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Working Paper

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THE DEMAND FOR MONEY IN AUSTRIA

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The Demand for Money in Austria

Abstract

In this paper, the demand for real money M1, M2, and M3 is estimated for Austria. The modelling takes place within the framework of a small vector autoregression. To estimate the demand for money, two-equation error-correction models are constructed, which contain the short-run dynamics and the long-run economic equilibrium. It is found that a stable money demand exists for all monetary aggregates. The long-run equilibrium of M1, after accounting for a structural break in 1979, can be characterised as a classical type of money demand, with no interest rate effects and a unity elasticity of real GDP. In the case of M2 and M3, we find a unit coefficient on income and a significantly negative influence of a long-term interest rate. The statistical properties of the estimated short-run money demand equations – considering in-sample and out-of-sample (35 observations) tests – are generally very good.

Keywords: monetary economics, money demand, Austria

JEL E41, C32

1. Introduction

On 1 January 1999, the European Central Bank (ECB) assumed responsibility for monetary policy in all eleven member countries of the European Monetary Union (EMU), including Austria. One consequence of a fully integrated European money market will be that the notion of a national demand for money will lose most of its meaning.

Consequently, this study on Austrian money demand is to a certain extent a contribution to economic history. It attempts to provide a comprehensive account of the demand for M1, M2 and M3 before Austria entered EMU. However, it also addresses important questions relating to the European demand of money, and thus it may be helpful in assessing future developments.

Studying the demand for money in Austria, a small and open country, is important for several reasons: First, it is interesting as an aim in itself. Although there exist thorough studies of Austrian money demand in the literature, they have become somewhat dated by now (see Ziegelschmidt (1985), Glück (1987) or Schebeck and Thury (1987)). Here we estimate money demand functions for three monetary aggregates within a small vector autoregression (VAR) to account for the simultaneity of the included variables and to ensure efficient estimation of the long-run coefficients of the model.

Second, as is well known, the Austrian central bank had performed a policy of exchange rate targeting via the deutschmark (see Schaumayer (1994) for a summary of Austrian monetary policy). One interesting question to ask is whether through this link foreign monetary disturbances were transmitted to the Austrian demand for money. In particular, it is possible that the turmoil of German Monetary Union (see, for example, Falk and Funke (1995), von Hagen (1993), Hansen and Kim (1995), Lütkepohl and Wolters (1998)) had a temporary or even permanent effect on Austrian money demand.

Third, in the literature attempting to estimate a European money demand function, a typical finding is greater stability compared to most estimates on a national level (see Kremers and Lane (1990), Monticelli and Strauss-Kahn (1993), Artis et al. (1993), Wesche (1997), Hayo (1999)). On the other hand, some critical observers, for instance Arnold (1994), argue that this result is a spurious statistical artefact. His critique is based on the finding that empirically, there appears to be no clear statistical correlation between the size of a currency area and the stability of the respective demand for money. Hence it is interesting to look in detail at the stability of the money demand function in a small country, which is strongly dependent on the most important country of the EMS, namely Germany.

Moreover, if the greater stability of the European demand for money were due the incorporation of important currency substitution effects between national monies (see Lane and Poloz (1992)), the omission of foreign variables in national money demand specifications should show up as a destabilising element in a national money demand study.

The rest of the paper is organised as follows: In the next section, the data base, data characteristics and the employed methodology are discussed. The outcome of the unrestricted cointegration analysis for the three monetary aggregates is reported in Section 3, and the tests for long-run restrictions in Section 4. Section 5 contains the estimation results for the short-run dynamic money demand equations, and the stability of these functions is investigated in the succeeding section. In the conclusion, we come back to the questions raised above and try to answer them in the light of the empirical results.

2. Data Base and Methodology

As a data base, we employ the OECD CD-ROM 1997/1 (Main Economic Indicators) for all variables except M2, giving quarterly series from 1965(1) to 1996(3). The actual estimation periods are shorter due to the loss of observations as a result of using lags, differencing and out-of-sample forecasting. The quarterly data for M2 is taken from various volumes of IMF's International Financial Statistics.[1]

The econometric methodology used here is a two-step procedure and is close to the one put forward by Clements and Mizon (1991) or Hendry and Mizon (1993). The first step involves the estimation of the long-run equilibrium of the variables, the cointegrating vector, and in the second step this information is included into a model of short-run dynamics as an error correction term.

A number of alternative ways to estimate the cointegration vector(s) have been proposed. We employ the reduced-rank procedure popularised by Johansen (1988) and Johansen and Juselius (1990). Since this method, based on maximum likelihood optimisation, can be severely biased in short samples (see Phillips (1994)), the plausibility of the estimates was checked by looking at the cointegrating vector estimated by the Engle-Granger-Method (1987) (not reported here).

[1] The values for GDP in 1996 are taken from Oesterreichische Nationalbank.

Stability of the estimated equation, as, for example, indicated by a good out-of-sample forecasting ability, is of crucial importance in the context of identifying a demand for money equation. The dependent variable is - here and elsewhere - an actual monetary aggregate. A regression explaining actual money can only be interpreted as a demand for money, if the quantity movements on the money market are exclusively due to changes in money supply. Reflecting these important considerations, 35 quarterly observations are reserved for an out-of-sample stability analysis.

The money demand relationship is specified here in the standard way, with a scale variable and a proxy to capture the opportunity costs of holding money (see Laidler (1993) for a comprehensive survey on money demand issues). The variables employed in this study are given in the first column of Table 1. Column two contains a short description of the variables and, for precise identification of the series, the reference number from the OECD (Main Economic Indicators) or IMF (International Financial Statistics) data base. Money and income variables enter the model in logarithms, while the interest rate, following the suggestion in Fair (1987, 473), is measured in percent per annum.

Tab. 1: Variables and unit root tests

Variable	Description	ADF-Value	First Differences	ADF-Value
M1	log of real money M1 OECD-No. 70548200	-1.44 [C,S,3,4,7]	ΔM1	-14.11** [C,S,3]
M2	log of real money M2 IFS, line 34 + 35	-2.96* [C,S,4,7]	ΔM1	-3.56* [C,S,1,2,3,7]
M3	log of real money M3 OECD-No. 70548300	-2.74 [C,S,3,4]	ΔM3	-3.15* [C,S,1,2,3]
GDP	log of real GDP OECD-No. 70100300	-2.16 [C,S,1,2,4,5]	ΔGDP	-15.84** [C,S,2,3,5]
INT	interest rate on govern- ment bonds OECD-No. 70558104	-2.39 [C,1]	ΔINT	-6.55** [3]
CPI	log of consumer price index OECD-No. 70446102	-1.18 [S,2,3,4]	ΔCPI	-3.88* [S,1,2,3]

Notes: Δ is the first difference operator. One (two) asterisk(s) indicates a rejection of the Null at the 5% (1%) significance level. The critical values are taken from MacKinnon (1991). In brackets, the lags and deterministic components included in the test equation are listed (C: constant, S: seasonals).

In view of the theoretical and empirical evidence (Laidler (1993, 160f)), we estimate the demand for real money, i.e. price homogeneity has been imposed. In general, the results of money demand studies seem to be quite robust with respect to the specific choice of the deflator. Here the general consumer price index has been chosen as a deflator for the income and money variables.

Concerning the time series properties of the series, column three of Table 1 lists the values of the unit root ADF-statistics for log-levels, and column five for first differences of these variables. The strategy of adding lags to the Dickey-Fuller regressions is based on the objective to remove any autocorrelation from the residuals, which is tested applying an LM-test for fifth-order autocorrelation. Lagged values, which do not appear helpful in this respect, are eliminated in a general-to-specific sequential testing process. In our view, this strikes an acceptable balance between the increase in standard errors due to the inclusion of the additional lags, and the aim of achieving white-noise errors.

In square brackets after the test values, the length of included lags is given, as well as information about the use of a constant (C) and seasonal dummies (S).[2] As can be seen from the table, most of the variables appear to be integrated of order one, or shorter I(1). It should be noted, though, that some of the results are sensitive to the number of included lags. We cannot rule out, for instance, that M2 is I(1), CPI is I(2) and interest rates follow an I(0) process.

To investigate the possibility of seasonal unit roots in the data, the test procedure outlined in Hylleberg et al. (1990) has been employed. Apart from a number of technical problems with the test, there are severe difficulties in economic interpretation, since it is not quite clear what seasonal unit roots mean in the context of money demand. In any case, no indication of unit roots other than at the zero frequency is found (see Appendix), but it must be mentioned that some of the results are not robust with respect to the test specification. Although Url and Wehinger (1990) find evidence for seasonal roots in some of the series, the conclusion of no seasonal roots is also in accordance with the evidence presented in Beaulieu and Miron (1990) and Hylleberg et al. (1993). In view of these results and the outcome of the ADF-tests, the variables are modelled as being I(1) and not seasonally integrated in the remainder of this paper. However, all of the models contain deterministic seasonal dummies.

Although there exists a variety of theoretically acceptable specifications of a demand for money function, especially regarding the opportunity costs of money, we have opted for a simple model. This allows the analysis to proceed with a relatively large number of degrees of freedom, leaves enough observations for out-of-sample analyses, and avoids the danger of overfitting the equations to the specific samples at hand. The general theoretical long-run relationship is specified as:

$$(1) \qquad \left(\frac{M}{P}\right)_t = \left(\frac{GDP}{P}\right)_t^{\beta_{11}} \ \mathrm{Exp}\,(\beta_{12}\ INT_t)$$

Note that the included interest rate is a long-term one (maturity of one year or more), as for example recommended by Poole (1988). He argues that the theory of the term structure holds, which says that the long-run interest rate is a weighted average of expected short-run rates in the future. Only if agents believe that the change in the opportunity costs of holding money is not transitory will they change the amount of money held. Moreover, the relevant opportunity costs need to be larger than the resulting information and transaction costs for any adjustments to occur. Generally, the correlation between short- and long-term rates is high and it does not seem to matter a lot whether the one or the other is utilised in the empirical analysis (see Laidler (1993, 155f)).

While including the inflation rate (ΔCPI) as an additional opportunity cost variable into the cointegrating vector did not lead to sensible outcomes, it does appear to play a role in the short-run dynamics. Since we use real variables in the model, inflation should not affect money demand in a perfect world. However, since there are rigidities in the real world, the inflation rate may help to explain money growth. For instance, it is possible that the correlation between interest rates and inflation is not perfect (see Baba et al. (1992)). In addition, inflation may be a proxy for the yield of real assets and if real assets play an important role in investor's portfolios, it will influence the decision to hold money. These considerations are supported by our empirical result that inflation is not significant as a regressor in the transaction-dominated narrow money growth equation. But it does influence the short-run dynamics of M2 and M3 money growth equations, and those contain money components which plays a larger role in portfolio decisions.

If it was our principal aim to maximise the fit of our model, we would have included - after performing a specification search - additional variables, like other interest rates, the swap rate with Germany, the share price index, etc. But the focus in this study is more on the short- and

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[2] A deterministic trend was never significant in the ADF-regression for these variables.

long-term stability of the money demand equation. And with regard to in-sample stability, analysed using recursive methods, and the forecasting performance over longer horizons, the slight improvement in fit to the specific sample, which could be achieved by including additional variables, does not have a beneficial influence on the stability of the system. Moreover, there are potential methodological advantages to be gained by modelling within a simple framework (see Hayo (1998)).

Basically, the cointegration analysis takes place in the following unrestricted VAR framework:

$$\Delta y_t = \sum_{i=1}^{L-1} \Gamma_i \Delta y_{t-i} + \alpha\beta' y_{t-L} + \Psi d + u_t \quad (2)$$

where:
- y_t = (M, GDP, INT)',
- Ψ, Γ_i = matrices of parameters,
- β = 3 by r matrix of cointegrating vectors,
- α = 3 by r matrix of the respective loadings of cointegrating vectors,
- r = number of cointegrating vectors of the system,
- d = vector of constant, seasonal dummies and other dummy variables,
- u_t = vector of residuals of the system,
- L = lag length of VAR.

In the next sections, the long-run estimates for the monetary aggregates are given.

3. Unrestricted Cointegration Analysis for M1, M2, and M3

A descriptive analysis of the M1 data shows that a shift in the series has taken place from 1979 onwards. Interestingly, this property has been noticed before by Ziegelschmidt (1985, 8) and Glück (1987, 210). They both argue that the break could be due to the introduction of a new banking law (Kreditwesengesetz) and an agreement to co-ordinate deposit interest rates (Habenzinsabkommen) in March 1979.

Moreover, the Austrian central bank decided to peg the schilling to the deutschmark. This resulted in an appreciation of the schilling and a credible commitment towards a strong, stable currency (see Hochreiter and Winckler (1994, 33f)). As Gnan (1995, 30) argues, in 1979 a change took place in the use of interest rates. He points out that from this time onwards the interest rate instruments have been directed towards maintaining the exchange-rate target and not been used for domestic policy purposes anymore.

Together these events appear to have caused a structural break in the long-run relationship between real narrow money and real income. Without a correction for these events, no meaningful and significant cointegrating vector can be found, independently of the included variables. Therefore, in the analysis of M1, deterministic seasonal dummies and a step-dummy from the second quarter of 1979 onwards has been included in the cointegrating relation (DU79).

In Table 2, the results of the estimates of the cointegrating vector using a VAR containing eight lags of the variables in levels and preserving 35 observations (covering the years 1988-1996) for forecasting purposes are given. The two likelihood ratio (LR) tests, shown in the first section of Table 2, test how many of the r estimated cointegrating vectors are statistically significant (see Johansen and Juselius (1990)).

Tab. 2: Estimating and testing cointegrating vectors for M1, M2, and M3 (1965:1-1987:4)

M1	Lag length: 8		
H_0	Eigenvalue	LR(r,r+1)	LR(r,N)
$r \leq 2$	0.27	26.9**	39.5*
$r \leq 1$	0.12	10.7	12.6
$r = 0$	0.02	1.9	1.9
Significant Eigenvector (standardised)			

	M1	GDP	INT	Constant	DU79	Loading parameter
$\hat{\beta}_1'$ of M1	1	-0.85	-0.023	0.32	0.17	$\hat{\alpha}_{11}$ = -0.24

M2	Lag length: 12		
H_0	Eigenvalue	LR(r,r+1)	LR(r,N)
$r \leq 2$	0.35	34.3**	48.2**
$r \leq 1$	0.11	9.3	13.9
$r = 0$	0.06	4.6	4.6
Significant Eigenvector (standardised)			

	M2	GDP	INT	Constant	Loading parameter
$\hat{\beta}_1'$ of M2	1	-1.11	0.23	-4.9	$\hat{\alpha}_{11}$ = -0.03

M3	Lag length: 7		
H_0	Eigenvalue	LR(r,r+1)	LR(r,N)
$r \leq 2$	0.26	24.4*	41.7**
$r \leq 1$	0.16	14.5	17.4
$r = 0$	0.03	2.8	2.8
Significant Eigenvector (standardised)			

	M3	GDP	INT	Constant	Loading parameter
$\hat{\beta}_1'$ of M3	1	-1.34	0.22	-4.07	$\hat{\alpha}_{11}$ = -0.02

Notes: LR(r,r+1) is the test statistics for the maximum eigenvalue test, and LR(r, N) for the trace test. One (two) asterisk(s) indicates a rejection of the Null at the 5% (1%) significance level. The critical values are taken from Osterwald-Lenum (1992).

We can infer from the table that there exists exactly one significant cointegrating vector, named $\hat{\beta}_1$. Furthermore, the relevant adjustment parameter of the loading vector $\hat{\alpha}_1$ is quite large (-0.24). The diagnostic statistics of this estimate do not indicate any statistical problems (available upon request). Of special importance is the rejection of non-normality and autoregression of the residuals, since the Johansen-procedure can react quite sensitively to violations of these assumptions.

The same modelling procedure is now applied to the monetary aggregate M2. The structural break of the series in 1979, which we have identified as being important for the cointegrating relationship for narrow money, does not appear to be significant for broader definitions of money. This suggests that the effects discussed above resulted primarily in a substitution between narrow money and components of M2.

The results of the cointegration analysis in a VAR with twelve lags are presented in the middle part of Table 2. As before, only one significant cointegrating vector can be found. However, compared to narrow money, the estimates of the long-run equilibrium are much more sensitive with respect to the choice of lag length. The relevant adjustment parameter for the error correction term in the money demand equation is much lower in absolute terms (-0.03) compared to M1. This implies that a deviation from the long-run equilibrium does not exert a strong pressure on money growth. Again the diagnostic tests do not signal any statistical problems.

Regarding M3, the structural break in 1979 of the series, which we have identified as being important for the cointegrating relationship for narrow money M1, does not appear to be of relevance. This supports the argument of substitution effects between M1 and M2 further. The cointegration analysis using M3 takes place within a VAR-model with seven lags, and the diagnostic tests turn out to be satisfactory. In last part of Table 2, the results of the cointegration analysis are listed. As before, we find one significant cointegrating vector. For M3, the relevant adjustment parameter in the $\hat{\alpha}$-vector is even smaller than the one for M2, indicating a very slow adjustment speed towards the long-run equilibrium.

It is interesting to note that the non-restricted estimate of the income elasticity increases with the broadening of the monetary aggregate. This could be a reflection of the growth in the holding of financial assets in Austria, as a large share of financial wealth is held in saving accounts which influence especially M3 and, to a lesser degree, M2.[3]

4. Restricted Cointegration Analysis for M1, M2, and M3

The analysis is commenced by testing restrictions on the cointegrating and adjustment vectors. As shown by Johansen (1992a, 1992b), tests on the adjustment vector can guide us in answering the question whether we have to model the equation of interest, here the demand for money, in a system context or not. In other words, we test whether the variables other than money are weakly exogenous with respect to the interesting parameters (see Engle et al. (1983)).

Starting with M1, we found in the previous section that the income elasticity of money demand as estimated by the $\hat{\beta}_1$-vector was nearly one. On the other hand, the interest rate enters the cointegration relationship with a theoretically inconsistent sign and its absolute effect is small. Testing the restriction that the income elasticity is unity, the interest semi-elasticity is zero, and using our finding of only one significant cointegrating vector (i.e. the matrix has a rank of one), an appropriate LR-test has been computed (see Johansen and Juselius (1990)). It is distributed as a Chi^2 with two degrees of freedom, and we cannot reject the hypothesis that the elasticity is indeed unity ($Chi^2(2) = 4.4$) as shown in column two in the first part of Table 3.

Tab. 3: Testing restrictions on cointegrating and adjustment vectors for M1, M2, and M3

M1				
Restrictions on $\hat{\beta}_1'$	$\hat{\beta}_1'=(1,-1,0)$	$\hat{\beta}_1'=(1,-1,0)$	$\hat{\beta}_1'=(1,-1,0)$	$\hat{\beta}_1'=(1,-1,0)$
Restrictions on $\hat{\alpha}_1$	$\hat{\alpha}_1$ unrestricted	$\hat{\alpha}_1=(u,0,0)$	$\hat{\alpha}_1=(u,u,0)$	$\hat{\alpha}_1=(u,0,u)$
Test statistics	$Chi^2(2)=4.4$	$Chi^2(4)=12.5$*	$Chi^2(3)=9.8$*	$Chi^2(3)=5.8$
M2				
Restrictions on $\hat{\beta}_1'$	$\hat{\beta}_1'=(1,-1,u)$	$\hat{\beta}_1'=(1,-1,0)$	$\hat{\beta}_1'=(1,-1,u)$	$\hat{\beta}_1'=(1,-1,u)$
Restrictions on $\hat{\alpha}_1$	$\hat{\alpha}_1$ unrestricted	$\hat{\alpha}_1$ unrestricted	$\hat{\alpha}_1=(u,u,0)$	$\hat{\alpha}_1=(u,0,0)$
Test statistics	$Chi^2(1)=0.02$	$Chi^2(2)=8.0$*	$Chi^2(2)=0.49$	$Chi^2(3)=14.0$**

[3] I owe this point to one of the referees.

M3				
Restrictions on $\hat{\beta}_1'$	$\hat{\beta}_1'$=(1,-1,u)	$\hat{\beta}_1'$=(1,-1,0)	$\hat{\beta}_1'$=(1,-1,u)	$\hat{\beta}_1'$=(1,-1,u)
Restrictions on $\hat{\alpha}_1$	$\hat{\alpha}_1$ unrestricted	$\hat{\alpha}_1$ unrestricted	$\hat{\alpha}_1$=(u,u,0)	$\hat{\alpha}_1$=(u,0,0)
Test statistics	$Chi^2(1) = 0.15$	$Chi^2(2) = 7.23$*	$Chi^2(2) = 0.15$	$Chi^2(3) = 11.3$*

The resulting restricted estimate of the long-run relationship can be called a classical version of money demand, as it is computed with constraints $\beta_{11} = 1$ and $\beta_{12} = 0$ imposed on equation (1). Moreover, additional tests (not included in the table) show that both deterministic terms (constant and DU79) included into the cointegration vector are significantly different from zero. We then keep these restrictions on the cointegrating vector and test for weak exogeneity of the adjustment parameters associated with the income or interest rate variable. Performing likelihood ratio tests of the adjustment coefficients involving the eigenvalues of the system, we have to reject weak exogeneity for both GDP and INT jointly (column 3). When testing them independently (see columns 4 and 5), we get a rejection of weak exogeneity only for the interest rate equation. Accordingly, we will analyse the money demand relationship further within a two-equation system.

In the following analysis, we have imposed these restrictions on the theoretical long-run economic equilibrium given in equation (1), the corresponding error correction term (ECMM1) of which is now calculated as:

(3) ECMM1 = M1 – GDP + 0.21 +0.23*DU79

Looking at the tests of restrictions on the adjustment and cointegration vector given in Table 3 for M2 reveals that the interest rate is weakly exogenous and thus we only have to specify a two-equation model consisting of money and income equations. Moreover, the unity restriction on the income elasticity of money demand cannot be rejected. In contrast to the case of narrow money, the interest rate semi-elasticity is not equal to zero. This makes good economic sense, as with the inclusion of interest bearing deposits in the money definition the interest rate is prone to play a stronger role. The following error correction term will be used in the analysis:

(4) ECMM2 = M2 - GDP + 0.26 INT – 5.5

Although the cointegrating vector is significant at a 1% level, it is not as pronounced and stable as the one computed for M1 after accounting for the break in 1979. In their analysis of M2 money demand, Schebeck and Thury (1987) had to include an impulse dummy to account for an outlier in 1984. Here we have refrained from including a dummy, as in our framework there is no obvious statistical reason for doing so.

We perform a similar analysis for M3. The restriction tests on the adjustment and cointegrating vector are presented in the lower part of Table 3 and reveal a very similar structure to the one we obtained for M2. The only difference is a somewhat larger influence of the interest rate on money demand, which can be rationalised by pointing towards the greater proportion of interest bearing deposits in money aggregate M3. Based on the estimate of the restricted cointegrating vector, the error correction term (ECMM3) has been computed as:

(5) ECMM3 = M3 - GDP + 0.34 INT – 6.6

5. Modelling Dynamic Money Demand Equations for M1, M2, and M3

The next step is to estimate the dynamic error correction model. We start the modelling process for M1 by estimating the unrestricted two-equation VAR in first differences of the variables M1 and INT, lagged values of GDP in differences, the restricted cointegrating vector as a lagged error correction term, and seasonal dummies. Based on an F-test criterion (5% nominal significance level) the lags of the unrestricted VAR are reduced, while maintaining the satisfactory statistical properties. This reduced or parsimonious VAR is used as a reference – called the system – for further simplification tests. Another, this time equation specific, sequential testing down process is then applied. As an estimator, FIML (full information maximum likelihood) has been utilised.

Before coming to the interpretation of the results, we need to look at the diagnostic statistics of the model. In the first part of Table 4a diagnostic tests for the system as a whole are given, while Table 4b contains equation specific tests (for a detailed description of the statistical tests see Doornik and Hendry (1997)). Except for forecasting, none of the tests indicates a violation of the null hypothesis, hence the excellent properties of the system carry over to the final model. As the diagnostic tests for heteroscedasticity (here of a White-type) do not reject, we have based the relevant tests on normal standard errors, especially since it is not quite clear whether the performance of HCSE in small samples is satisfactory (cf. Leamer (1988)).

Moreover, in accordance with these test results, using heteroscedasticity-consistent standard errors does not really change the results (available upon request). Finally, the likelihood-ratio test for over-identifying restrictions of the system does not reject, suggesting that the restricted dynamic model parsimoniously encompasses the VAR (cf. Clements and Mizon (1991)).

Tab. 4a: Vector tests of dynamic systems for M1, M2, and M3

	LR system	VecAR-test	VecNorm	VecWhite	Chow1-test	Chow2-test
M1 system	$Chi^2(9)$ = 5.2	F(20,130) = 0.76	$Chi^2(4)$ = 1.99	F(69,150) = 1.04	F(70,76) = 1.98**	F(70,76) = 1.77**
M2 system	$Chi^2(10)$ = 7.9	F(20,120) = 0.63	$Chi^2(4)$ = 3.52	F(93,111) = 0.90	F(70,71) = 1.64*	F(70,71) = 1.43
M3 system	$Chi^2(10)$ = 7.9	F(20,122) = 0.74	$Chi^2(4)$ = 0.52	F(96,111) = 0.77	F(70,72) = 2.31**	F(70,72) = 1.95**

Notes: LR system is the LR test against the VAR system, VecAR is a vector autocorrelation test, VecNorm tests for normality, and VecWhite for heteroscedasticity. Chow1-test is the standard Chow test, and Chow2-test takes parameter uncertainty into account. One (two) asterisk(s) indicates a rejection of the Null at the 5% (1%) significance level.

Tab. 4b: Equation tests of dynamic systems for M1, M2, and M3

	AR-test	Norm-test	White-test	Arch-test	SE
M1 system					
ΔM1	F(5,66) = 1.18	$Chi^2(2)$ = 0.24	F(23,47) = 0.78	F(4,63) = 0.16	0.0232
ΔINT	F(5,66) = 1.13	$Chi^2(2)$ = 1.44	F(23,47) = 1.36	F(4,63) = 0.95	0.2378
M2 system					
ΔM2	F(5,58) = 2.36	$Chi^2(2)$ = 2.59	F(31,31) = 0.60	F(4,55) = 0.39	0.0107
ΔGDP	F(5,58) = 1.53	$Chi^2(2)$ = 0.87	F(31,31) = 0.75	F(4,55) = 0.82	0.0149
M3 system					
ΔM3	F(5,62) = 2.04	$Chi^2(2)$ = 0.04	F(32,34) = 0.51	F(4,59) = 0.09	0.0097
ΔGDP	F(5,62) = 1.59	$Chi^2(2)$ = 0.51	F(32,34) = 1.09	F(4,59) = 0.99	0.0161

Notes: AR-test is a single equation LM-test for autocorrelation, Norm-test tests whether residuals are normally distributed, White-test looks for heteroscedasticity, and Arch-test for Arch effects. SE are the equation standard errors. One (two) asterisk(s) indicates a rejection of the Null at the 5% (1%) significance level.

For M2 and M3, we also map the variables into I(0)-space and continue the analysis in a dynamic two-equation error correction model consisting of ΔM2 and ΔGDP, and ΔM3 and ΔGDP respectively. A quick glance at Tables 4a and 4b suffices to see that none of the in-sample tests indicates a problem, and that the final model is a statistically acceptable reduction of the VAR system.

Coming to the actual estimation results, in the left part of Table 5 the ΔM1-equation is presented which can be interpreted as a dynamic money demand function.

Tab. 5: FIML Estimation of ΔM1, ΔM2, and ΔM3 Equation

ΔM1			**ΔM2**			**ΔM3**		
Variables	Coeffi.	SEs	Variables	Coeffi.	SEs	Variables	Coeffi.	SEs
$\Delta M1_{t-3}$	-0.20*	0.085	ΔGDP_{t-11}	0.13**	0.043	$\Delta M3_{t-3}$	0.18*	0.089
$\Delta M1_{t-7}$	-0.30**	0.084	ΔINT_{t}	-0.01*	0.004	$\Delta M3_{t-4}$	0.39**	0.093
ΔGDP_{t-7}	0.32**	0.043	ΔINT_{t-3}	0.01**	0.004	ΔGDP_{t-1}	0.12**	0.044
ΔINT_{t-2}	-0.03**	0.009	ΔCPI_{t}	-1.17**	0.204	ΔGDP_{t-3}	-0.16**	0.053
$ECMM1_{t-1}$	-0.28**	0.053	ΔCPI_{t-3}	1.12**	0.183	ΔGDP_{t-7}	0.25**	0.056
$Seasonal_{t}$	-0.06**	0.009	$ECMM2_{t-1}$	-0.02**	0.002	ΔINT_{t}	-0.01**	0.004
$Seasonal_{t-2}$	0.04**	0.006	$Seasonal_{t}$	-0.05**	0.009	ΔINT_{t-3}	0.01**	0.004
			$Seasonal_{t-1}$	-0.04**	0.009	ΔCPI	-1.28**	0.197
			$Seasonal_{t-2}$	-0.03**	0.007	ΔCPI_{t-3}	0.81**	0.202
						ΔCPI_{t-4}	0.45*	0.206
						$ECMM3_{t-1}$	-0.01**	0.001
						$Seasonal_{t}$	-0.02**	0.008
						$Seasonal_{t-2}$	-0.02**	0.008

Notes: Standard errors are given in brackets below coefficients. One (two) asterisk(s) indicates a rejection of the Null at the 5% (1%) significance level.

First, we find that the error correction term ECCM1 has a significant and negative influence on the growth of real M1. Thus we can conclude that it not only has a statistically significant influence, but - judging from the parameter size - it is also of significance from an economic point of view.[4]

[4] See McCloskey and Ziliak (1996) or Leamer (1978) for a discussion of economic versus statistical significance.

The income variable has a positive influence on money growth, which is in accordance with economic theory. While we found that money demand appears to be of a classical type in the long-run, in the error correction model there exists a significant negative effect of interest rate changes – with a lag of half a year - on money growth. This highlights the importance of opportunity cost effects for the demand for narrow money in the short-run. Reflecting the fact that the series are non-seasonally adjusted, some seasonal dummies are significant. The estimates for M2 in column 3 and 4 of Table 5 show that changes in real GDP have a positive effect on real money growth, although with a relatively long lag. The interest rate effect is negative in the actual period and positive with a three quarter lag, but the net effect of the coefficients is negative. Inflation is also represented by two counteracting influences with similar lag length as identified for the interest rate changes, and the negative impact effect is larger, too.

ECMM2 has the expected negative sign and is statistically significant. However, as already signalled by the results of the cointegration analysis, the absolute size of the adjustment coefficient is now small compared to narrow money. Therefore, a long-run disequilibrium does not influence the short-run behaviour of money growth very much. Another important observation is that the standard error of the ΔM2-equation is smaller than the one of the ΔM1-equation.

It is interesting to compare the study by Schebeck and Thury (1987), who specify a single equation model for M2 over the period 1954-1985, with our results. First, the standard error of 1.07% of the ΔM2-equation is much lower than the one reported in Schebeck and Thury (1987) for their favourite specification, which is 1.27%. Second, they report a much larger adjustment coefficient. Third, the comparison of the two models can be further extended by answering the question of whether our model encompasses the one by Schebeck and Thury (1987). Such an analysis has to take into account that there are differences with respect to variables choice, they use final demand as a scale variable and the prime rate to measure opportunity costs. A proper encompassing test in the context of non-nesting models is to use the fitted values of their preferred model as an additional explanatory variable in the money demand equation of our two-equation system. Computing the fitted values of Schebeck and Thury's model using the bond rate instead of the prime rate, which was not available to us over the whole time period, and including these into ΔM2 as an additional regressor does not result in a significant coefficient estimate. The marginal significance level for the fitted values is $p = 0.25$, with none of the variables displayed in Table 5 for the ΔM2-equation becoming insignificant. If we use the prime rate instead, starting in 1975, the marginal significance level of the fitted values is $p = 0.15$. Thus we conclude that our money demand equation, being part of a two-equation system, encompasses Schebeck and Thury's model over the listed time periods. Arguably, this shows that - for the question at hand - using a system approach is superior to modelling in a single equation framework.

Finally, we have to interpret our findings for M3, shown in columns 5 and 6 of Table 5. The error correction term incorporating the long-run equilibrium is significant, but the adjustment parameter very small. According to this estimate, the adjustment after a shock to the long-run relationship takes place only very slowly, and it influences the actual money growth rate only slightly.

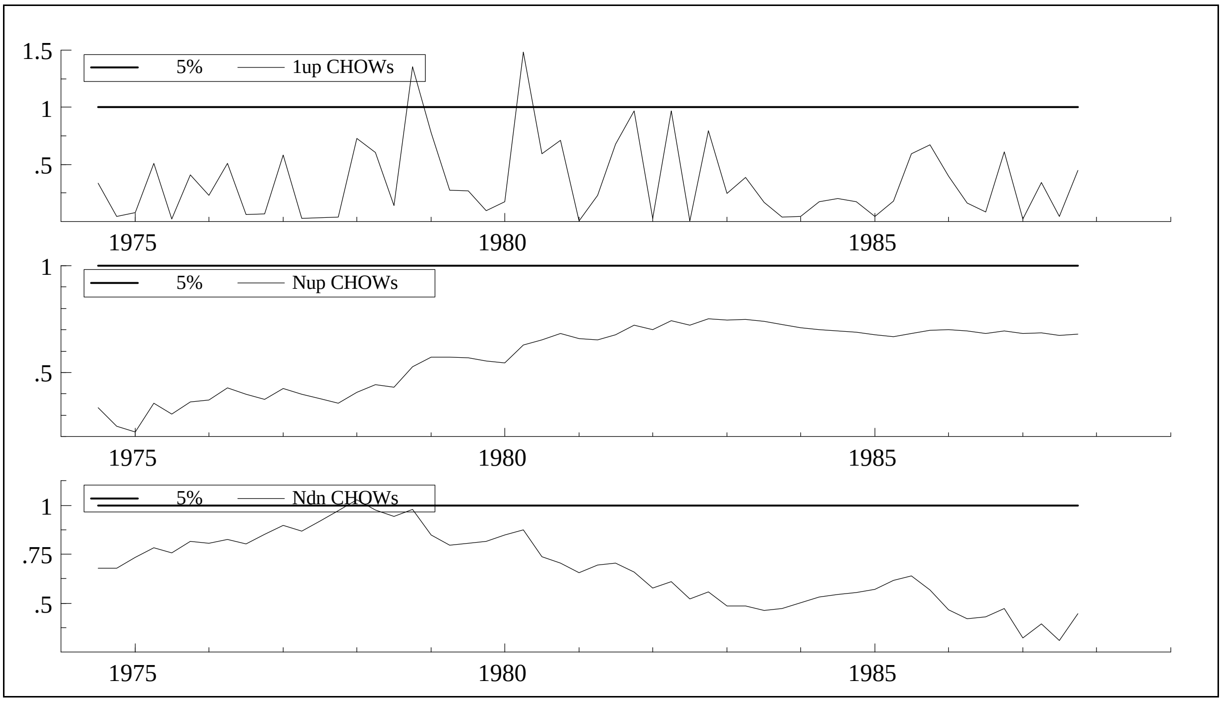
Moreover, it is noteworthy that the standard error of the ΔM3 money demand equation is very low (0.97%). Combining this finding with our results for M1 and M2 gives rise to the hypothesis that the broader is the monetary aggregate, the smaller are its fluctuations. At the same time, inertia is much higher for broader aggregates. We can infer from the small adjustment parameters of the cointegration vectors for M2 and M3 that the tendencies to return to equilibrium after a shock are very weak.

In the ΔM3 equation, apart from some money growth lags, we find an interesting pattern in the coefficients of the short-run variables. The income effect is positive with a one-period lag, negative with a three-period lag and again positive with a lag of seven quarters. Looking at the absolute value of coefficients shows that the net effect is positive. With respect to the interest rate we find that the impact effect is negative but there is a counteracting influence of a similar size after three lags. Finally, inflation displays a negative correlation with money growth in the actual period, but this is being compensated by positive effects after three and four quarters, with a negative net effect prevailing. Hence, especially compared to narrow money, the short-run dynamics are much more complex, and M3 money growth is much less determined by long-run relationships.

6. Graphical Analysis of Money Demand Stability for M1, M2, and M3

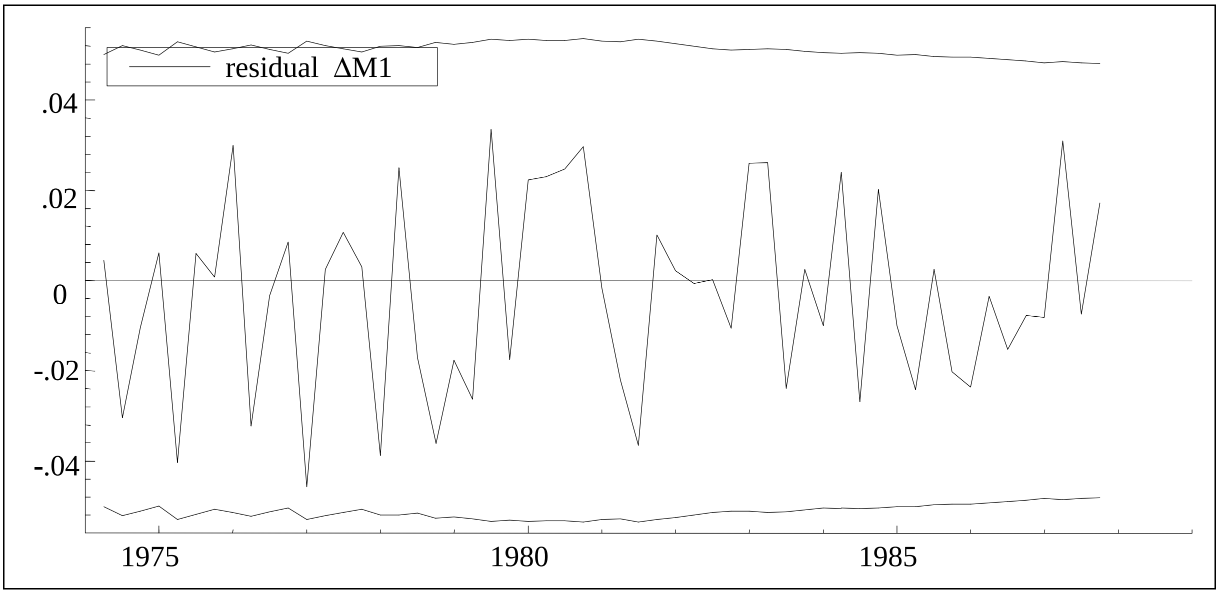
To get an impression of the stability of the final two-equation model for M1, a number of Chow-tests has been computed recursively (see Figure 1). The first of the graphs gives the conventional one-step Chow-test, with the null hypothesis being constant parameters. The second graph displays a forecast F-test, which is a Chow-type test with increasing forecast horizon. In the last graph a break-point F-test with decreasing forecast horizon is shown. There are only few rejections, notably occurring in the one-step ahead tests.

Fig. 1: Recursive Chow-tests of final two-equation model for ΔM1



To assess the specific stability properties of the money demand function ΔM1, the recursively calculated one-step residuals with their corresponding standard errors are computed in Figure 2. No outliers or coefficient shifts can be detected.

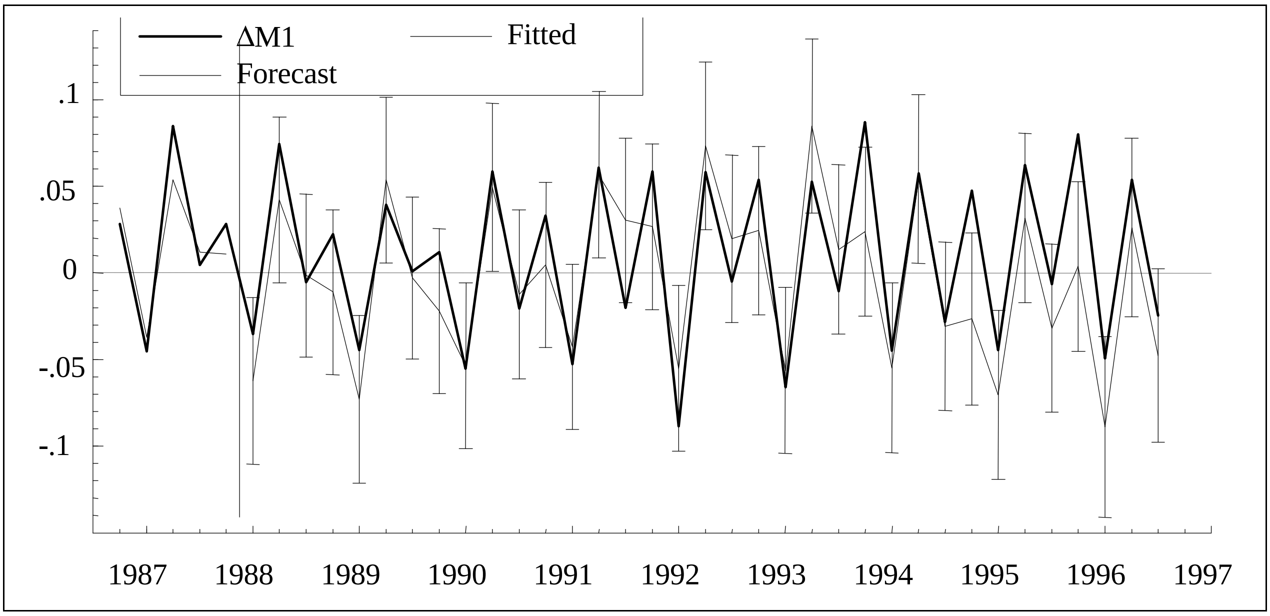
Fig. 2: One-step residuals of ΔM1-equation



We can see from the forecasting Chow-tests in Table 4a that out-of-sample stability is rejected for the system. This is to a large extent due to problems with the interest rate equation.

Concentrating again on ΔM1, we see in Figure 3 one-step ahead forecasts with their corresponding 95% confidence intervals (two standard errors).

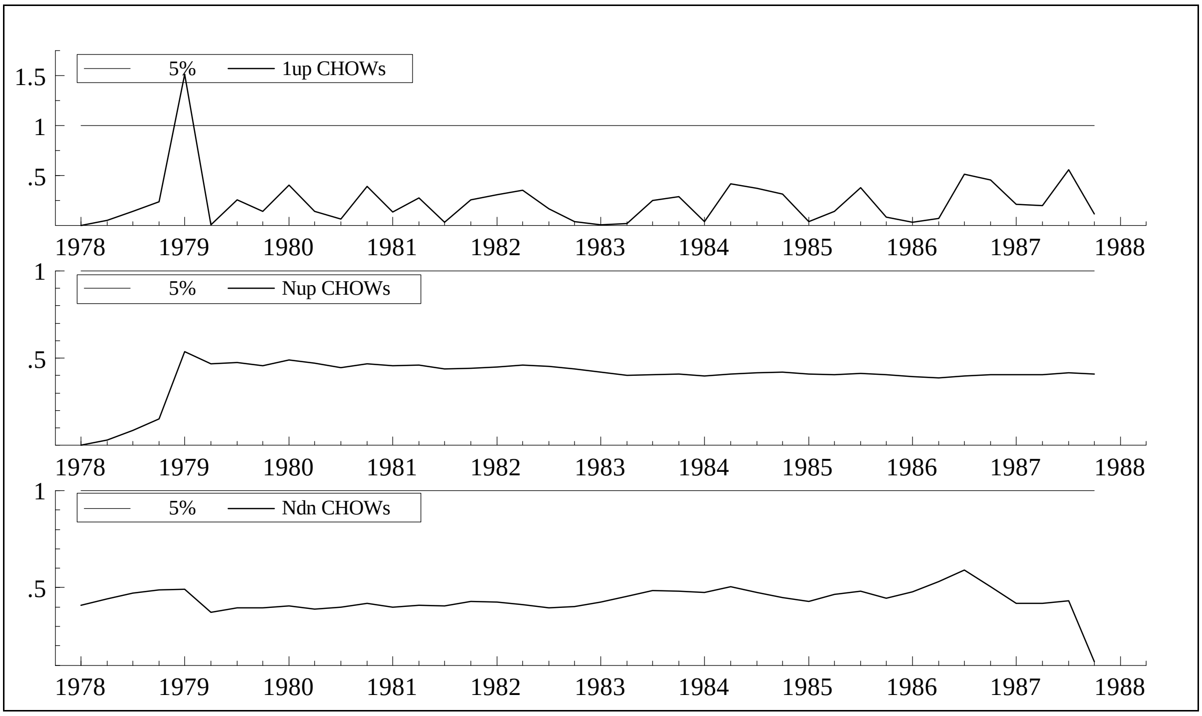
Fig. 3: One-step ahead forecasts of ΔM1



Most actual values stay clearly within their corresponding confidence intervals over the forecasting period of nine years, with only four exceptions. Therefore, the general impression of stability using a large number of out-of-sample observations is good.

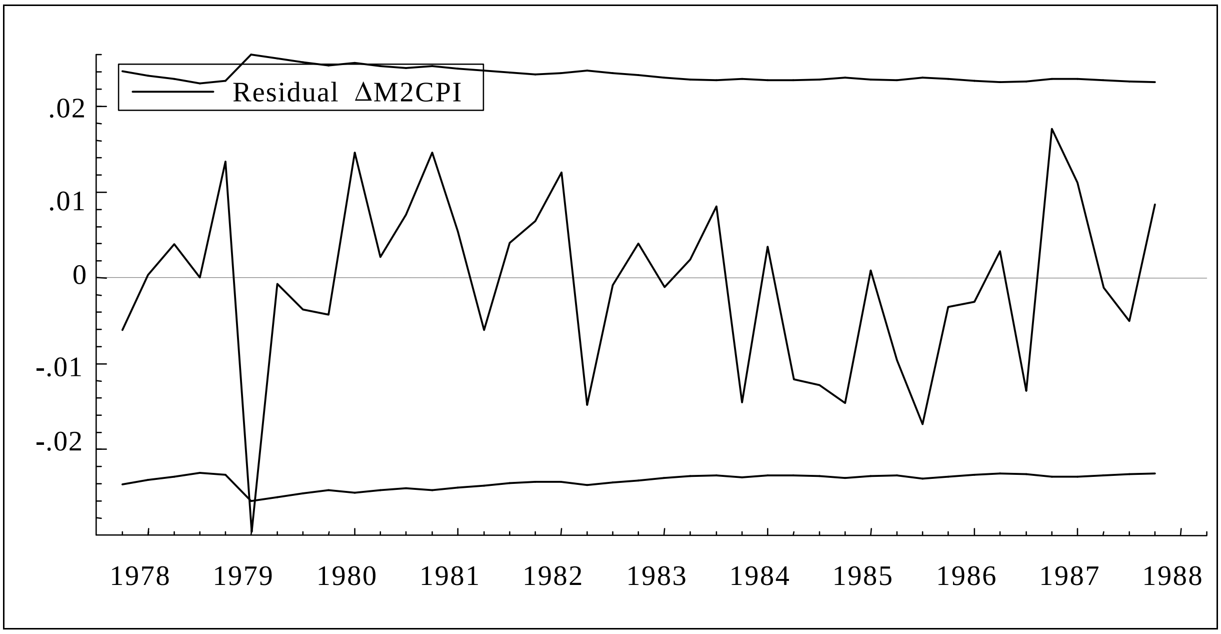
Next, the recursive Chow-tests for the dynamic two-equation model of M2 are displayed in Figure 4. Here we have to report only one violation of the null hypothesis of stable parameters, namely in the one-step-ahead Chow-test statistics for 1979. Since we discovered a shift in the long-run narrow money demand function around that time period, this may simply reflect a corresponding reaction of the M2 growth rate.

Fig. 4: Recursive Chow-tests of the final two-equation model for ΔM2



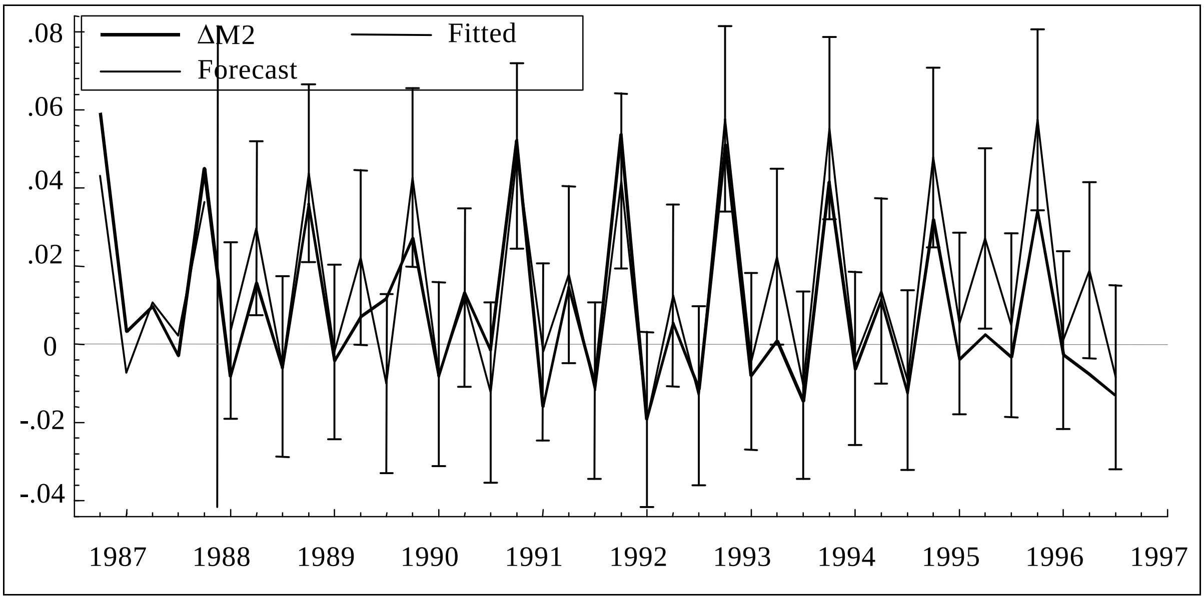
Calculating the one-step residuals of the money demand equation leads to Figure 5. We find a violation of the 95% confidence interval in 1979 only, which underlines the finding reported above using the recursive Chow-test.

Fig. 5: One-step residuals of ΔM2-equation



To focus on the money demand equation, a graph plotting the one-step-ahead forecasts for the money equation is presented in Figure 6.

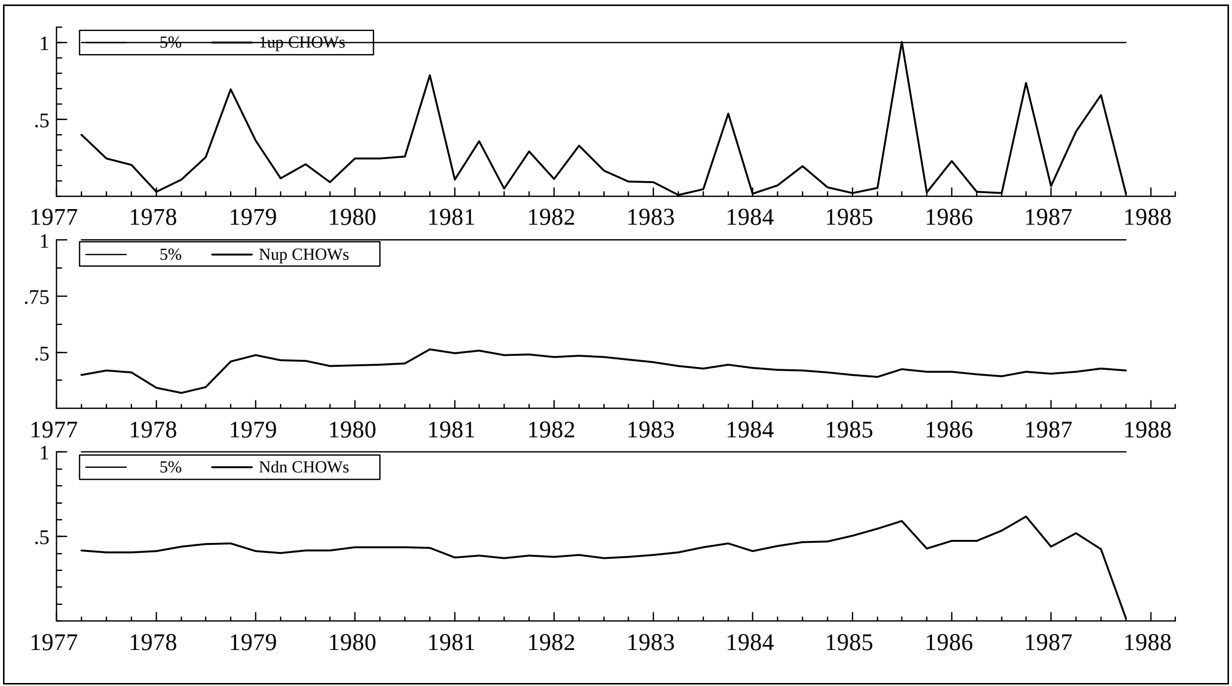
Fig. 6: One-step ahead forecasts of ΔM2



According to the forecasting tests provided in Table 4a, the M2 system shows the best out-of-sample performance. In the ΔM2 equation, there are only two outliers at the end of the 35 quarter forecasting period, in 1995:2 and 1996:2. At this point in time, it is difficult to say whether this indicates some temporary fluctuations or a permanent structural break. In principle, we cannot exclude the possibility of the latter, since we would expect some adjustments to occur in view of the entry of Austria to EMU. However, contrary to some observers, such as Arnold and de Vries (2000), who expect an almost instantaneous adjustment of money demand behaviour, it is maintained here, and argued in more detail in Hayo (1999), that this process will take some time. Thus we should not expect an immediate breakdown of estimated equations that are based on pre-EMU observations.

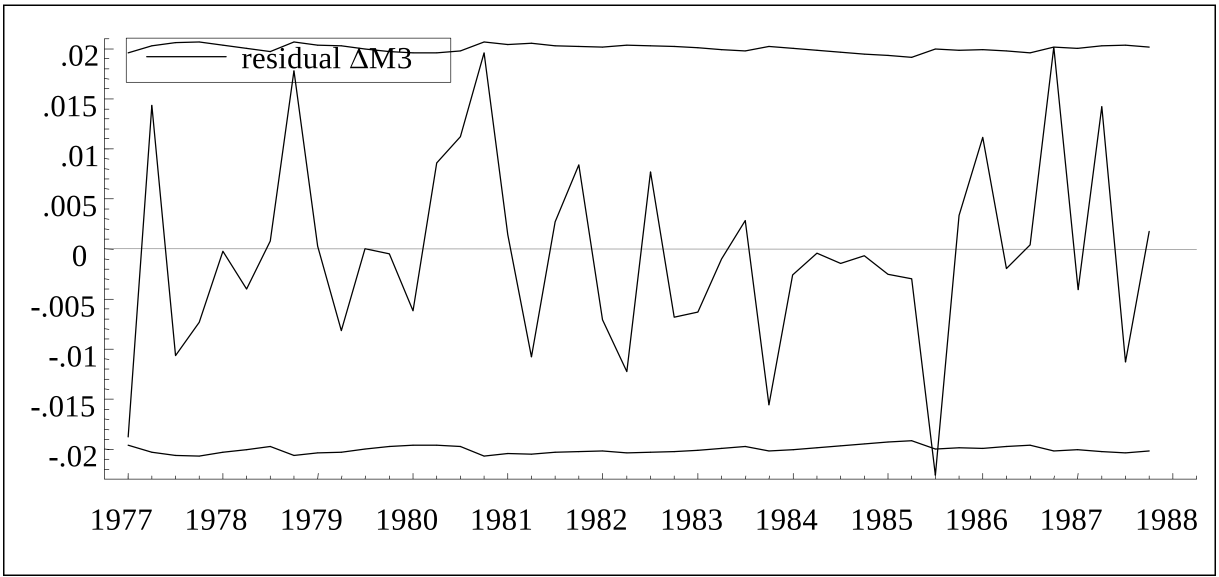
Finally, to assess the in-sample parameter stability of the two-equation system for ΔM3, recursive Chow-tests are plotted in Figure 7.

Fig. 7: Recursive Chow-tests of the final two-equation model for ΔM3



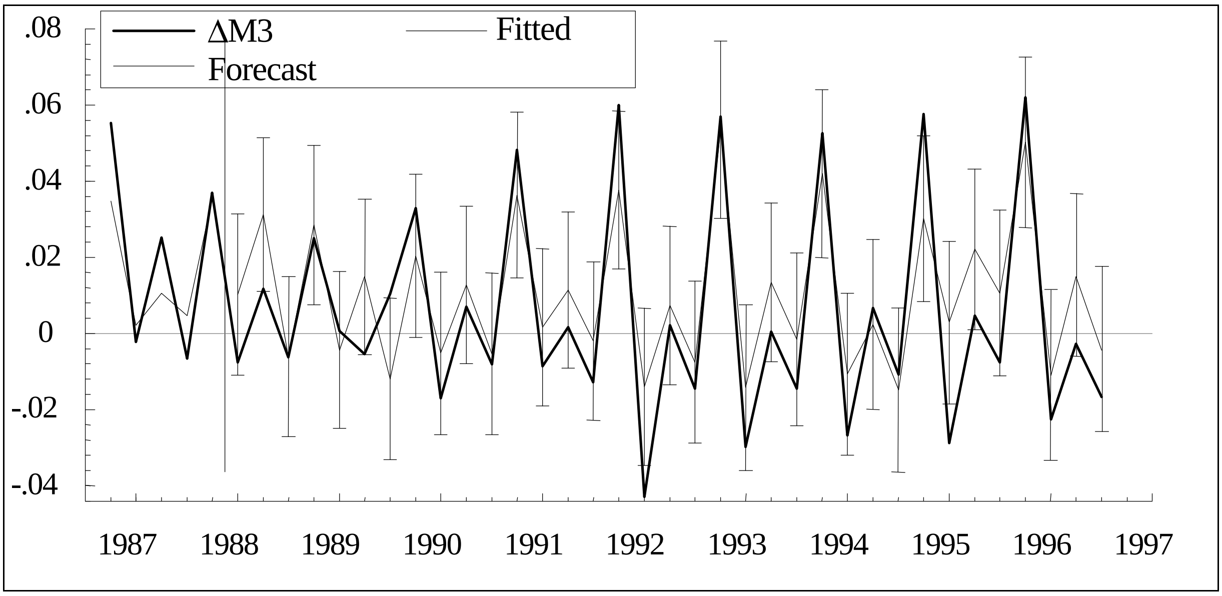
The only outlier is the observation in 1985(3), and it is just about significant. Again the model appears to be very stable over the estimation period. A similar statement applies to the recursively computed one-step residuals of the money demand equation, given in Figure 8, where only the mentioned outlier proves to be significant.

Fig. 8: One-step residuals of ΔM3-equation



Now we turn to the out-of-sample forecasting performance of the estimated dynamic money demand equation for M3. Both Chow-statistics for the two-equation system listed Table 4a reject parameter stability. What does this imply for the money demand equation?

Fig. 9: One-step ahead forecasts of ΔM3



The actual values for broad money and the model-based forecasts with 95%-confidence intervals are given in Figure 9. In five periods the actual values lie outside the confidence intervals, which is the worst result among the three monetary aggregates analysed in this study. One has to take into account, though, that M3 standard errors are smaller than those of the other monetary aggregates, and hence the respective confidence intervals are narrower. Moreover, no violation of stability occurs during the last six quarters of the sample period. Taken together, we would regard these results as sufficient evidence to support the existence of stable demand equations for monetary aggregates M1, M2, and M3.

5. Conclusion

Coming back to the questions raised in the introduction, we can give the following tentative answers:

The first question addresses the issues of size of parameter effects, identification and stability of the money demand functions for Austria. We can summarise our findings as follows. With respect to all three monetary aggregates, after accounting for a structural break occurring 1979 in the M1 cointegrating vector, we find stable long- and short-run money demand equations. These are in accordance with economic theory, both in their long-run as well as their short-run components. The estimated long-run interest rate (semi-) elasticity for M1 is zero and the income elasticity is unity. This reflects a classical type of money demand, dominated by economic transactions. Regarding the broader money measures M2 and M3, the long-run equilibrium contains an interest rate effect as well, which is somewhat larger for the broader aggregate.

The corresponding error-correction term is an important explanatory variable in the short-run M1 money demand function. A disequilibrium in the long-run relationship exerts strong pressure on narrow money growth. This result is due to the dependence of this aggregate on transactions and therefore economic activity.

In contrast to narrow money, it is noteworthy that the long-run equilibrium is not very influential in determining the short-run dynamics of money growth for M2 and M3. This suggests that the pressure on money demand to return to its long-run equilibrium is rather weak and the adjustment time may be considerable. One reason for this effect may be found in the other role time deposits and especially saving accounts play in Austria: according to Mooslechner (1995), saving accounts are the main instrument for capital accumulation of private households. Hence to capture these effects accurately, we would need to model private saving decisions as well.

Considering the statistical properties of the estimated models, we found no serious evidence of misspecification. The only statistical problems are connected with some outliers causing slight in-sample and out-of-sample instabilities. However, employing almost nine years of out-of-sample observations should reveal any important structural break in the parameters or an overfitting of the model. No such evidence was uncovered.

The second question raised in the introduction is related to the effects of Austrian monetary policy of exchange rate targeting on the stability of money demand. Here we can just point to the apparent stability of our money demand estimates. The monetary fluctuations in Germany after German Monetary Union reported in the literature have had no visible effect on the demand for money in Austria. But there is evidence that the beginning of the ‘hard currency’ period in 1979 and the changes in banking regulations mentioned above caused a structural break in the long-run money demand equilibrium for M1. Since we do not observe a similar break in the M2 money demand function, but a temporary fluctuation in M2 growth, this supports the view that a substitution between sight deposits and time deposits has taken place. However, in this framework we cannot definitely settle the question whether the change in monetary policy objectives caused money demand to shift. It may also be the case that not the objectives have changed but that monetary policy instruments have become much more market oriented.

Related to the aspect of changing the monetary objective towards targeting a monetary aggregate, we can be somewhat more precise. Based on the finding of a stable money demand, targeting a monetary aggregate would have been a viable policy alternative for the Austrian central bank (ceteris paribus). If monetary targeting is interpreted as referring to a medium-term time horizon, M1 would be a good target for such a policy. It is strongly tied to transaction purposes and displays a rather tight long-run equilibrium behaviour. On the other hand, it is characterised by higher short-run fluctuations.

If money targeting is interpreted as a short-horizon target, then broader aggregates are preferable, with M3 being the smoothest one. Their long-run equilibria are less influential, but at the same time the overall variations of the series are also lower, and they appear to be less vulnerable with respect to structural changes.

One should stress, though, that a stable money demand is only a necessary but not sufficient condition for successfully switching to a different monetary policy regime. For instance, one would need to look at an appropriate reform of the institutional framework. Further, the analysis is conditional on a specific policy regime, and by fundamentally changing policies, there is always the danger of affecting the underlying economic structure, as emphasised by Lucas (1976). One can also argue that the stability of money demand in Austria is due to a lack of financial innovations. If this was true, we should expect stability to decrease over time. Up to now, however, no such effect seems to be present.

Finally, coming to the questions concerning the implication the results may have on the question of greater stability of larger currency unions, we find evidence rather in favour of Arnold’s (1994) position. Currency substitution effects do not seem to undermine the stability of the money demand in Austria, in spite of the fact that it is a small country, its money and capital markets are strongly dependent on the developments in Germany, and its monetary policy is directed towards holding a peg with the deutschmark.

This may be interpreted as evidence in favour of the claim that the reported higher stability of an aggregate European money demand function does not really come from the elimination of destabilising currency substitution effects. However, we should be cautious not to expand the scope of the results too far. Austria did not actively participate in the co-ordination of monetary policies in the EU, especially with respect to re-alignments and credit facilities, which may have prevented investors from engaging in currency substitution. There is also evidence that money aggregates taking account of currency substitution may be becoming more important in predicting GDP than the national aggregates (see Angeloni et al. (1994)). So perhaps we will see destabilising currency flow becoming more important in the future.

To summarise, the finding of a stable demand for money for a small economy with strong links to another country does not imply that the observed stability of the European money demand function is necessarily only a statistical artefact. But it does not make currency substitution a likely explanation for the stability at a European level. In any case, although Austria has only a small weight in the euro monetary aggregates, its membership will contribute to the stability of the demand for money in Europe, at least during the first years of EMU.

Appendix

Seasonal unit root tests using an intercept, seasonal dummies and a deterministic trend

Variable	long-run root	semi-annual root	pair of annual roots
M1	-1.32	-3.21*	72.22**
M2	-1.34	-5.19**	47.86**
M3	-0.41	-4.32**	51.67**
GDP	-2.07	-5.36**	10.61**
INT	-2.94	-8.58**	40.23**
CPI	-0.0002	-6.24**	87.13**

Notes: The second column contains the test of ordinary integration (at frequency zero), the third column tests for two cycles per year (at frequency ½) and the fourth column for one cycle per year (at a frequency ¼ and ¾ respectively). One (two) asterisk(s) indicates a rejection of the Null at the 5% (1%) significance level. The critical values are taken from Hylleberg et al. (1990).

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