the relative price between these commodities remains constant.[16] Though different national moneys may be close substitutes with respect to their *store of value* function, they do not substitute each other as a medium of transaction. French francs, for example, perform transaction services in France, but not in Germany or in Italy. Without a monetary union simple-sum aggregates of different national moneys have to be regarded with caution.

2.3 What Level of Aggregation?

Unfortunately, a satisfactory resolution of the aggregation problem is generally impossible. While the theoretical assumptions for consistent aggregation are rather strong, aggregation is inevitable in empirical applications. In applied econometrics therefore the issue is not whether consistent aggregation is possible, but rather at what level of aggregation or disaggregation the analysis should be carried out. Since national money demand functions consider already aggregate relationships the question arises if further aggregation is justified. Criteria for the choice of the aggregation level are the purpose of the estimation, the error structure, and the availability and quality of the data (Barker and Pesaran 1990).

2.3.1 Purpose of the Estimation

With the transition to European Monetary Union, monetary policy will be formulated for the whole currency area. For this purpose a function predicting money demand in Europe is needed. Aggregation is recommended if an aggregated function leads to better forecasts of the area-wide money demand than the disaggregated functions. Generally, it does not appear possible to deduce whether or not it is better to use aggregated data if the aggregate behavior is to be predicted.[17]

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[16] The condition is known as Hick's composite commodity theorem.

[17] See Edwards and Orcutt (1969). The same result applies for the existence of cointegrating relationships. It cannot be concluded that if a cointegrating relationship was found with the disaggregated equations, cointe-

Theil (1954) showed that the variance of the residuals of the aggregate equation must be always larger than the variance of the sum of the disaggregate residuals because aggregation results in a loss of information if the disaggregate relations are not identical. Thus, no advantage is to be expected from estimating and forecasting with an aggregate money demand function. The conclusion, however, rests on Theil's assumptions that the disaggregate equations are perfectly specified. This assumption generally will be violated in empirical applications, so that the aggregate equation may lead to better forecasts. This is especially true if, with integrated financial markets, national money demand becomes increasingly influenced by financial developments in other countries. While a correctly specified money demand equation will have to include foreign variables, it is impossible to consider all relevant foreign variables in the estimation. Aggregation is one potential solution to this problem. While aggregation induces an aggregation bias because the parameter estimates are constrained to the same value across countries, the specification bias caused by the exclusion of foreign variables in the national equations may decrease and it is not clear which bias is more disturbing.

2.3.2
Error Structure

If money demand shocks across Europe are negatively correlated, an aggregated money demand function will lead to better estimates than the national functions. A negative correlation of money demand shocks will result if currency substitution is the main cause for national money demand instability. Targeting a European monetary aggregate may lead to greater stability if currency substitution destabilizes the national money demand functions but leaves a European aggregate unaffected.

2.3.4
Data

Though for many empirical investigations data are not available on a disaggregated level, all data exist on a national basis here. Nevertheless, two problems remain. The first one is the consistent definition of a European monetary aggregate, the second one the choice of an appropriate exchange rate for the conversion of national variables into a common currency.

Money holdings can be classified according to three different criteria (see Goodhart 1990). These criteria are the currency of denomination, the residence of the holder, and the location

gration is also to be found on the aggregated level. It is possible to have cointegration at the aggregate level without having cointegration at the disaggregate level, and vice versa (Granger 1990).

of the bank. Most countries define money as deposits held by residents with local banks. If national monetary aggregates in their current definition are added together, this leads to omission of money holdings that should be counted to European money. A consistent definition of a European monetary aggregate should include the deposits held by residents from one European country with banks in another member country of the European Union. Community-wide consistency of national monetary aggregates is achieved if all countries refer to the same definition, based on one of the three criteria, which take account of cross-border monetary holdings. Currently, the national definitions do not meet this requirement. The problem also arises with M3H because it relates to the two criteria of the residence of the holder and the location of the bank, irrespective of the currency of denomination.

Nevertheless, cross-border deposits are not included here and the European aggregate is defined as the sum of the national definitions of M3H. Though cross-border deposits will certainly become more important in the future, their significance for money demand in the past was limited. Monticelli and Papi (1996) found that a European aggregate consisting of M3 in its traditional definition has a closer relation to output and interest rates than a monetary aggregate including cross-border deposits. It can be assumed that cross-border deposits are mainly held as savings instruments and do not perform transaction functions for their holders (Giucca and Levy 1992). Moreover, the data on cross-border deposits are of poor quality.[18]

The second question concerning the computation of aggregate variables is the choice of an exchange rate. There are almost no theoretical arguments for the conversion of national variables into a common currency, though the choice of the exchange rate influences the behavior of the aggregated variables considerably. Three different conversion methods can be chosen: current exchange rates, a fixed base year exchange rate or purchasing power parities.

Proponents of current exchange rates argue that anyone wanting to convert money balances from one currency into another has to change his money at the market exchange rate. Using market exchange rates, expenditures converted into a common currency also reflect the differences in the price levels between the countries, not simply differences in real income. If money and income are both converted with current exchange rates, the exchange rate enters the left and the right hand sides of the regression, artificially increasing the correlation between the

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[18] The definition of money according to the localization of the bank is statistically the easiest to pursue, but makes economically not much sense because holdings in financial centers, such as the United Kingdom, tend to weaken the relation between money and output. On the other hand, a splitting between resident's and non-resident's holdings is difficult to estimate accurately, see Goodhart (1990).

dependent and the independent variable. Moreover, devaluations are often high and can easily dominate the growth of the real variables, causing an atypical behavior of the aggregates.

Alternatively, money and income could be converted with base year exchange rates, which correspond to the market relation at a fixed date. Base year and market exchange rates can deviate considerably since devaluations have been frequent in the European Monetary System. The longer the sample period, the less a base year rate will correspond to market relations. Apart from avoiding the artificial correlation introduced with current exchange rates, there seem to be no arguments in favor of base year exchange rates.

A third possibility is the transformation with purchasing power parities. Purchasing power parities are the rates of currency conversion that equalize the purchasing power of different currencies and eliminate the differences in price levels between countries. When real income for different countries is converted into a common currency by means of purchasing power parities, it is expressed at the same set of international prices so that comparisons between countries reflect only differences in the volume of goods and services purchased.[19] To avoid a double deflation, real magnitudes are converted with the purchasing power parity of a base year. Thus, no correlation between independent and dependent variables is introduced through the use of purchasing power parities.[20]

In the literature, different choices have been made with regard to the exchange rate. Kremers and Lane (1990) use purchasing power parities, while Monticelli and Strauss-Kahn (1991) advocate current exchange rates. As no clear case can be made for either of the conversion methods on theoretical grounds, aggregates are constructed using all three procedures.[21]

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[19] In economic theory purchasing power parities often appear as equilibrium exchange rates to which the actual exchange rates are assumed to converge. The purchasing power parities calculated by the OECD serve for the comparison of international prices and volume of GDP. They are not relevant as equilibrium exchange rates.

[20] While current and base year exchange rates correspond to actual market outcomes, the calculation of purchasing power parities poses some problems. The estimated purchasing power parities depend on the base year and the commodity basket chosen. Moreover, there is no method to compute purchasing power parities that satisfy a set of desirable properties, see Gulde and Schulze-Ghattas (1992).

[21] Funke (1995) argues that each of the three conversion methods above introduces a bias into the aggregates. The growth rate of an unbiased aggregate should equal the average growth rates of the national variables. Bayoumi and Kenen (1993) compute a weighted average of growth rates for the analysis of a European monetary aggregate. This approach is not used here because for the investigation of long-run relationships the levels of the time series are needed, not only the first differences.

2.4
Results for European Money Demand

The aggregated variables show the same characteristics as the aggregates derived by Kremers and Lane (1990) and Funke (1995). Variables converted into Deutsche Mark with the purchasing power parities of the year 1990 (see OECD 1990) are indexed by *P*. The index *B* indicates conversion with base year rates and *E* with current exchange rates.[22]

FIGURE 1 ABOUT HERE

Figure 1 shows aggregate real money for the four European countries. The downward movement of aggregate real money based on current nominal exchange rates reflects the nominal appreciation of the Deutsche Mark relative to the other European currencies. The aggregation at base-period exchange rates produces a pattern similar to that resulting from aggregation at purchasing power parities. The difference in the levels of the series results from the different weighting pattern introduced by the exchange rate.

FIGURE 2 ABOUT HERE

Figure 2 shows aggregate real income. If income is aggregated with current exchange rates, movements in the exchange rates dominate real growth so that a rather atypical picture emerges. Interest rates are aggregated with the three different real GDP weights corresponding to each of the three conversion methods and, as Figure 3 shows, are less sensitive to the aggregation method chosen.[23]

FIGURE 3 ABOUT HERE

For the aggregate variables the unit root tests indicate that most time series are *I(1)*. Exceptions are real money for EG 3, converted with purchasing power parities and with base year exchange rates where the Augemented Dickey Fuller Test indicates that the first differences are non-stationary. With the Phillips Perron Test, however, they turn out to be stationary so that these variables are also treated as *I(1)*. In testing for the lag length, the Akaike information criterion suggests $k = 3$ for the system EG 3 (B) and k = 2 for the other systems. Table 4 gives univariate and multivariate statistics for the residuals.

TABLE 4 ABOUT HERE

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[22] For the aggregates constructed with base year and current exchange rates, nominal money and nominal income are added and then deflated with an aggregated consumer price index and an aggregated GDP deflator, respectively. The aggregated price indices are weighted averages of national price indices, the weights being the country's share in aggregated real GDP.

[23] The aggregates for the three countries Germany, France, and the Netherlands show the same characteristics.

In general, the specification of the models seems satisfactory. With regard to autocorrelation and normality, the systems for the EG 3 aggregates perform better. The test statistics for the EG 4 countries did not improve considerably when more lags were included. As Falk and Funke (1995) found that the German Monetary Union had an impact on the European demand for money, a dummy was included in all estimations. Table 5 lists the test statistics for the determination of the cointegration rank. For each aggregate system a single cointegrating vector is found.

TABLE 5 ABOUT HERE

Table 6 shows the parameter estimates and the error correction coefficients. In general, the coefficients are economically plausible and quite similar across the different country groups.

TABLE 6 ABOUT HERE

For the EG 3 (P) system and the EG 3 (B) system the income elasticity is close to one and the intrest rate elasticity is negative. For the EG 3 (E) system, converted with current exchange rates, the income elasticity is considerably higher and the interest rate elasticity has the wrong sign. The results for the EG 4 (P) system and the EG 4 (B) system are similar, though the income elasticity is slightly higher than in the EG 3 estimations. For the EG 4 (E) system the income elasticity is even negative, a result that is not in line with economic theory. This implausible result is possibly caused by the strong depreciation of the Italian Lira and the British Pound relative to the DM during the sample period. Except for the EG 3 (E) system, the error correction terms are significantly negative and of the same magnitude as in the national estimations.

3
Testing for Aggregation Errors

Next, the relation between the money demand equations on the national and the European level is investigated. In testing for aggregation errors two different strands are pursued in the literature (see Lee, Pesaran, and Pierse 1990). First, one can check whether aggregation results in biased parameter estimates. Second, one can compare the predictive performance and the forecasting behavior of the aggregate and disaggregate functions.

3.1 Coefficient Equality

Theil (1954) shows that equality of parameters across the disaggregated equations is a sufficient condition for absence of an aggregation bias.[24] However, he assumed that the Klein-Nataf consistency requirement holds, meaning that the aggregated variables are defined as the sum of the disaggregated variables. In our case, the disaggregated equations are specified in a semi-logarithmic form. To meet the Klein-Nataf consistency requirement, aggregated money and income would have to be defined as the sum of the variables in logarithms instead as the logarithm of the sum of the variables. Otherwise, the specification for the aggregate equation would be implausible from an economic point of view. In effect, different model specifications are compared, not only the performance of an aggregate versus a disaggregate equation system.[25] Table 7 presents the results of likelihood ratio tests for the equality of the long-run coefficients of the disaggregate and the aggregate equation.

TABLE 7 ABOUT HERE

Only for EG 3 (B) equality of the parameters for the aggregate and the national functions is not rejected on the 5 % level of significance. For all other systems equality is rejected. Especially for the United Kingdom the coefficients of the national function differ considerably from those of the aggregate function. It seems therefore that money demand in Europe is not similar enough to justify aggregation.

3.2 Predictive Performance

The predictive accuracy of the aggregated money demand function is crucial for monetary targeting. Grunfeld and Griliches (1960) propose a criterion to compare the aggregate and disaggregate equations based on their predictive performance. The idea is to evaluate if money demand on the aggregate level can better be explained by an aggregate equation or by the disaggregated equations taken together. The Grunfeld-Griliches criterion thus is concerned with the power of explanation obtained by the regression rather than with the errors in estimating the true economic coefficients. It relies on the comparison of the coefficients of

[24] The equality of the parameters across the disaggrated equations is a sufficient, but not a necessary condition, see Pesaran, Pierse, and Kumar (1989). Different parameter estimates do not lead to an aggregation bias, if the explanatory variables remain in the same proportion to each other.

[25] Wesche (1996) performs simulations to investigate this issue. For the parameter values which are in general encountered in money demand estimation, testing equality of the parameter estimates seems to be a reasonable approximation also with logarithmic aggregation as the aggregation bias is insubstantial in this case.

determination of the aggregate and disaggregate regressions, though they cannot be compared directly because they are relative measures of fit.[26] Grunfeld and Griliches therefore construct a "composite" R^2 that is compared to the ordinary R^2 from the aggregate equation. The composite R^2 is defined as the percentage of the total variance of aggregate real money that is explained by the variation in the sum of fitted money demand from the national disaggregate regressions.

$$R_c^2 = 1 - \frac{S_c^2}{S_m^2} \quad (3)$$

S^2_c denotes the variance of the sum of residuals of the individual regressions and S^2_m the variance of aggregate real money. A comparison of the composite R^2 to the R^2 of the aggregate regression answers the question whether one obtains more information about aggregate money demand by computing regressions for the single countries than by simply taking a regression of aggregate money on the aggregate income and interest rates.

The problem of the logarithmic specification for the aggregate and the disaggregate equations arises also here. For the money and the income equation, the antilogs of the residuals are taken, added together, and then transformed into logarithms again. As interest rates are non-logarithmic, the residuals from the interest rate equations are simply added together.

TABLE 8 ABOUT HERE

Results are shown in Table 8. The first three columns show the composite R^2, the next three columns show the R^2 of the aggregate regressions. For EG 3 (P) and EG 3 (B) the aggregate systems perform better for the money demand equations and the interest rate equations. In all other cases the national systems perform better. Thus, the Grunfeld-Griliches criterion indicates that the disaggregate equations work better than the aggregate specification. This is even more discouraging as the micro equations and the macro equations apply the same specification. Generally, an advantage for specifying equations on the disaggregated level is the possibility to differentiate between the micro units (see Barker and Pesaran 1990).[27]

Nevertheless, in most cases the difference between the explanatory value of the aggregate and the disaggregate systems is small. To investigate the significance of this difference, an F-test ist performed. In estimating an aggregate equation, all parameters are restricted to the same

[26] For the R^2 of the national regressions the variance of national real money stands in the denominator while for the aggregate R^2 the variance of aggregate real money is in the denominator.

[27] If one takes the residual cross-correlation of national money demand into account, the predicitive performance of the disaggregate regressions could still be improved compared to the aggregate regression.

value whereas in national estimations the coefficients are allowed to differ between countries. The F-statistic is defined as

$$F = \frac{(RSS - URSS)/m}{URSS/(T-l)}\,. \quad (4)$$

RSS is the sum of squared residuals in the restricted estimation, *URSS* the sum of unrestricted squared residuals,[28] *m* is the number of restrictions, *T* the number of observations, and *l* the number of estimated parameters.

TABLE 9 ABOUT HERE

Table 9 shows the results. Only for the systems converted with current exchange rates, the aggregate equations explain money demand significantly worse. For the other systems, the differences in the explanatory vaulue are insignificant.

Edwards and Orcutt (1969) argue that aggregate and disaggregate equations should not be compared with respect to their explanatory value but to their forecasting performance as the R^2 bears no relation to the forecasting performance of an equation. This means that regressions with a lower R^2 may forecast better and vice versa.

TABLE 10 ABOUT HERE

Table 10 compares mean squared forecast errors for the aggregate and the disaggregate equations for the last eight quarters of the sample period. For the systems converted with current exchange rate, the national equations obviously perform better. Surprisingly, for the EG 4 (P) and EG 4 (B) aggregates the aggregate forcast error is lower. Thus, the forecast errors show no clear picture in favor of the national or the European equations.

3.3
Currency Substitution

A standard argument to explain the superior performance of a European money demand function is currency substitution. The currency substitution hypothesis implies that people change from one currency into another in reaction to expected changes in the exchange rates or other factors, which are difficult to measure. If currency substitution is present, the residuals of the money demand equations should be negatively correlated because the model does not include foreign variables.

TABLE 11 ABOUT HERE

[28] With respect to the problem of logarithmic aggregation, the same approach as for the Grunfeld-Griliches Test is followed.

Table 10 shows the cross-correlation coefficients for the residuals of the national money demand equations. The results do not support the currency substitution hypothesis. Only between Italy and Germany there is a significant negative residual cross-correlation. All other correlations are either insignificant or even positive. This is in line with the results of Angeloni, Cottarelli, and Levy (1994) and Lane and Poloz (1992) who find only weak correlation of money demand errors across the European countries. A study by the Deutsche Bundesbank (1995) also finds no significant effects of currency substitution on German money demand with respect to the European currencies, except for Italy. Currency substitution thus seems not to be the cause for the stability of a European money demand function.

4
Conclusion

The paper investigates the stability and the predictive performance of a European money demand function. Two different groups of countries were considered, corresponding to a "small" and a "large" monetary union. The aggregate money demand function for the core countries Germany, France, and the Netherlands performs better than the money demand function for the four largest European countries Germany, France, Italy, and the United Kingdom.

As there are no theoretical arguments for the choice of a particular exchange rate, three conversion methods are used. Conversion of real magnitudes with purchasing power parities and conversion with base year exchange rates leads to similar results but the results for the aggregate money demand function sobtained with current exchange rates differ considerably and the parameter estimates are economically implausible. This result indicates that exchange rates are not yet stable enough to lead to a meaningful European money demand function. Without exchange rate stability, a precondition for a meaningful definition of a European monetary aggregate is lacking. After the transition to European Monetary Union, however, this problem disappears as exchange rates will cease to exist.

Currency substitution does not seem to be the major cause for the stability of a European function. The correlation of the residuals of the national money demand functions is weak, thus suggesting that currency substitution is of minor importance. Instead, the stability of the European function apparently relies on the structural similarity of the national money demand equations, at least for Germany, France, and the Netherlands. Therefore, the European Central Bank should only follow a strategy of monetary targeting, if a small and stability-orientated group of countries is to join.

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Tables and Figures

Table 1. Residuals for the national money demand systems.

	Germany *k = 3*		*France* *k = 3*		*Italy* *k = 2*		*United Kingdom* *k = 2*		*Netherlands* *k = 2*	
L-B	184.335		153.009		214.218		240.570		170.261	
LM (1)	3.644		5.779		5.713		8.904		9.137	
LM (4)	14.966		11.074		24.136		15.050		8.451	
NV	8.364		7.841		60.677		36.896		26.346	
	ARCH	*NORM*	*ARCH*	*NORM*	*ARCH*	*NORM*	*ARCH*	*NORM*	*ARCH*	*NORM*
M3HR	0.78	2.48	3.71	0.41	0.24	19.17	2.63	12.23	2.59	3.69
GDPR	1.81	6.02	0.70	5.03	2.17	4.21	10.97	30.79	1.60	17.07
GBY	12.11	0.79	5.40	3.04	0.69	41.70	1.55	1.22	0.64	3.04

Notes:
M3HR is real broad money, GDPR real gross domestic product and GBY is the government bond yield, *k* is the order of the VECM. The upper panel shows multivariate statistics for the system as a whole, the lower panel univariate statistics considering each equation separately. Ljung-Box is a test for residual autocorrelation of the first 20 lags, distributed as $\chi^2(162)$ for Germany and France, and as $\chi^2(171)$ for Italy, the UK, and the Netherlands. The critical values for the 5 % level are 192.70 and 202.51. LM(1) and LM(4) are Lagrange multiplier tests for first and fourth order autocorrelation. They are distributed as $\chi^2(9)$, the critical value for the 5% level is 16.92. 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 12.59. 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* based on the Lagrange multiplier principle and is distributed as $\chi^2(k)$.

Table 2. Test for Cointegration.

H0	*Germany* λ_{max}	Trace	*France* λ_{max}	Trace	*Italy* λ_{max}	Trace	*United Kingdom* λ_{max}	Trace	*Netherlands* λ_{max}	Trace
$r \leq 0$	23.40	32.57	12.27	23.62	10.38	15.14	27.40	36.01	18.00	27.74
$r \leq 1$	8.73	9.17	10.91	11.35	3.63	4.76	8.47	8.61	9.00	9.74
$r \leq 2$	0.44	0.44	0.43	0.43	1.13	1.13	0.14	0.14	0.73	0.73

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. In the German equation system a dummy, taking the value of one in 1990:3, is included. The constant is unrestricted.

Table 3. Long-Run Estimates and Error Correction Parameters.

	DEU	*FRA*	*ITA*	*GB*	*NL*
M3HR	1.000	1.000	1.000	1.000	1.000
GDPR	-1.251	-1.267	-0.957	-0.304	-1.683
GBY	0.097	0.014	-0.009	0.191	0.329
a	-0.040	-0.068	-0.016	-0.031	-0.014
	(-4.615)	(-3.425)	(-0.430)	(-3.390)	(-3.836)

Notes:
D: first differences, α shows the error correction term for the money demand equation. T-values in parenthesis.

Table 4. Residuals for the aggregate money demand system.

	EG 3 (P) *k = 2*		*EG 3 (B)* *k = 3*		*EG 3 (E)* *k = 2*	
L-B	197.661		172.839		173.622	
LM (1)	3.491		5.382		3.795	
LM (4)	8.267		5.872		13.485	
NV	8.923		10.475		16.045	
	ARCH	*NORM*	*ARCH*	*NORM*	*ARCH*	*NORM*
M3HR	0.39	0.42	0.98	0.36	12.76	17.11
GDPR	2.46	5.19	2.39	5.60	8.59	12.19
GBY	5.27	5.21	10.77	5.58	6.75	4.88
	EG 4 (P) *k = 2*		*EG 4 (B)* *k = 2*		*EG 4 (E)* *k = 2*	
L-B	249.896		229.871		201.336	
LM (1)	5.690		7.014		2.134	
LM (4)	13.776		18.976		14.919	
NV	11.202		13.931		17.460	
	ARCH	*NORM*	*ARCH*	*NORM*	*ARCH*	*NORM*
M3HR	2.31	0.72	3.56	2.72	11.98	13.15
GDPR	1.41	4.69	2.30	5.69	12.31	8.90
GBY	1.32	4.60	2.06	4.14	1.10	6.32

Notes:
EG 3 corresponds to the systems considering the aggregated variables for Germany, France, and the Netherlands, EG 4 to the four major European countries. A P stands for conversion with purchasing power parities, B means conversion with base year exchange rates, E with current exchange rates. The sample period is 1973:1 to 1994:4; k is the order of the VECM. The upper panel shows multivariate, the lower panel univariate statistics. The Ljung-Box test is distributed as $\chi^2(162)$ forE4B, as $\chi^2(171)$ for all the systems. The critical values are 192.70 and 202.51. For the other tests, see notes to Table 1.

Table 5. Test for Cointegration.

H0	*EG 3 (P)*		*EG 3 (B)*		*EG 3 (E)*	
	λ_{max}	Trace	λ_{max}	Trace	λ_{max}	Trace
r ≤ 0	21.06	29.48	16.73	21.91	15.57	23.57
r ≤ 1	8.40	8.42	4.79	5.19	5.84	8.00
r ≤ 2	0.01	0.01	0.39	0.39	2.17	2.17
H0	*EG 4 (P)*		*EG 4 (B)*		*EG 4 (E)*	
	λ_{max}	Trace	λ_{max}	Trace	λ_{max}	Trace
r ≤ 0	19.36	27.86	17.54	23.74	15.76	27.12
r ≤ 1	8.32	8.50	6.18	6.19	10.14	11.35
r ≤ 2	0.18	0.18	0.02	0.02	1.21	1.21

Notes:
Critical values for the 90 % significance level are 13.39 (r ≤ 0), 10.60 (r ≤ 1), and 2.71 (r ≤ 2) for the λ_{max} statistic and 26.70 (r ≤ 0), 13.31 (r ≤ 1), and 2.71 (r ≤ 2) for the trace statistic. The constant is unrestricted.

Table 6. Long-Run Estimates and Error Correction Parameters.

	EG 3 (P)	*EG 3 (B)*	*EG 3 (E)*
M3HR	1.000	1.000	1.000
GDPR	-1.171	-1.056	-1.861
GBY	0.049	0.085	-0.027
a	-0.048	-0.020	0.078
	(-4.110)	(-2.890)	(3.557)
b	*EG 4 (P)*	*EG 4 (B)*	*EG 4 (E)*
M3HR	1.000	1.000	1.000
GDPR	-1.251	-1.413	2.154
GBY	0.042	0.037	0.075
a	-0.065	-0.053	-0.035
	(-3.344)	(-2.664)	(-4.124)

Notes:
D: first differences, α shows the error correction term for the money demand equation. T-values in parenthesis.

Table 7. Likelihood Ratio Test for Coefficient Equality.

	EG 3 (P)	*EG 3 (B)*	*EG 3 (E)*
Germany	7.69	3.15	11.34
France	4.37	5.56	0.65
Netherlands	7.69	5.43	9.31
	EG 4 (P)	*EG 4 (B)*	*EG 4 (E)*
Germany	8.54	3.74	21.43
France	4.15	4.57	5.34
Italy	7.82	8.17	5.45
United Kingdom	24.68	24.74	25.79

Notes:

The null-hypothesis is that the income and interest rate elasticity of the respective national money demand function are equal to that of the European money demand function. The test-statistic is distributed as $\chi^2(2)$, the critical value for the 5 % level of significance is 5.99.

Table 8. Grunfeld-Griliches Test.

		composite R²			*aggregate R²*	
	EG 3 (P)	*EG 3 (B)*	*EG 3 (E)*	*EG 3 (P)*	*EG 3 (B)*	*EG 3 (E)*
M3HR	0.899	0.898	0.915	0.903	0.904	0.681
GDPR	0.885	0.892	0.904	0.853	0.867	0.698
GBY	0.323	0.322	0.332	0.324	0.356	0.278
	EG 4 (P)	*EG 4 (B)*	*EG 4 (E)*	*EG 4 (P)*	*EG 4 (B)*	*EG 4 (E)*
M3HR	0.870	0.866	0.927	0.854	0.860	0.446
GDPR	0.823	0.842	0.944	0.823	0.783	0.353
GBY	0.408	0.413	0.442	0.371	0.389	0.345

Notes:
For money and income a logarithmic transformation of the residuals is applied.

Table 9. F-Test.

		EG 3			*EG 4*	
	(P)	*(B)*	*(E)*	*(P)*	*(B)*	*(E)*
M3HR	-0.081	-0.188	5.523	0.240	0.097	13.159
GDRP	0.559	0.676	4.284	0.590	0.750	21.125
GBY	-0.004	-0.150	0.162	0.125	0.079	0.347
DGF	(26,75)	(23,71)	(26,75)	(36,75)	(36,75)	(36,75)

Notes:
DGF shows the degrees of freedom for the test in the respective column. All critical values for the 5 % level of significance are below 1.67.

Table 10. One step ahead mean squared forecast errors.

		composite forecast error			*aggregate forecast error*	
	EG 3 (P)	*EG 3 (B)*	*EG 3 (E)*	*EG 3 (P)*	*EG 3 (B)*	*EG 3 (E)*
M3HR	0.685	0.907	0.712	0.768	0.544	0.855
GDPR	0.115	0.114	0.127	0.135	0.151	0.111
GBY	0.192	0.193	0.194	0.205	0.181	0.239
Total	0.992	1.214	1.033	1.108	0.876	1.205
	EG 4 (P)	*EG 4 (B)*	*EG 4 (E)*	*EG 4 (P)*	*EG 4 (B)*	*EG 4 (E)*
M3HR	0.339	0.437	0.334	0.277	0.291	1.205
GDPR	0.046	0.050	0.085	0.046	0.049	0.743
GBY	0.239	0.234	0.230	0.209	0.192	0.268
Total	0.624	0.721	0.649	0.532	0.532	2.216

Notes:
The forecast errors are normalized with the variance of the respective variable in the forecasting period 1992:1 to 1994:4. The last line gives the forecast error for the whole system.

Table 11. Residual Correlation.

	$fres_t$	$ires_t$	$ures_t$	$nres_t$
$dres_t$	0.033 (0.308)	-0.267 (-2.459)	0.288 (2.659)	0.250 (2.304)
$fres_t$		0.125 (1.151)	0.115 (1.058)	-0.066 (-0.609)
$ires_t$			-0.181 (-1.680)	-0.118 (-1.097)
$ures_t$				0.165 (1.526)

Notes:
The table shows the correlation coefficients between the residuals from the money demand equations. The t-values in parenthesis are the ratio of the correlation coefficient to the inverse of the square root of the sample size.

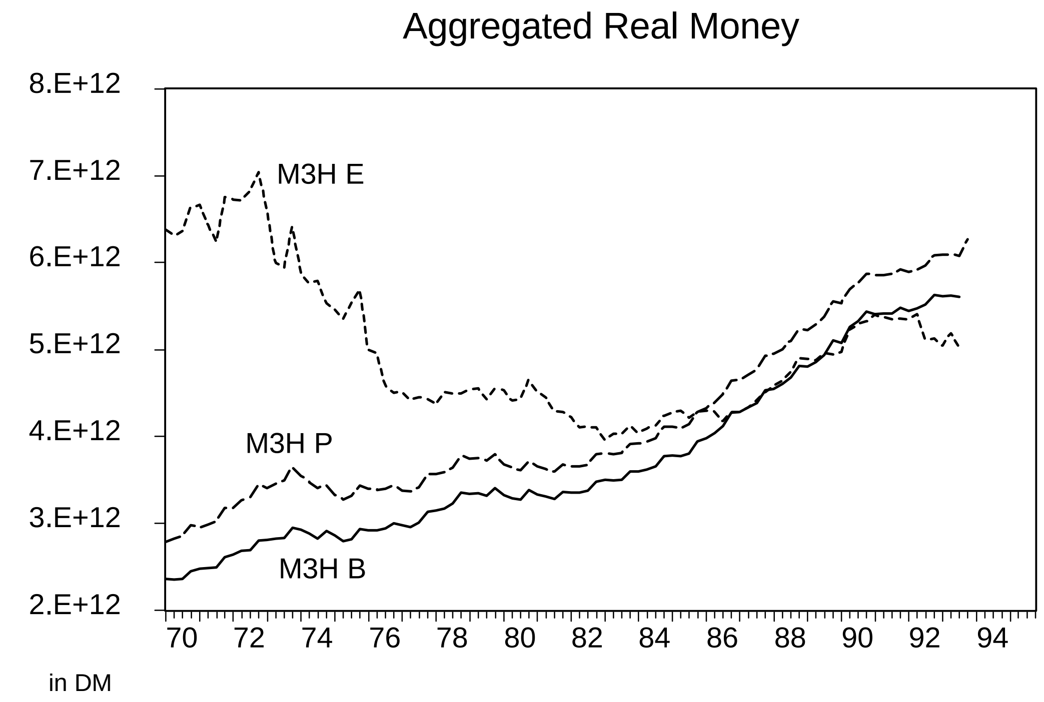
Aggregated Real Money
8.E+12
7.E+12
6.E+12
5.E+12
4.E+12
3.E+12
2.E+12
M3H E
M3H P
M3H B
70
72
74
76
78
80
82
84
86
88
90
92
94
in DM

Fig. 1.

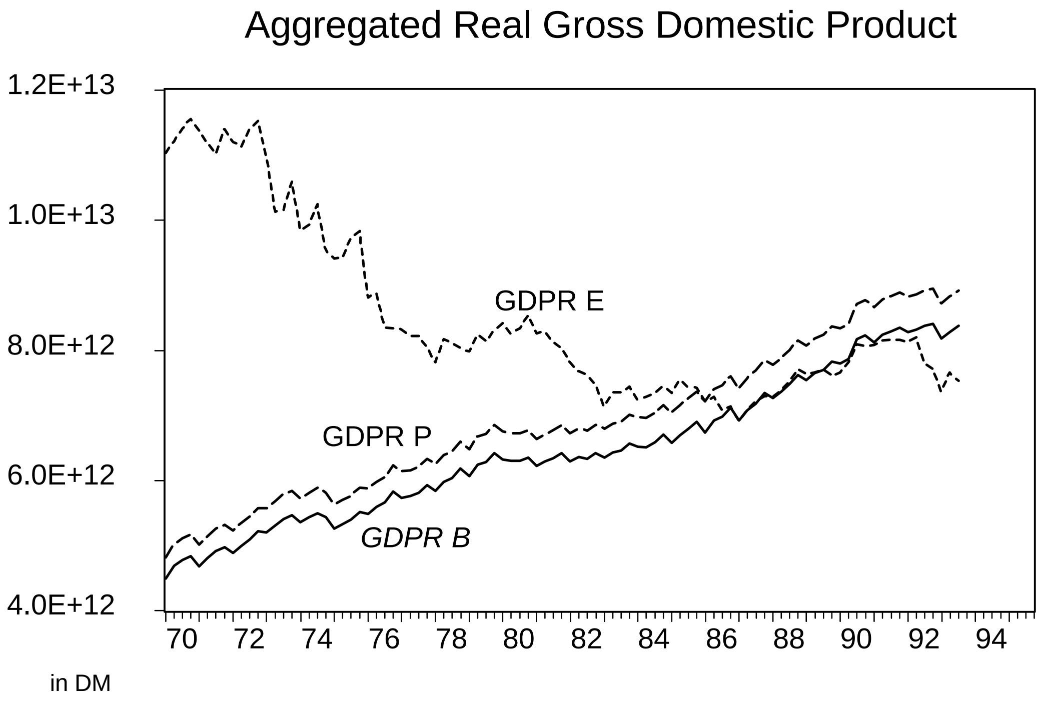
Aggregated Real Gross Domestic Product
1.2E+13
1.0E+13
8.0E+12
6.0E+12
4.0E+12
GDPR E
GDPR P
GDPR B
70
72
74
76
78
80
82
84
86
88
90
92
94
in DM

Fig. 2.

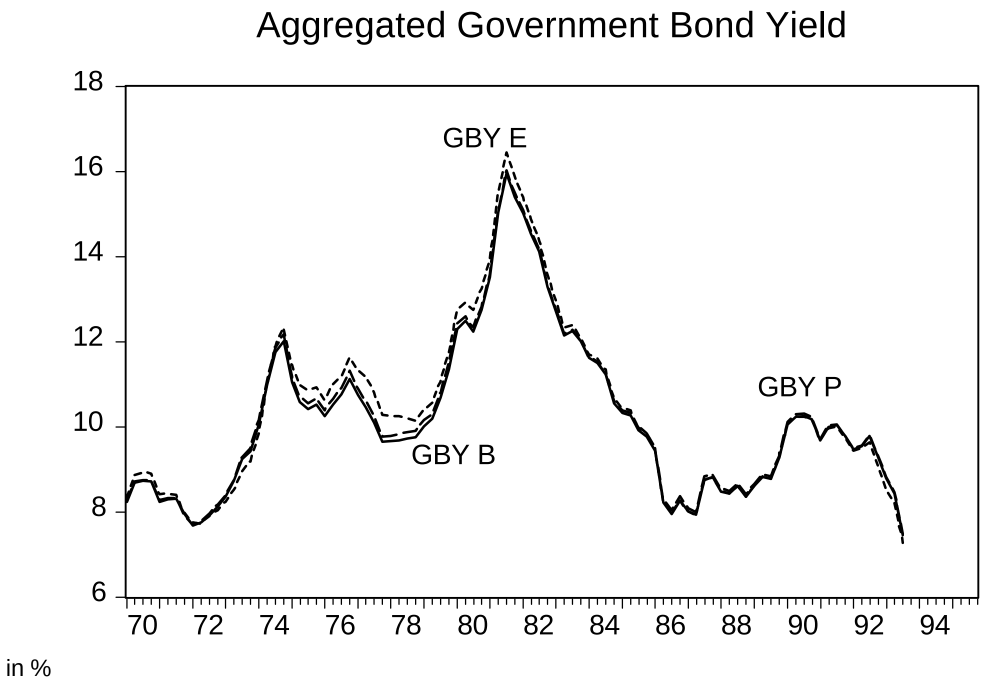
Aggregated Government Bond Yield
18
16
14
12
10
8
6
70
72
74
76
78
80
82
84
86
88
90
92
94
GBY E
GBY P
GBY B
in %

Fig. 3.