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A Small Monetary System for the Euro Area Based on German Data [1]

by

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Abstract

Previous euro area money demand studies have used aggregated national time series data from the countries participating in the European Monetary Union (EMU). However, aggregation may be problematic because macroeconomic convergence processes have taken place in the countries of interest. Therefore, in this study, quarterly German data until 1998 are combined with data from the euro area from 1999 until 2002 and these series are used for fitting a small vector error correction model for the monetary sector of the EMU. A stable long-run money demand relation is found for the full sample period. Moreover, impulse responses do not change much when the sample period is extended by the EMU period provided the break in the extended data series is captured by a simple dummy variable.

Keywords: Monetary policy, money demand, cointegration analysis
JEL classification: C32

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1 Introduction

The European Central Bank (ECB) has announced to pursue a policy strategy which is based on two pillars. One of these is monetary targeting while the other one includes assessment of other economic variables and especially inflation indicators. Given the importance of a stable currency it is not surprising that a number of studies have been performed which analyze various aspects of the ECB policy and its foundations. For example, Golinelli & Pastorello (2002) survey a large number of articles on money demand relations for the euro area and Vlaar & Schubert (1999) and Brand & Cassola (2000) consider small multivariate dynamic models to study the transmission of monetary policy.

A major obstacle in these studies is the lack of long time series for the main variables of the euro area because the euro was introduced in 1999 only. Therefore previous studies partly or exclusively use data from the pre-euro period. Typical variables of interest in money demand studies or investigations of the monetary transmission mechanism are money stock variables such as M3, income data such as Gross Domestic Product (GDP), interest rates and price levels. The corresponding pre-euro time series have been constructed by aggregating data from the European Monetary Union (EMU) countries. There are different possible aggregation methods which all have their advantages and drawbacks. For example, an EMU GDP series may be constructed by adding up the GDP series for all the EMU countries. In that case it has to be decided how to convert the individual GDP series into euro denomination. One may, for instance, use current exchange rates prior to the introduction of the euro. Alternatively, fixed exchange rates from some base period may be used. Some authors also apply purchasing power parity rates or the official irrevocable euro conversion rates. The aggregation problem has been discussed, for example, by Fagan & Henry (1998), Beyer, Doornik & Hendry (2001) and Bruggeman, Donati & Warne (2003).

There is, however, another problem related to the aggregation of data from the pre-euro period. This problem arises from the Maastricht criteria[2] which the EMU participants had to satisfy prior to the introduction of the euro. Many countries did not satisfy some of these criteria when they were announced in 1996. In fact, in some countries the economic conditions were quite far away from the Maastricht criteria. Therefore major adjustment

[2]The Maastricht criteria specify reference values for government deficit and debt, the inflation rate and the long term interest rates. For instance, the deficit criterion is met when the government deficit does not exceed 3% of GDP, while the debt criterion is met when gross government debt is not exceeding 60% of GDP.

processes were introduced by the governments and central banks. A substantial literature is available that analyzes the convergence process in Europe (see, e.g., Kočenda & Papell (1997), Beine & Hecq (1998), Tsionas (2000) and Holmes (2002)). These adjustment and convergence processes are likely to be a further obstacle for the construction of time series data for the euro area in the pre-euro period. Clearly, if adjustment processes have resulted in major changes in the economic systems, structural change may be a problem for modelling data from both the pre-euro and the euro period. Also, it is not clear whether the stable models and relations found on the basis of such data do in fact reflect the current situation adequately or whether they describe a situation which is largely influenced by the convergence process. After all, in most of the studies the pre-euro period is considerably longer than the euro period and, hence, the pre-euro period has a dominating weight.

A problem may also arise from the fact that the euro area is likely to grow over the next years because a number of countries are candidates for joining the EMU. In that case, new historical data for the extended area have to be constructed which again may be of doubtful quality due to the current adjustment processes in the EMU candidate countries. Using such new aggregated data may also change the results found on the basis of the present EMU member states.

In this study we use a different approach by combining German data from the pre-euro period with those from the EMU countries for the period starting in 1999. There are a number of arguments in favor of using German data until the end of 1998. First of all, Germany is in many respects the largest country in the EMU. Furthermore, Germany fulfilled some important criteria at least roughly at the time when the Maastricht treaty was established. For example, Germany had a long lasting record of relatively low inflation rates. Its public debt was 60.4% of GDP in 1996 and, hence, was low in comparison with countries like Italy and Spain, where the debt was 124% and 70.1% of GDP, respectively (see European Monetary Institute (1998)). Moreover, Germany's government deficit ratio was 3.4% in 1996 while that of Italy was 6.7% and that of Spain was 4.6%. Thus, in contrast to other large EMU countries, Germany was close to satisfying the debt criteria already at the time when the Maastricht criteria were announced. Moreover, the ECB monetary strategy is similar to the policy strategy of the Bundesbank (the German central bank) which has used a monetary targeting strategy for a long time. For these reasons it seems plausible to view Germany as a predecessor of the euro area. In Germany's monetary sector no substantial economic adjustments were necessary at the time when the euro was introduced.

The main question we will address in this study is whether combining the data in the way described in the foregoing results in a simple model for the monetary sector which is time invariant throughout the sample period. For this purpose we will fit a small, textbook-type model which worked well for Germany in the pre-euro period and check if it also describes the combined German and EMU data well. We decided to focus on a small vector error correction model (VECM) in the present study because it captures different features of the data. For instance, it incorporates important long-run relations as well as the general dynamic structure of the relations between the variables. For our purpose, separating the long-run relation from the short-run dynamics has the advantage that it may be easier to see where structural changes may have occurred. In other words, we may be able to determine whether structural changes have occurred in all parts of the relations, in the long-run relations only or just in the short-run adjustment processes, if changes occured at all.

We analyze small VECMs similar to one constructed by Lütkepohl (2004) for the money stock M3, GDP and a long-term interest rate. Thus, the analysis is centered around a possible textbook-type money demand relation where the demand for money depends on the transactions volume measured by GDP and an opportunity cost variable. In contrast to other studies, we use seasonally unadjusted data because seasonal adjustment procedures are particulary problematic for series with structural shifts. We analyze data for the period 1975-2002 but will also consider subperiods to investigate possible changes in the estimated parameters and impulse response functions. We find some changes in the dynamic structure of the data. On the other hand, we also find a stable long-run money demand relation and similar impulse responses for the period before and after the introduction of the Euro.

The remainder of the paper is structured as follows. The data used is described in Section 2. In Section 3, we introduce the modeling framework and present the main results from our empirical cointegration analysis which also includes detailed stability and other diagnostic checks. We end Section 3 with an impulse response analysis before conclusions are drawn in Section 4. A detailed data description and some supporting material for our analysis are given in the Appendix.

2 The Data

Naturally, euro area data are only available from 1999 onwards. While other studies have used artificial data obtained from some aggregation method applied to national euro area time series, we use a different strategy here. We combine German data from the pre-euro period with euro area time series from 1999 onwards. This strategy might be advantageous in comparison with alternative approaches that use artificial euro area data prior to 1999 because it avoids the choice of an aggregation method and the somewhat peculiar concept of analyzing an artificial currency area. Clearly, our approach of avoiding the aggregation problem for the pre-euro period introduces major shifts in time series such as GDP and the money stock. This problem is similar to what happened at the time of German reunification in 1990. From that time onwards many German series refer to the unified Germany whereas data prior to the reunification often refer to West Germany only because reliable data for East Germany are not available. The shift in German data was successfully captured by dummy variables in some previous studies (see, e.g., Hubrich (1999), Lütkepohl & Wolters (2003), Brüggemann (2003) and Lütkepohl (2004)). Therefore we hope to take care of the shift in the series used in the present study in a similar way, although the shift has admittedly a different magnitude in the present case. Notice that in terms of population West Germany was roughly 80% of all of Germany at the time of the unification whereas the population of Germany was only about 27% of the population of all EMU countries in 1999 when the euro was introduced.[3]

We analyze a small system with three variables only: M3, GDP and a long-term interest rate.[4] Quarterly, seasonally unadjusted data for the period $1975Q1 - 2002Q4$ is used. Here we only provide a brief description of the relevant time series. More details on the data sources and the construction of the variables used in our analysis can be found in Appendix A.1. The year 1975 is chosen as the sample beginning because it was the year where the German Bundesbank officially started its monetary targeting strategy. The end of the sample is determined by the data availability at the time when we started the study. Although the German monetary union took place in $1990Q3$, the M3 series provided by the Bundesbank corresponds to West Germany until $1990Q1$ and to the unified Germany afterwards ($1990Q2 - 1998Q4$). In contrast, the German real GDP series refers to West Germany until $1990Q2$ and to the unified Germany afterwards ($1990Q3 - 1998Q4$). Both changes in the definitions have to be captured by dummy variables in our subsequent analysis. The original German figures have been converted to euros using the irrevocable euro conversion rate. The real M3 series is obtained from the nominal series by multiplying with the GDP deflator. Data on the euro area level corresponds to the area of the eleven euro area countries (EUR11)

[3]Source: Numbers based on Eurostat online database and the 'Statistisches Jahrbuch 2003' of the German Statistisches Bundesamt.

[4]Lütkepohl (2004) uses GNP instead of GDP data for the German system. Seasonally unadjusted GNP data is not available on the European level, hence we have used GDP data for Germany and the euro area.

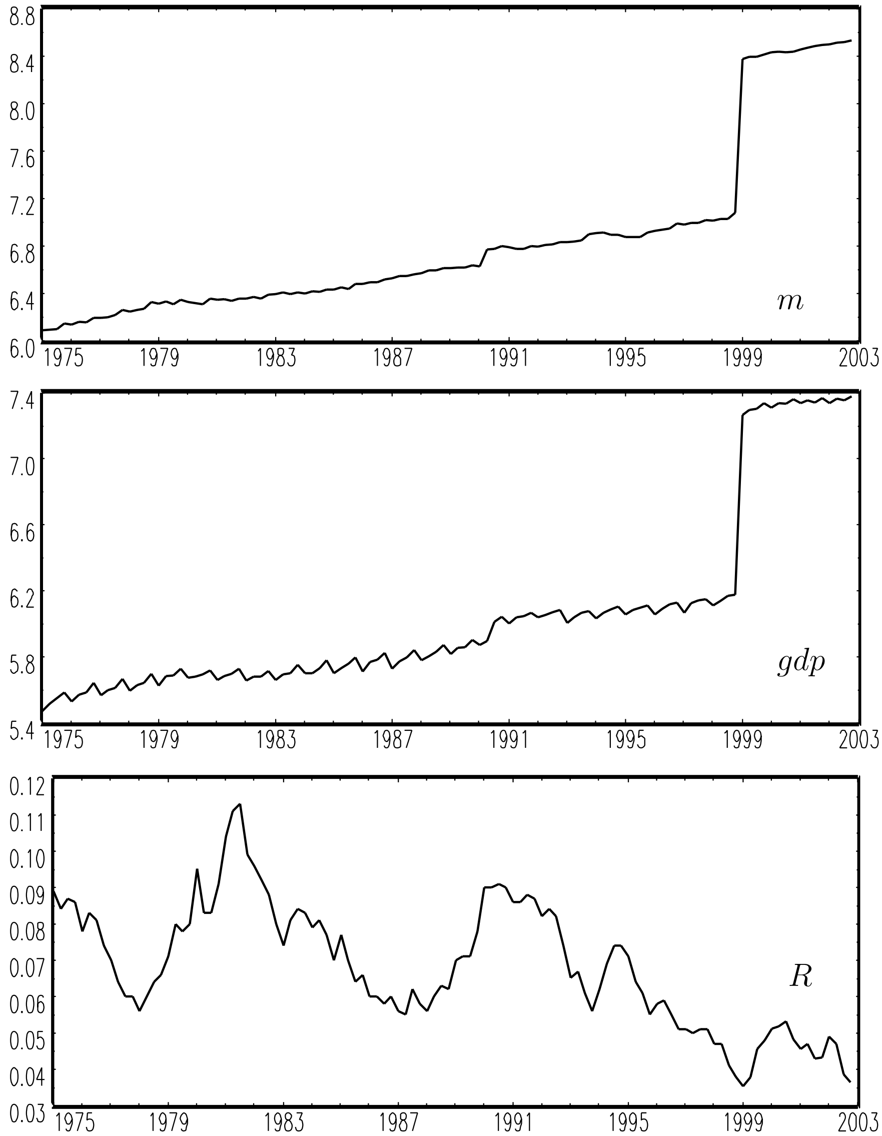

Figure 1: Graphs of time series used.

plus Greece for the period from $1999Q1-2000Q4$ and to the twelve euro countries (EUR12) afterwards. Real GDP and M3 are obtained from ECB and Eurostat databases. Real M3 is again obtained by deflating with the GDP deflator. The long term interest rate is the average bond rate for Germany until the end of 1998 and a 5 year government bond rate afterwards. The three variables in our analysis are the logarithm (log) of real M3 (m), the log of the real GDP (gdp) and the long term interest rate R.

Time series plots of these three series are given in Figure 1. The German unification leads to a level shift in m and gdp in 1990. A similar level shift with larger magnitude is present at the beginning of 1999 when we use euro area data instead of German data. Given the modelling experience with the level shift due to German unification it might also be possible to model the shift in 1999 using a small set of dummy variables. However, given that the data used are obtained from different statistical institutions and may also correspond to slightly different definitions it is likely that the dynamics of German and European time series are different. Notice also the different magnitude of seasonal fluctuations in the German and EMU GDP data. Consequently, it is well possible that the changes in the combined series cannot be captured by simple dummies. Visual inspection of the interest rate series does not reveal obvious breaks.

All series have a trending behavior and may have unit roots. The unit root properties have been analyzed taking into account the structural shifts in at least two of our series. We have applied unit root tests for different subperiods and give the results in Table A.1 in the Appendix. Overall the tests provide robust evidence for one unit root in each of the underlying series. We therefore proceed under the assumption that the underlying series are integrated of order 1, denoted as I(1).

3 Empirical Analysis

Given that our series are well described as I(1) series, we consider a multivariate model which allows explicitly for cointegration. More precisely, the general model used in our analysis is a VECM of the form

$$\Delta y_t = \alpha\beta' y_{t-1} + \Gamma_1 \Delta y_{t-1} + \cdots + \Gamma_{p-1} \Delta y_{t-p+1} + C d_t + u_t, \qquad (1)$$

where y_t is the K-dimensional vector of observable time series variables, Δ denotes the differencing operator such that, e.g., $\Delta y_t = y_t - y_{t-1}$, d_t contains the deterministic variables and u_t is a white noise error process with zero mean and time invariant, positive definite covariance Σ_u. The quantities α, β, Γ_i $(i = 1, \ldots, p-1)$ and C are parameter matrices. The matrices α and β are both $(K \times r)$, where r is the cointegrating rank and all other matrices have suitable dimensions. We have also experimented with deterministic terms in the cointegrating relations. They were not maintained in our final models, however. Therefore the model (1) is general enough for our purposes.

In our case, $y_t = (m_t, gdp_t, R_t)'$ is three-dimensional and the deterministic term possibly includes a linear trend, a constant, seasonal dummy variables as well as shift and impulse dummies. We use the notation $IyyQq$ and $SyyQq$ for impulse and shift dummies, respectively. Here yy stands for the year and q signifies the quarter in which the dummy variable assumes a value of 1. For example, $I90Q2$ denotes an impulse dummy which has the value 1 in the second quarter of 1990 and is zero elsewhere. Similarly, $S99Q1$ denotes a shift dummy variable which is zero until the last quarter of 1998 and has the value 1 from the first quarter of 1999 onward.

An important decision in setting up a VECM as in (1) concerns the number of cointegrating relations r. We will therefore investigate the cointegrating rank of our system next.

3.1 Cointegrating Rank Tests

We have first analyzed the cointegrating rank of the three variables using the tests proposed by Saikkonen & Lütkepohl (2000) which allow for level shifts in the data. Detailed results are given in Table A.2 in the Appendix. In addition to the full sample period we have also performed tests for various subperiods. Two of the subperiods use German data only and range from $1975Q1 - 1998Q4$ and from $1984Q1 - 1998Q4$. The longer one of these two subperiods covers the full range of German data in our sample. In previous studies it was found, however, that there may have been some structural change in the German monetary system in 1983 (see, e.g., Juselius (1998)). Therefore we also use a reduced sample of German data that starts in 1984. It is then, of course, plausible to combine also the reduced sample with the EMU data for 1999-2002 which results in a sample period $1984Q1 - 2002Q4$. To account for the shifts in the series we include an impulse dummy $I90Q2$ and a shift dummy $S90Q3$ in all models. The impulse dummy takes care of the fact that the shift in the money variables occurs already in the second quarter of 1990 while the income variable shifts only in $1990Q3$. For all sample periods covering EMU data, we also include a shift dummy $S99Q1$. Notice also that, in accordance with the lag order, the first observations of each sample are used as lagged right-hand side variables only. Thus, the actual sample size is even smaller and depends on the lag order used.

Using the different sample periods, alternative lag lengths and specifications of the deterministic trend terms, there is some evidence for one cointegration relation. If a linear trend is included in unrestricted form, rank 0 is in most cases not rejected. However, if the cointegration relation represents a money demand relation, one would not expect a trend in the cointegration relation because the money and income variables, that is, the variables with a possible deterministic linear trend, should not be driven apart by a linear trend. In other words, a specification with a trend orthogonal to the cointegrating relations may be more plausible here. Using this specification, the evidence for cointegrating rank 1 is quite clear. Only for the sample period $1984Q1-2002Q4$ rank $r = 0$ cannot be rejected at the 10% level. This may be due to insufficient power of the tests, given that the sample is relatively small and shifts in the series have to be accounted for. It must be emphasized that little is known about the properties of cointegration tests in models with more than one level shift. Consequently, we interpret the results in Table A.2 as evidence for one long-run relation and in the following we consider only models with cointegrating rank $r = 1$. This choice is also fully in line with results in Lütkepohl (2004) based on a similar data set for Germany only.

3.2 The Empirical Models

We have estimated VECMs with cointegrating rank $r = 1$ and different lag orders. An intercept and seasonal dummies are included as deterministic terms in all models. A separate trend term in the cointegration relation turned out to be unnecessary for describing our data and, as we have noted earlier, it is also implausible in a money demand relation. Therefore it is not included. Also the shift dummy variables were not needed in the cointegration relation and hence we included them only in differenced form. More precisely, we include impulse dummies $I90Q2$ and $I90Q3$ ($= \Delta S90Q3$) to account for the German unification whenever data from 1990 are included in the sample. Moreover, $I99Q1$ ($= \Delta S99Q1$) is included in all models for data which include the EMU period. Because of the possible change in the seasonal pattern of the EMU data we have also included an extra set of seasonal dummy variables for the EMU period.

For each considered sample period we have estimated the optimal lag order of the VECM using information criteria. Based on model diagnostics and, in particular, tests for residual autocorrelation we found that the lag lengths suggested by information criteria (2 or 0) were not sufficient for a congruent statistical model. Hence, we increased the lag order to 4. A range of diagnostic tests for some of the models we have tried are shown in Table A.3 in the Appendix. In particular, we tested for residual autocorrelation, nonnormality and ARCH[5] and present p-values for models estimated by Johansen's reduced rank ML procedure (Johansen (1995)) in the table. For the two sample periods starting in $1975Q1$ the p-values in Table A.3 do not signal any severe model deficiencies although there may be some ARCH in the residuals of the model for the sample that ends in $2002Q4$. Because there may be some residual autocorrelation left in the order 2 models, we have also fitted order 4 models to the sample periods $1984Q1-1998Q4$ and $1984Q1-2002Q4$. It turns out,

[5] All tests are described in more detail in Lütkepohl (2004).

however, that the residual autocorrelation problem is not fully solved by increasing the lag order to 4. Note, however, that Brüggemann, Lütkepohl & Saikkonen (2004) found that the multivariate residual autocorrelation tests may be severely oversized in small samples. This may explain the small p-values for the shorter time periods at least partly. Of course, it is also possible that residual autocorrelation is not fully captured by the models. In fact, the significant autocorrelation tests may signal a different type of model deficiency. Therefore we will also discuss other model checks in the following. For the shorter sample periods we have chosen both, lag orders 2 and 4 in some of the subsequent analysis. Especially for the short samples a parsimonious order choice seemed preferable to avoid loosing many degrees of freedom.

So far we have just considered general misspecification tests. In the present situation, the structural stability of the models is of particular interest. Therefore we have also performed a stability analysis. Some results of formal stability tests are shown in Figures A.1 and A.2 in the Appendix. The graphs report results from a sequence of single equation and system based Chow test variants. Ndn and Nup denote the break point and forecast Chow tests described in detail in Doornik & Hendry (2001, Sec. 15.6). Overall the stability tests do not provide much evidence of model instability in the EMU period. In particular, none of them is significant at the 5% level.

Thus the overall conclusion from our analysis so far is that merging the German and EMU data does not go unnoticed in the empirical analysis. Still it is possible to find relatively simple VECMs which capture many features of the data quite well. Therefore it seems reasonable to take a closer look at some features of particular interest.

3.3 The Cointegration Relation

The cointegration relation is one relation of obvious interest in our system of variables. We write it in the form

$$m_t = \beta_{gdp} gdp_t + \beta_R R_t + ec_t, \tag{2}$$

where ec_t denotes the deviations from the cointegration relation. We present the reduced rank ML estimates (Johansen (1995)) of the parameters with standard errors in the upper half of Table 1. Because even in the shorter sample period starting in $1984Q1$ the weight of the German data is still large relative to the EMU period, we have also included results from a model fitted to $1991Q1-2002Q4$ which starts after the German reunification. Notice that no deterministic terms enter the cointegrating relation in our estimated models. In (2), the

Table 1: Estimated Cointegration Parameters with Standard Errors in Parentheses

estimation method	sample period	no. of lagged differences	β_{gdp}	β_R
ML	$1975Q1 - 1998Q4$	4	1.17(0.09)	−6.15(1.30)
	$1984Q1 - 1998Q4$	4	1.30(0.01)	−2.76(0.15)
	$1984Q1 - 1998Q4$	2	1.29(0.01)	−2.92(0.18)
	$1975Q1 - 2002Q4$	4	1.15(0.09)	−6.50(1.30)
	$1984Q1 - 2002Q4$	4	1.29(0.03)	−3.23(0.35)
	$1984Q1 - 2002Q4$	2	1.29(0.03)	−3.57(0.34)
	$1991Q1 - 2002Q4$	2	0.70(0.25)	−5.47(0.66)
S2S	$1975Q1 - 1998Q4$	4	1.33(0.06)	−2.56(0.80)
	$1984Q1 - 1998Q4$	4	1.31(0.01)	−2.71(0.15)
	$1984Q1 - 1998Q4$	2	1.30(0.01)	−2.83(0.18)
	$1975Q1 - 2002Q4$	4	1.33(0.06)	−2.59(0.78)
	$1984Q1 - 2002Q4$	4	1.31(0.02)	−2.81(0.32)
	$1984Q1 - 2002Q4$	2	1.30(0.03)	−3.25(0.32)
	$1991Q1 - 2002Q4$	2	1.18(0.20)	−3.82(0.54)

Note: Intercept and seasonal dummies are included in all models in d_t. Impulse dummies $I90Q2$ and $I90Q3$ are included in all models for sample periods which cover the year 1990 and $I99Q1$ is included in all models for sample periods covering the year 1999. An extra set of seasonal dummies is included for $1999Q1 - 2002Q4$ for all models covering the EMU period. Computations are performed with JMulTi, Version 3.01 pre (see Lütkepohl & Krätzig (2004)).

cointegration relation is written in the form of a possible money demand relation. Here β_{gdp} represents the long-run income elasticity and β_R is a semi-elasticity because m_t and gdp_t are in logs whereas R_t is not.

Obviously, the parameter estimates in the upper part of Table 1 suggest to interpret the cointegration relation as a money demand function. The income elasticity is slightly larger than one as in some other studies for Germany (e.g., Issing & Tödter (1995), Scharnagl (1998), Lütkepohl & Wolters (2003)) and the euro area (see the survey in Golinelli & Pastorello (2002) or Bruggeman et al. (2003)). The interest rate semi-elasticity is negative, as one would expect for an opportunity cost variable in a demand equation. All estimates of the income elasticities are in fact quite close except for the very short sample period starting in $1991Q1$. For the latter period the estimated income elasticity falls below one. Notice, however, that the standard deviation becomes much larger than for the other periods. In fact, there may be a problem with the ML estimator in this case. This estimator is known to produce strongly distorted estimates occasionally in small samples (see, e.g., Brüggemann & Lütkepohl (2004)). This property of the ML estimator may also be responsible for the substantial differences in the estimated interest rate semi elasticities. Therefore, we decided to check the results by another, more reliable procedure and we have also used an estimation method proposed by Ahn & Reinsel (1990) which is described in detail in Lütkepohl (2004) under the name S2S procedure. Brüggemann & Lütkepohl (2004) found that this estimator does not have the undesirable property of producing the occasional outliers sometimes seen in ML estimation. The results are also given in Table 1. The income elasticities and also the interest rate semi-elasticities estimated with this procedure are much closer together for the sample periods presented in Table 1.

In summary, based on the S2S estimator, extending the German time series by the euro area series does not have a substantial impact on the estimators of the cointegration parameters. Even if the relative weight of the EMU period is increased by deleting some of the German data at the beginning of the sample period, this does not lead to substantial changes in the estimates. Therefore the results in Table 1 overall support a stable long-run money demand relation for the full sample period.

To further analyze the stability of the coefficients of the long-run money demand relation, we have also computed recursive estimates of the parameters in the error correction term. In other words, we concentrate out the short-run and deterministic parameters on the basis of the full sample and then estimate α and β recursively. Thus, if there is any instability it is shifted to the error correction term and should show up in the α and β parameters. The recursive ML and S2S estimates of β_{gdp} and β_R are depicted in Figure 2 for the critical period where the German and EMU data have been merged ($1995Q1 - 2002Q4$). The recursive S2S estimates are computed as follows. The short-run and deterministic parameters are concentrated out by regressing Δy_t and y_{t-1} on $(\Delta y_{t-1}, \dots, \Delta y_{t-p+1}, d_t)'$ and denoting the resulting residuals by R_{0t} and R_{1t}, respectively. Then the model $R_{0t} = \Pi R_{1t} + \epsilon_t$ is recursively estimated by OLS and the first $r = 1$ column of the estimated Π matrix is used as an estimator for α. Denoting the estimator based on the first τ observations by $\hat{\alpha}_\tau$ and the corresponding estimator of the residual covariance matrix by $\hat{\Sigma}_\tau$, the recursive estimates of the last $K - r = 2$ elements of $\beta = (1, \beta_1, \beta_2)'$ are obtained from

$$(\hat{\beta}_1, \hat{\beta}_2)_\tau = (\hat{\alpha}_\tau' \hat{\Sigma}_\tau^{-1} \hat{\alpha}_\tau)^{-1} \hat{\alpha}_\tau' \hat{\Sigma}_\tau^{-1} \left(\sum_{t=1}^{\tau} (R_{0t} - \hat{\alpha}_\tau R_{1t}^{(1)}) R_{1t}^{(2)'} \right) \left(\sum_{t=1}^{\tau} R_{1t}^{(2)} R_{1t}^{(2)'} \right)^{-1}.$$

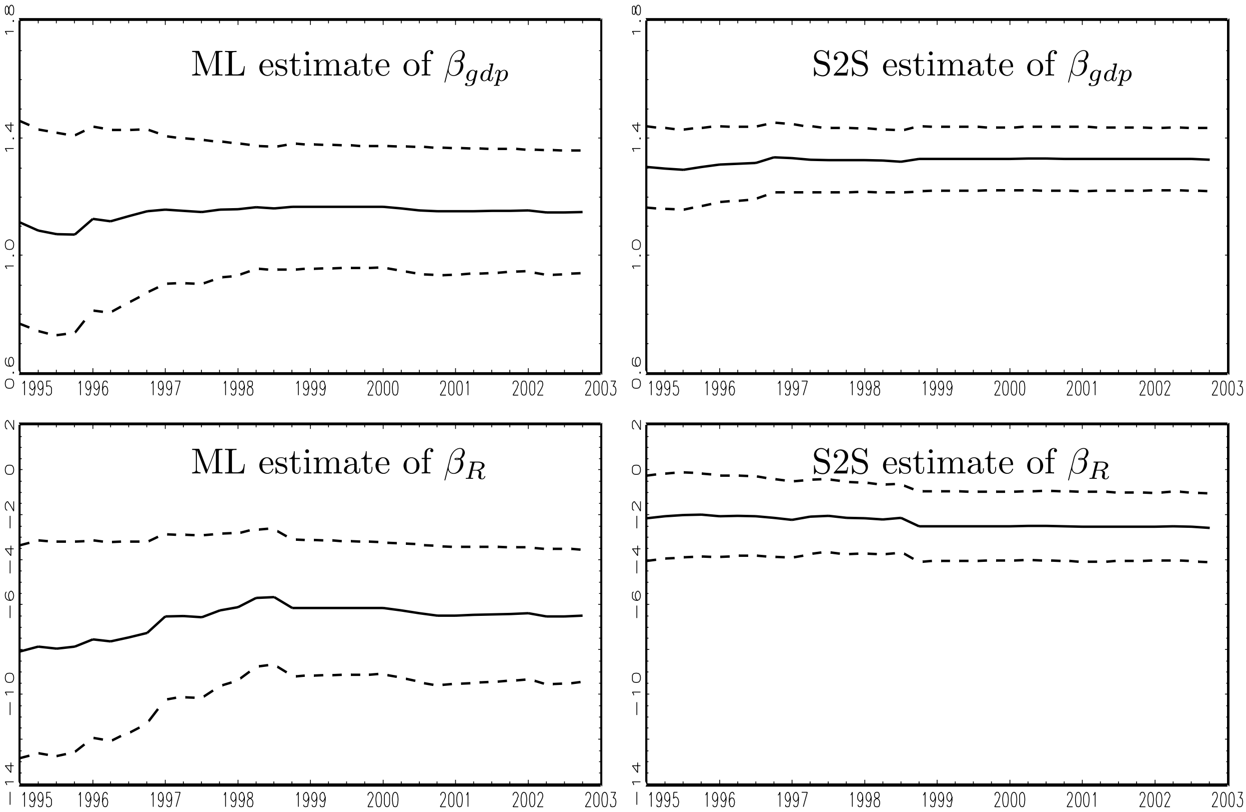

Figure 2: Recursive estimates of cointegration parameters of VECM with 4 lagged differences for sample period $1975Q1 - 2002Q4$ with ± 2 standard error bounds. ML estimates (left) computed with PcGive 10.3 (see Doornik & Hendry (2001)). S2S estimates (right) computed with Gauss 5.0.

Here $R_{1t}^{(1)}$ and $R_{1t}^{(2)}$ denote the first element and the last two elements, respectively, of R_{1t}. The recursive S2S estimates are shown in the last column of Figure 2. Clearly, they look even more stable than the recursive ML estimates.

To see whether the stable recursive estimates of the cointegration parameters are perhaps a consequence of the long period of German data prior to the time where recursive estimates are computed, we have also computed recursive estimates based on the shorter data period from $1984Q1 - 2002Q4$. They are shown in Figure 3. Both the ML and the S2S estimates again look quite stable.

Overall our results show that merging German and EMU data as we have done it here is a useful strategy for investigating the euro area long-run money demand relation. It results in stable models if only quite simple modifications are made to account for the differences in the data. More precisely, in the present case it suffices to include an impulse dummy variable for the period were the data are merged and an extra set of seasonal dummies for the EMU period.

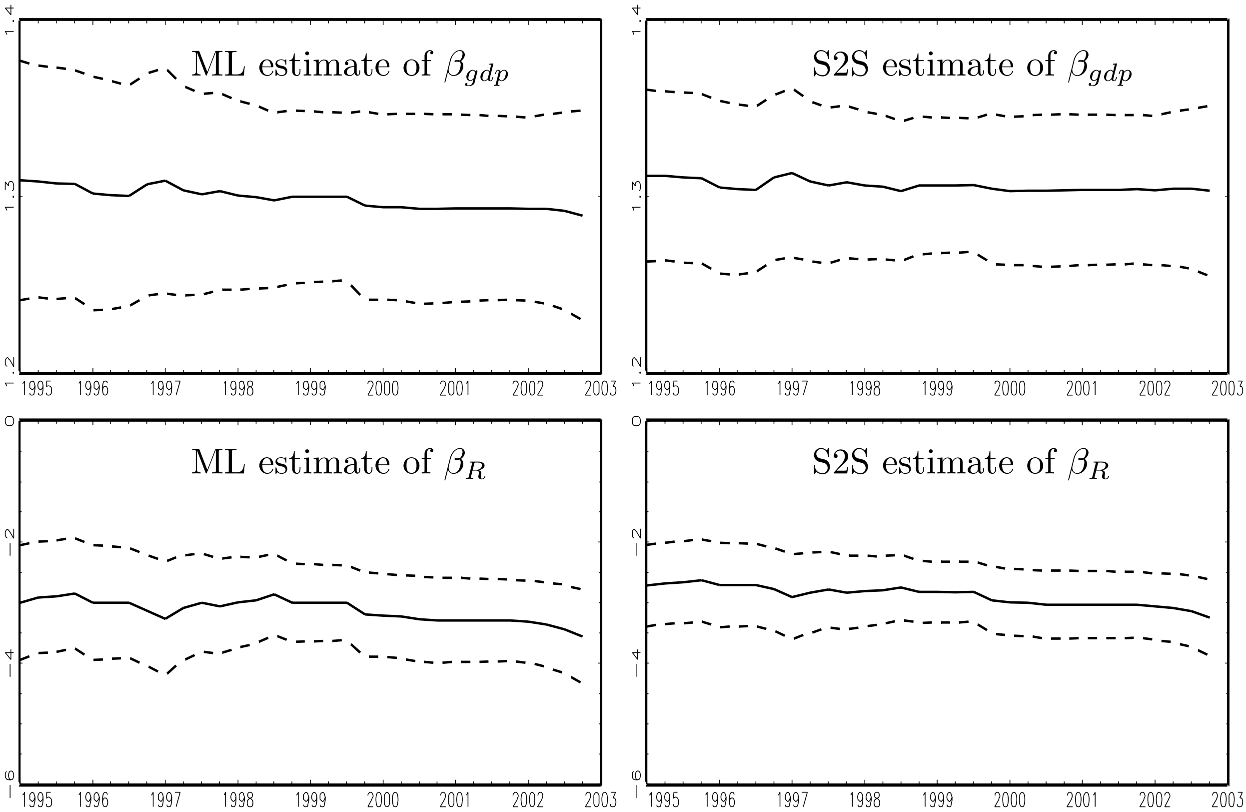

Figure 3: Recursive estimates of cointegration parameters of VECM with 2 lagged differences for sample period $1984Q1 - 2002Q4$ with ± 2 standard error bounds. ML estimates (left) computed with PcGive 10.3 (see Doornik & Hendry (2001)). S2S estimates (right) computed with Gauss 5.0.

Our long-run money demand relation is well in line with results of other authors who have used aggregated data from the pre-euro period. Similar results are obtained with different aggregation methods and despite the fact that substantial adjustment processes have taken place in some of the EMU countries (see the survey in Golinelli & Pastorello (2002)). By aggregating the individual country data some smoothing seems to have taken place. It is also important to note that in all the studies reviewed in Golinelli & Pastorello (2002) only data from the pre-euro period are used. Carstensen (2004) who uses at least some data from the EMU period and a different specification, finds that it is unstable. Only if additional stock market series are included in the model, stability is reestablished. In contrast, Bruggeman et al. (2003) who use data until 2001 argue that a stable money demand relation can be found for the euro area. Thus, when actual data from the euro period are included, previous research does not give a unique answer to the stability question.

Even though our results are similar to those of others especially when exclusively data from the pre-euro period are used, we feel that using our approach to avoid the aggregation problem has some advantages.

1. Aggregation smoothes the data and may make the money demand relation appear more stable than it actually is in the euro period. Hence, avoiding the aggregation problem altogether may shed additional light on the actual stability of the long-run money demand relation during the euro period.

2. In future years a number of other countries will most likely enter the EMU. For some of these countries it may be difficult to obtain reliable data from the 1980s, say. It is not clear what the effect of aggregating such data with those from the present EMU countries will be. In contrast, our approach of adding the data only at the time when the new countries join the EMU and have completed the economic adjustment at least to some extent, is still easily applicable.

3. More elaborate models with further variables for the monetary sector of some countries have been constructed. Clearly, the aggregation problem is aggravated if further time series have to be constructed from individual country series. The outcome of such aggregation exercises is uncertain. Of course, it is also not clear that our approach works for more elaborate models. In any case, it offers a viable alternative.

Issues related to analyses of the transmission process of monetary policy are often studied by an impulse response analysis. Therefore, in the next subsection we will consider impulse responses obtained from our models and we will check if our approach also leads to sensible results for the short-run dynamics.

3.4 Impulse Responses

Because the estimated instantaneous correlations between the residuals of all equations of a given model are quite small[6], it is justified to consider forecast error impulse responses (Lütkepohl (1991)) for an analysis of the dynamic interactions between the variables. Moreover, we are mainly interested in possible differences between the dynamics in Germany and in the extended sample period. If there are differences they should also be reflected in the forecast error impulse responses even if it may be problematic to interpret the residuals as structural innovations.

[6] Using a $\pm 2/\sqrt{T}$ criterion, we only find significant contemporaneous correlation between residuals of the income and interest rate equation in a model for the period 1991Q1-2002Q4 estimated with S2S. In all other specifications the correlations are not significantly different from zero according to this criterion.

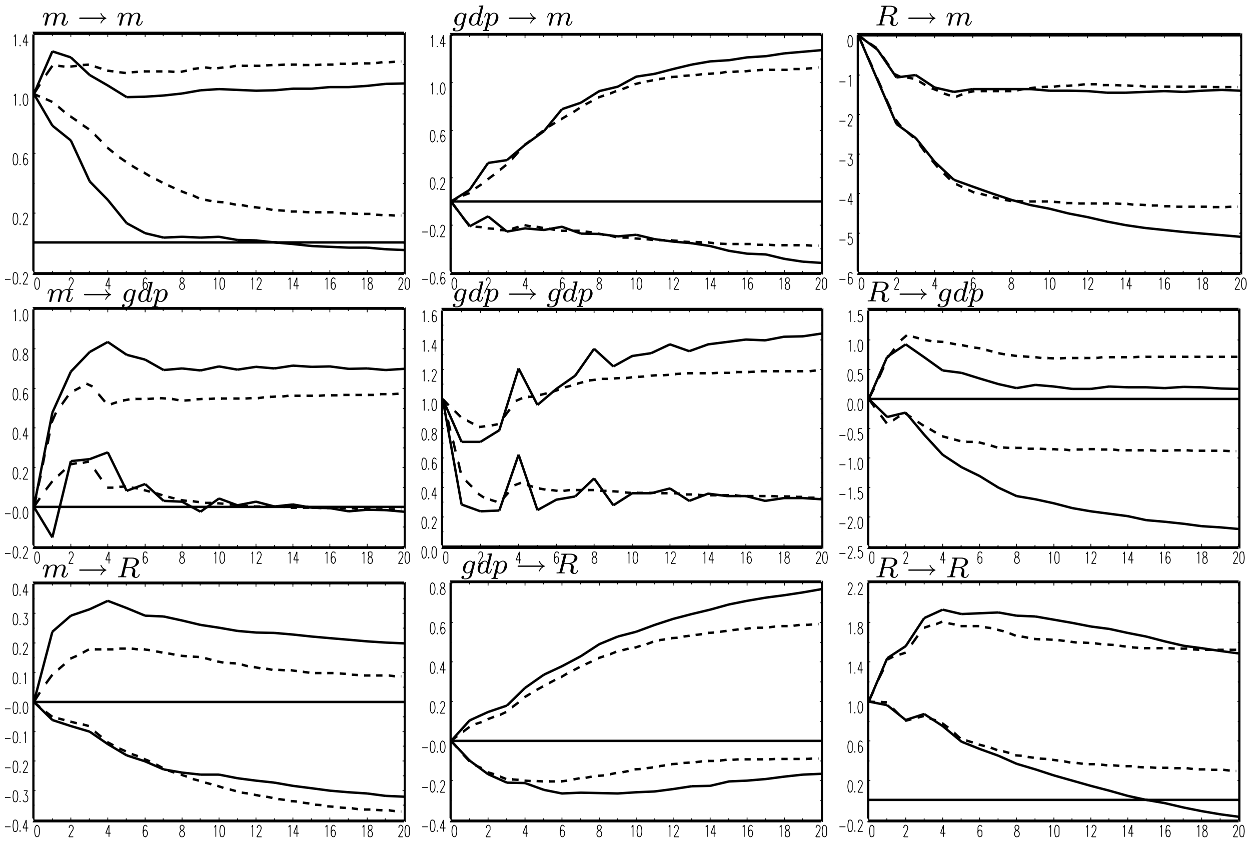

Figure 4: Impulse response intervals based on VECMs with four lagged differences estimated by S2S. Sample: ——: 1975Q1-1998Q4, - - -: 1975Q1-2002Q4. Computations performed with JMulTi, Version 3.02 pre (see Lütkepohl & Krätzig (2004)).

We have computed impulse responses for the different models and estimation methods. In Figure 4 we show 95% confidence intervals (CIs) of impulse responses corresponding to the sample periods $1975Q1 - 1998Q4$ and $1975Q1 - 2002Q4$ based on S2S estimators. Here Hall bootstrap CIs as described in Benkwitz, Lütkepohl & Wolters (2001) are shown. They have the advantage that in contrast to conventional bootstrap CIs for impulse responses they have a built-in bias correction. In Figure 4 impulse response CIs for the purely German system (sample period $1975Q1 - 1998Q4$) are compared to the corresponding CIs for the extended period.

The CIs in Figure 4 for Germany (solid lines) have quite plausible appearances. They indicate that a one-time impulse in the money demand has a potentially permanent effect on the money stock. It may lead to a long lasting or permanent increase in income and does not affect the long-term interest rate much although there may be a decrease in the interest rate in the longer term. A surprise one-time increase in income leads to an increase in money demand and interest rates but both effects are not significant. Finally, an impulse in the interest rate tapers off only slowly, it decreases money demand and may lead to a small negative reaction of income after about eight quarters. In other words, an interest rate increase may not lead to a reduction of income in the next few quarters in our system.

Considering now the broken lines in Figure 4 which represent the corresponding CIs based on the full sample period, it is seen that they are qualitatively similar and in any case overlap substantially with the CIs for the German period. This result indicates that adding the data from the EMU period has not changed the adjustment processes within the estimated process much.

Clearly, this may be partly due to the large weight of the German data which cover 24 years, whereas only four years of EMU data are included. Therefore we have also computed impulse response CIs for the periods $1984Q1 - 1998Q4$ and $1984Q1 - 2002Q4$ and compare them in Figure 5. Again the CIs overlap substantially. The only change that allows a different interpretation can be seen in the upper left panel of Figure 5. Using a model for the extended sample leads to a significant and permanent increase in real money balances after a positive shock to money demand, while this effect was not significant in a model with only German data. This may just be the consequence of using more observations and therefore a more precisely estimated impulse response (reflected by smaller confidence bands). All other intervals allow the same interpretation for both sample periods and thus, the figure presents again support for our data construction.

The overall conclusion is again that the general dynamics of the estimated models for the German and the EMU period are quite similar. Hence, combining the data may be an acceptable strategy if interest centers on the long-run, cointegration relations or the impulse responses.

Larger systems have been used by Vlaar & Schubert (1999) and Brand & Cassola (2000) to analyze the monetary transmission mechanism in the euro area in more detail. Given our positive experience with a small monetary system, similar studies for larger systems could be performed with data constructed as in the present study. A more detailed structural analysis of the European monetary transmission based on our method of combining data is, however, left to future research.

4 Conclusions

Macroeconomic time series of the EMU period are still rather short. Therefore empirical studies are often based on data from the pre-euro period which are obtained by aggregating

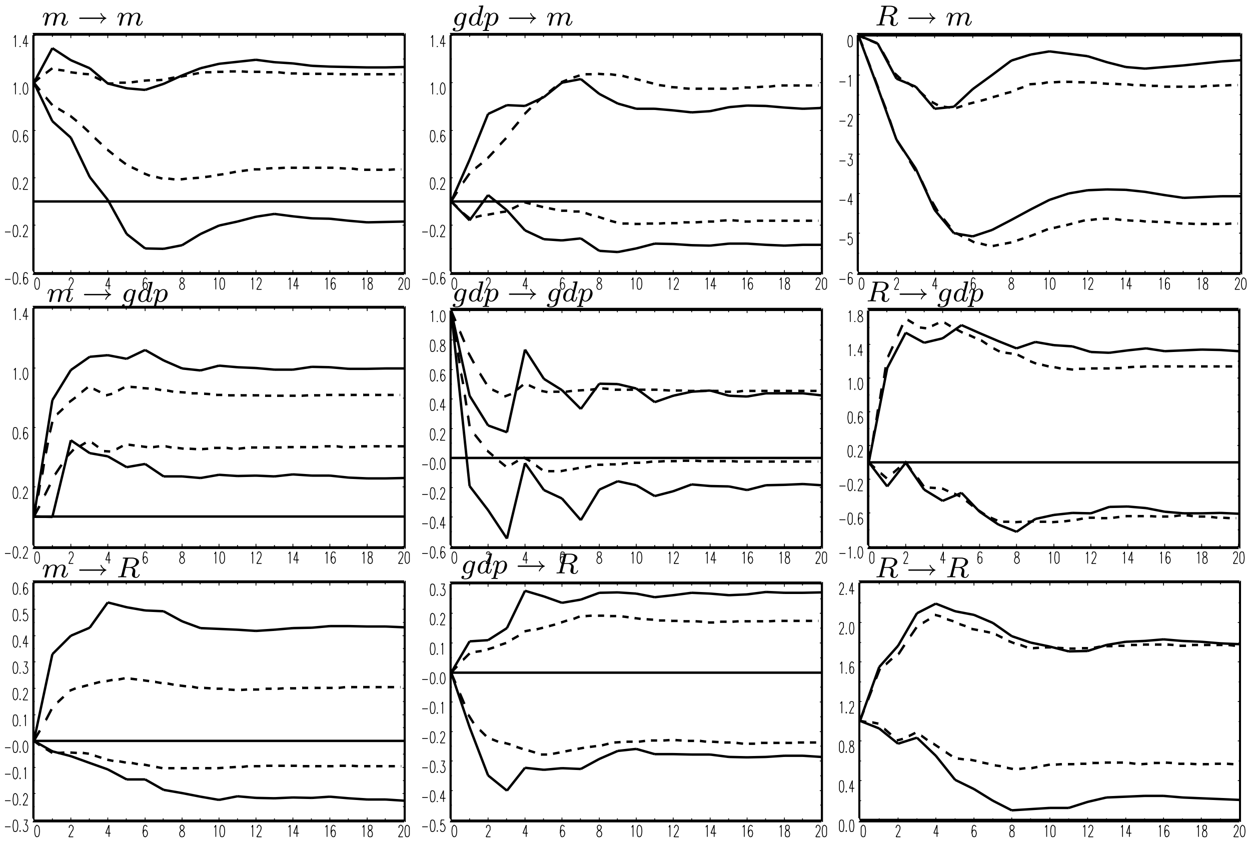

Figure 5: Impulse response intervals based on VECMs with two lagged differences estimated by S2S. Sample: ——: 1984Q1-1998Q4, - - -: 1984Q1-2002Q4. Computations performed with JMulTi, Version 3.02 pre (see Lütkepohl & Krätzig (2004)).

the relevant series from the individual member states. Such an approach has the disadvantage that prior to the EMU there have been major adjustment processes in some of the participating economies. Consequently, the pre-EMU data may have a quite different structure than data from the EMU-period. Therefore we have proposed to combine German data with EMU series because Germany is the largest EMU country and its economic conditions were close to those required for entry in the EMU for a number of years before 1999.

Using a small textbook-type model for the monetary sector we have demonstrated that such a strategy leads to quite acceptable results. We have constructed a small quarterly VECM for seasonally unadjusted log real M3, log real GDP and a long-term interest rate. The data range from $1975Q1 - 2002Q4$. They are constructed based on German time series from $1975Q1 - 1998Q4$ which are combined with euro area series for $1999Q1 - 2002Q4$. The model requires only impulse dummy variables for the German reunification and for the introduction of the euro to lead to a plausible long-run money demand relation. The long-run parameter estimates do not change much when the sample period is extended from the German period to the full period and stability tests do not indicate a break in the cointegration relation. We have also deleted the first years of the sample to increase the relative weight of the EMU-data and found similar results. In fact, it turns out that also impulse responses from the model do not change much when the German sample is extended by EMU series. Overall we have found strong evidence that combining German and EMU data is a useful strategy.

Admittedly our models are not fully satisfactory in all respects. For instance, some diagnostic tests were not quite satisfactory. Clearly, when combining data which are collected in very different ways, one cannot expect to capture fully all data features with a simple linear model. It is encouraging, however, that the major long-run relation was not covered up by the data deficiencies. Thus, a similar approach to extending EMU time series may be fruitful in further studies as well. In fact, a major advantage of our approach is that it can also be used when new countries enter the EMU. No aggregation of past data is necessary to account for the extended currency area.

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A Appendix

A.1 Variables and Data Sources

Quarterly, seasonally unadjusted data for the period 1975Q1-2002Q4 is used. M3 data corresponds to West Germany until 1990Q1 and to the unified Germany afterwards (1990Q2-1998Q4), while GDP data corresponds to West Germany until 1990Q2 and to the unified Germany afterwards (1990Q3-1998Q4). German DM-figures have been converted to EUR using the irrevocable euro conversion rate. Data on the euro area level corresponds to the area of the eleven euro area countries (EUR11) plus Greece for the period from 1999Q1-2000Q4 and to the twelve euro countries (EUR12) area afterwards. The variables of our analysis are taken from sources listed below and are transformed as follows.

M3 Monthly German nominal M3 data were taken from the database available at the *Deutsche Bundesbank*. Monthly data for the euro area were obtained from the ECB database. The quarterly values are the values for the last quarter of each month. The variable m corresponds to the logarithm of real money obtained as log(M3)-log(Price index).

GDP Germany: Quarterly real gross domestic product from *Deutsches Institut für Wirtschaftsforschung, Volkswirtschaftliche Gesamtrechnung*. Euro area: Quarterly real gross domestic product from Eurostat (New Cronos, Quarterly National Accounts). The variable gdp is log GDP.

Price index Germany: GDP deflator (1995=100) from *Deutsches Institut für Wirtschaftsforschung, Volkswirtschaftliche Gesamtrechnung*. Euro area: GDP deflator (1995=100) from Eurostat (New Cronos, Quarterly National Accounts).

Long term interest rate (R) Germany: Average bond rate (*Umlaufsrendite*), monthly values from database available at the *Deutsche Bundesbank*. Euro area: 5 year government bond yield, monthly values from ECB monthly report. The quarterly values are the values for the last quarter of each month.

A.2 Additional Tables and Figures

Table A.1: Unit Root Tests

Panel A: Unit Roots Tests Allowing for Structural Breaks

Var.	Sample	Lag. diff.	Det. terms	Test stat.	Critical values 10%	5%	1%
m	1975Q1-2002Q4	AIC,HQ:1	$S90Q2, S99Q1, SD, c, t$	3.16	5.47	6.79	9.73
		SC: 0	$S90Q2, S99Q1, SD, c, t$	2.87			
	1975Q1-1998Q4	AIC: 1	$S90Q2, SD, c, t$	-1.82	-2.76	-3.03	-3.55
		HQ,SC: 0	$S90Q2, SD, c, t$	-1.55			
	1991Q1-2002Q4	AIC, HQ, SC: 0	$S99Q1, SD, c, t$	-1.64			
Δm	1975Q1-2002Q4	0	$I90Q2, I99Q1, SD, c$	20.46	2.98	4.13	6.93
	1975Q1-1998Q4	0	$I90Q2, SD, c$	-8.02	-2.58	-2.88	-3.48
	1991Q1-2002Q4	0	$I99Q1, SD, c$	-5.34			
gdp	1975Q1-2002Q4	AIC:1	$S90Q3, S99Q1, SD, c, t$	1.77	5.47	6.79	9.73
		SC,HQ: 0	$S90Q3, S99Q1, SD, c, t$	2.36			
	1975Q1-1998Q4	AIC: 6	$S90Q3, SD, c, t$	-2.22	-2.76	-3.03	-3.55
		HQ,SC: 0	$S90Q3, SD, c, t$	-2.67			
	1991Q1-2002Q4	AIC, HQ: 8	$S99Q1, SD, c, t$	-1.06			
		SC: 0	$S99Q1, SD, c, t$	-2.91			
Δgdp	1975Q1-2002Q4	0	$I90Q3, I99Q1, SD, c$	8.44	2.98	4.13	6.93
	1975Q1-1998Q4	5	$I90Q3, SD, c$	-3.21	-2.58	-2.88	-3.48
		0	$I90Q3, SD, c$	-13.3			
	1991Q1-2002Q4	7	$I99Q1, SD, c$	-3.37			
		0	$I99Q1, SD, c$	-7.55			

Panel B: Augmented Dickey-Fuller Tests

Var.	Sample	Lag. diff.	Det. terms	Test stat.	Critical values 10%	5%	1%
R	1975Q1-1998Q4	AIC: 3	c, t	-2.50	-3.13	-3.41	-3.96
		HQ: 1	c, t	-1.98			
		SC: 0	c, t	-1.62			
	1991Q1-2002Q4	AIC,HQ, SC: 1	c, t	-2.96			
	1975Q1-2002Q4	AIC:3	c, t	-2.84			
		HQ, SC: 1	c, t	-2.41			
ΔR	1975Q1-1998Q1	0	c	-8.35	-2.57	-2.86	-3.43
		2	c	-4.37			
	1991Q1-2002Q4	0	c	-5.08			
	1975Q1-2002Q4	2	c	-4.83			
		0	c	-8.94			

Note: c, t and SD are a constant, a linear trend and seasonal dummies, respectively. Shift dummies for the second and third quarter of 1990 as well as the first quarter of 1999 are abbreviated as $S90Q2$, $S90Q3$ and $S99Q1$. $I90Q2$, $I90Q3$ and $I99Q1$ are impulse dummies which are one in the respective quarter and zero elsewhere. The number of lagged differences has been determined using information criteria with a maximum lag order of $p_{max} = 8$. The given sample period includes presample values. Results for $1975Q1 - 2002Q2$ with two dummy variables are based on cointegration tests proposed by Saikkonen & Lütkepohl (2000) for the null hypothesis of cointegration rank zero. Critical values for these tests are computed from the response surface given in Trenkler (2004). The tests with one break point are those recommended by Lanne, Lütkepohl & Saikkonen (2002). Critical values for these tests are taken from Lanne et al. (2002), while those in Panel B are obtained from Table 20.1 in Davidson & MacKinnon (1993). Computations are performed with JMulTi, Version 3.02 pre (see Lütkepohl & Krätzig (2004)).

Table A.2: Cointegration Tests Allowing for Level Shifts, $y_t = (m_t, gdp_t, R_t)'$

Sample	deterministic terms	lagged differences	H_0	test value	critical values 90%	95%
1975Q1-1998Q4	$c, t, SD,$	4	$r = 0$	16.82	26.07	28.52
	$S90Q3, I90Q2$		$r = 1$	4.10	13.88	15.76
			$r = 2$	3.43	5.47	6.79
	$c, t^{orth}, SD,$	4	$r = 0$	21.75	18.67	20.96
	$S90Q3, I90Q2$		$r = 1$	4.73	8.18	9.84
1984Q1-1998Q4	$c, t, SD,$	2	$r = 0$	27.54	26.07	28.52
	$S90Q3, I90Q2$		$r = 1$	7.67	13.88	15.76
			$r = 2$	0.03	5.47	6.79
	$c, t^{orth}, SD,$	2	$r = 0$	30.35	18.67	20.96
	$S90Q3, I90Q2$		$r = 1$	4.40	8.18	9.84
1975Q1-2002Q4	$c, t, SD, S90Q3,$	4	$r = 0$	20.71	26.07	28.52
	$S99Q1, I90Q2$		$r = 1$	5.13	13.88	15.76
			$r = 2$	0.00	5.47	6.79
	$c, t^{orth}, SD, S90Q3,$	4	$r = 0$	20.51	18.67	20.96
	$S99Q1, I90Q2$		$r = 1$	2.67	8.18	9.84
1984Q1-2002Q4	$c, t, SD, S90Q3,$	2	$r = 0$	19.26	26.07	28.52
	$S99Q1, I90Q2$		$r = 1$	14.07	13.88	15.76
			$r = 2$	1.35	5.47	6.79
	$c, t^{orth}, SD, S90Q3,$	2	$r = 0$	12.83	18.67	20.96
	$S99Q1, I90Q2$		$r = 1$	6.02	8.18	9.84

Note: Results are for cointegration tests proposed by Saikkonen & Lütkepohl (2000). c, t and SD are a constant, a linear trend and seasonal dummies respectively. t^{orth} is a linear trend which is orthogonal to the cointegration relation. Shift dummies for the second quarter of 1990 and the first quarter of 1999 are abbreviated as $S90Q2$ and $S99Q1$. $I90Q3$ is an impulse dummy which is one in the third quarter of 1990, else zero. The given sample period includes presample values. Critical values are computed from the response surface given in Trenkler (2004). Computations are performed with JMulTi, Version 3.02 pre (see Lütkepohl & Krätzig (2004)).

Table A.3: p-values of Diagnostic Tests for Models Estimated by ML

sample period	lag order	LM(2)	$Q(20)$	LJB^{DH}	LJB^{L}	ARCH(1)	ARCH(2)
$1975Q1 - 1998Q4$	4	0.53	0.61	0.89	0.78	0.43	0.90
$1984Q1 - 1998Q4$	4	0.10	0.04	0.85	0.80	0.33	0.05
$1984Q1 - 1998Q4$	2	0.06	0.15	0.92	0.90	0.15	0.77
$1975Q1 - 2002Q4$	4	0.32	0.10	0.77	0.82	0.03	0.38
$1984Q1 - 2002Q4$	4	0.00	0.00	0.99	0.98	0.18	0.09
$1984Q1 - 2002Q4$	2	0.00	0.03	0.95	0.95	0.04	0.27

Note: LM(2) is an LM test for second order autocorrelation, $Q(20)$ denotes an adjusted portmanteau test involving 20 autocorrelation matrices. Two versions of multivariate Lomnicki-Jarque-Bera tests for nonnormality as described by Doornik & Hansen (1994) (LJB^{DH}) and Lütkepohl (1991) (LJB^{L}) and multivariate first and second order ARCH tests (ARCH(1) and ARCH(2), respectively) are considered. All the tests are described in more detail in Lütkepohl (2004). Computations are performed with JMulTi, Version 3.02 pre (see Lütkepohl & Krätzig (2004)).

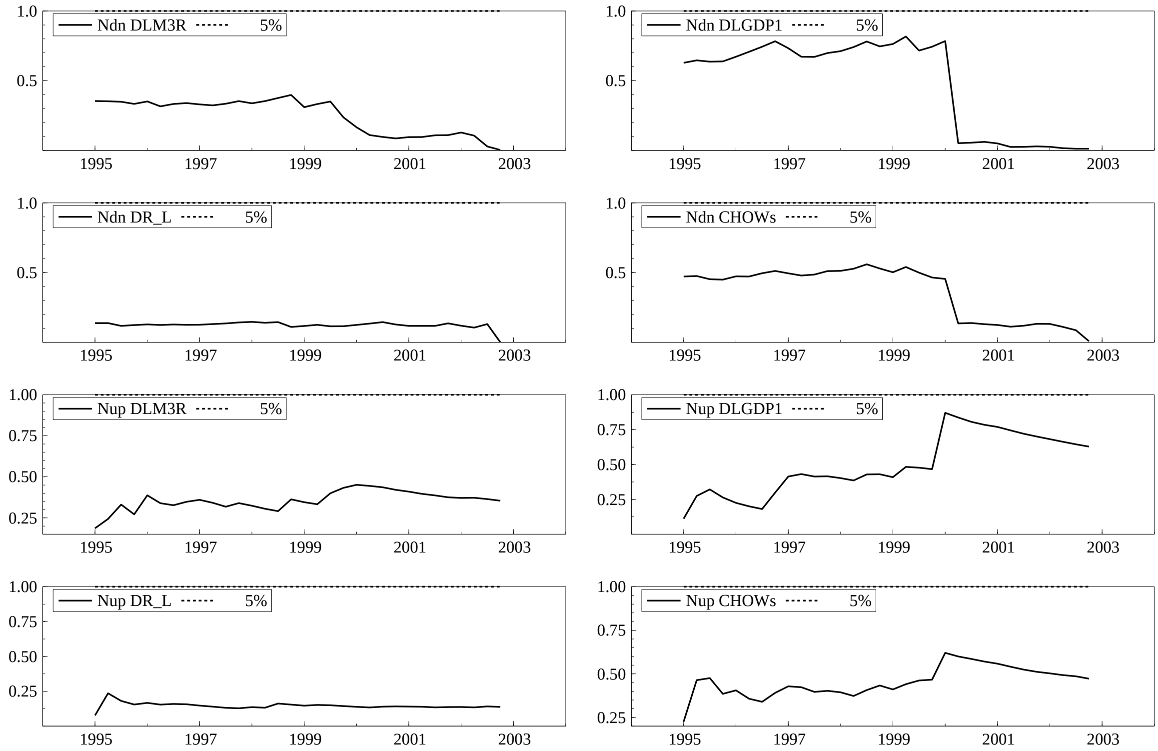

Figure A.1: Results from single equation and system breakpoint (Ndn) and forecast (Nup) Chow-tests for VECM with 4 lagged differences. Sample period 1975Q1-2002Q2. Computations performed with PcGive 10.3 (see Doornik & Hendry (2001) for details).

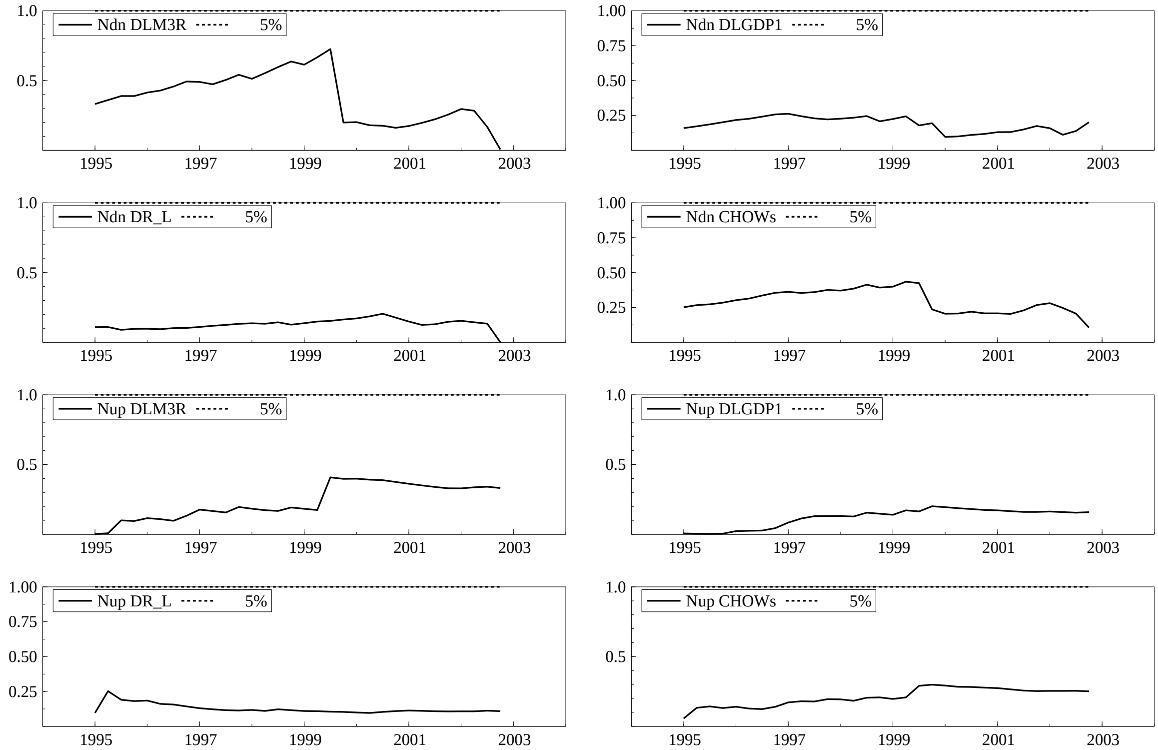

Figure A.2: Results from single equation and system breakpoint (Ndn) and forecast (Nup) Chow-tests for VECM with 2 lagged differences. Sample period 1984Q1-2002Q2. Computations performed with PcGive 10.3 (see Doornik & Hendry (2001) for details).