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The Long-Run Stability of European Money Demand

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Abstract

The European Central Bank uses a monetary strategy which represents a combination of monetary targeting and direct inflation targeting. In this context, the stability of the long-run European money demand function is widely seen as a precondition for a strategy of monetary targeting. This paper investigates the aggregate demand for money in Europe including those countries representing the initial group in the European Monetary Union. First, we identify stable (in the sense of cointegrated) European money demand functions for M1 as well as for M3. Second, we investigate parameter constancy over time and do not find suggestive evidence of structural instability. Overall, the results provide empirical support for the European Central Bank to target a European monetary aggregate.

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ent approaches: the single equation error correction model (SEECM) and the triangular error correction model (TECM). Second, we perform several tests for structural stability. These tests have in common that they are based on the residuals from the fully modified ordinary least squares (FMOLS) estimation method applied to the TECM as suggested by Phillips and Hansen (1990). This class of tests based on the FMOLS residuals has up to now not been applied to the case of European money demand.

The following section contrasts the alternative specifications of error correction models. Section III presents the estimates of European money demand functions for narrow and broad money. In section IV we apply the range of tests for the long-run stability of money demand in Europe. The final section draws conclusions for the monetary policy strategy of the ECB.

II. Error Correction Models of European Money Demand

A. Single Equation Error Correction Modeling and Cointegration Tests

The Goldfeld equation (expressed in logarithms) provides a useful starting point of the analysis.[3] In equilibrium, real money demand $(m\text{-}p)$ is assumed to depend on real income (y) and on the level of interest rates (r):

$$(m-p)_t = {}_1 y_t + {}_2 r_t + {}_t . \qquad (1)$$

The parameters β_1 and β_2 reflect the income and the interest elasticity of money demand. The demand for narrow money is often assumed to depend on the short-term interest rate; the demand for broad money on the long-term rate. The error term ($(r$) reflects unsystematic changes of money demand. In conjunction with the partial adjustment hypothesis:

$$(m-p)_t - (m-p)_{t-1} = \left[(m-p)_t - (m-p)_{t-1}\right] \qquad (2)$$

we yield the Goldfeld equation:

$$(m-p)_t = {}_1 y_t + {}_2 r_t + (1- \;)(m-p)_{t-1} + {}_t . \qquad (3)$$

However, the implied dynamics of the Goldfeld equation often prove to be

3.For a lucid discussion of the theoretical background of this equation and the respective empirical evidence see Goldfeld and Sichel (1990).

where $\left[u'_{1t}u'_{2t}u'_{3t}\right]' \equiv u_t = e_t - \ e_{t-1}$ with $e_t \sim N(0, \ _e); u_t \sim N(0, \ _u)$; and θ being a (3 × 3)-parameter matrix for the moving average of order of one. Phillips and Hansen (1990) develop the semi-parametric FMOLS estimation procedure to estimate the cointegrating parameter vector & $\equiv \left[\ _1 \ \ _2\right]'$. Define the matrices $= \lim_{T\to\infty} \frac{1}{T} \ _{i=1}^{T} \ _{j=1}^{T} E\left[u_j u'_i\right]$ and $= \lim_{T\to\infty} \frac{1}{T} \ _{i=1}^{T} \ _{j=1}^{i} E\left[u_j u'_i\right]$ with the kernel estimators being:

$$\hat{} = T^{-1}\sum_{t=1}^{T} \hat{u}_t\hat{u}'_t + T^{-1}\sum_{s=1}^{l} w(l,s)\sum_{t=s+1}^{T}(\hat{u}_{t-s}\hat{u}'_t + \hat{u}_t\hat{u}'_{t-s}) \text{ and}$$

$$\hat{} = T^{-1}\sum_{t=1}^{T} \hat{u}_t\hat{u}'_t + T^{-1}\sum_{s=1}^{l} w(l,s)\sum_{t=s+1}^{T}\hat{u}_{t-s}\hat{u}'_t, \tag{6}$$

respectively, where $w(\cdot)$ is a weight function depending on the lag truncation parameter l. The estimators $\hat{}$ and $\ddot{}$ can be partitioned in conformity with and The FMOLS estimator of β is then given in (7):

$$\hat{}^{+} = \left(\sum_{t=1}^{T}(m_t^{+}x'_t - \ \hat{}^{+\prime}_{2:3,1})\right)(x_t x'_t)^{-1}, \tag{7}$$

where $x_t = \left[y'_t \ r'_t\right]'$ and $m_t^{+} = m_t - \ \hat{}_{1,\ 2:3}\ \hat{}^{-1}_{2:3,\ 2:3}\left[\hat{u}'_{2t}\hat{u}'_{3t}\right]'$. The expression $\hat{}^{+}_{2:3,\ 1} = \ \hat{}_{2:3,\ 1} - \ \hat{}_{2:3,\ 2:3}\ \hat{}^{-1}_{2:3,\ 2:3}\ \hat{}_{2:3,\ 1}$ represents the bias due to the endogeneity of the regressors after the fully modified correction.

The FMOLS estimation is a modified version of OLS to take into account the serial correlation in the cointegration residuals, u_{1t}, and the endogeneity bias caused by the causal influence from the endogenous to the exogenous variables, as well as the cross lagged correlations between the variables, which are specified in the short-run dynamics in the SEECM. Phillips (1990) demonstrates that FMOLS estimation has the same asymptotic efficiency as the maximum-likelihood estimation of the vector autoregressive ECM where at the outset of the modeling all variables are assumed endogenous.

$$\text{SupF} = \sup_{t/T \quad r} F_{Tt,} \quad \text{for} \qquad (0.1)$$

$$\text{with} \quad F_{Tt} = vec(S_{Tt})'(\,\hat{\ }_{1|2,3} \quad V_{Tt})^{-1} vec(S_{Tt});$$

$$S_{Tt} = \sum_{i=1}^{t} (x_i \hat{u}_{it}^{+'} - \hat{\Lambda}_{2:3,1}^{+});$$

$$V_{Tt} = M_{Tt} - M_{Tt} M_{TT}^{-1} M'_{Tt}; \qquad (9)$$

$$M_{Tt} = \sum_{i=1}^{t} x_i x'_i,$$

where $\hat{\ }_{1|2,3} = \hat{\ }_{11} - \hat{\Omega}_{1,2:3} \hat{\Omega}_{2:3,2:3}^{-1} \hat{\Omega}_{2:3,1}$ is the long-run variance of u_{1t} conditional on u_{2t}.With respect to the choice of ,we follow Andrews(1991) who suggested the interval [0.15, 0.85].

Hansen(1992) also suggests an LMP test under the alternative of *no* cointegration. Consequently, the SupF test may be applied to check whether there is a one-time change in the cointegrating vector while the LMP statistic tests for the stability of the long-run relationship. The LMP test statistic is

$$LMP = tr\left(M_{TT}^{-1} \left(\sum_{t=1}^{T} S_{Tt} \,\hat{\ }_{1|2,3}^{-1} S'_{Tt} \right) \right) \qquad (10)$$

where all symbols have the same meaning as in (9) for the SupF test.

The asymptotic distributions of the SupF and LMP test are non-standard and depend on the structure and number of regressors in the cointegrating vector. The critical values for both cases are tabulated in Hansen (1992).

Hao and Inder (1996) develop a CUSUM test for parameter constancy of cointegration relationships based on FMOLS residuals. Their test procedure extends the CUSUM test based on the OLS-residuals designed by Ploberger and Kramer (1992).

Hao and Inder investigate parameter instability by allowing the cointegrating relationship to depend on time as formulated in (11)

$$m_{\pm} = {}'_{t} x_t + u_{1t} \qquad (11)$$

The statistic for the FMOLS residual based CUSUM test is defined as:

$\hat{\Sigma} = T^{-1}\Sigma_{t=1}^{T}(\Delta x_t \Delta x_t')$ Under the null we have $\Sigma = 0$ and therefore $_t = u_{1t}$ which is tested against the alternative $H_1 : \Sigma > 0$. Therefore, under H_1 is I(1) and no cointegration relation exists. The asymptotic distribution of w LM is also non-standard and depends on the nature of regressors in the cointegrating vector.

IV. Empirical Evidence

This study on European money demand comprises those eleven countries which formed the initial monetary union in 1999. This country group includes Austria, Belgium, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal and Spain.[5] We use the monetary aggregates M1 and M3. Data are taken from the International Financial Statistics. The data are quarterly and seasonally adjusted. Whenever available, the series for M3 are for the harmonized aggregate M3H. The database ranges from 1979:1 to 1996:4 where in several cases corrections or extrapolations had to be carried out.[6] The period of estimation is 1980:1-1996:4.

Aggregation of national series to European series requires rates for currency conversion. This paper uses fixed purchasing power parity rates calculated for 1993 and published in OECD (1995). These conversion rates are used for the aggregation of money stocks, nominal and real income. The aggregate European income figures are used to derive a series for the implied European deflator. The national shares in European income are also used to aggregate the national interest rates. All variables except for interest rates are logarithmized. Figure 1 contains graphs displaying the aggregate European series.

Augmented Dickey-Fuller tests indicate that all variables are non-stationary[7] so that we analyze money demand within the cointegration methodology.

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5. Luxembourg does also belong to this group but remains excluded due to its small quantitative importance.
6. More detailed information on the sources of data is provided in Clausen(1998).
7. Results are available on request.

grating relationship for money demand excluding a scale variable. Short-term and long-term interest rates are not restricted to be included in the estimated models. We assume a geometric lag distribution and choose the maximum lag order to be 5. With 4 variables and 5 lags, 720 regressions have to be carried out. We choose the specification on the basis of the *minimum* of the t_{ECM}-statistic. After the deletion of insignificant coefficients we arrive at our final models. Equations (15) and (16) present the results.

We find cointegration in both models of European money demand since the t_{ECM}-statistics are below the critical value of -2.02 from Kremers, Ericsson and Dolado (1992). The equations pass all standard diagnostic tests. Constant terms are insignificant. Real demand for M3 is nearly proportional to real GDP while the real demand for M1 behaves under-proportionally.[8]

Surprisingly, long-term instead of short-term interest rates are identified as the relevant opportunity cost variable in the demand for *narrow* money. In the demand for broad money, both interest rates enter the cointegration relation with the expected signs.

$$\Delta m_{1,t} = -\underset{(-3.76)}{0.1225}\left[m_1 - \underset{(-138.5)}{0.8794}\,y\right]_{t-1} - \underset{(-5.23)}{0.3710}\,r_t^l \qquad (15)$$

$S.E.$: 0.0073 $D.W.$: 1.65

$AR(1)$: χ^2 (1)=1.2946[0.2552]

$AR(4)$: χ^2 (1)=2.7858[0.0951]

$ARCH(4)$: F(4,57)=0.9778[0.4485]

Normality : χ^2 (2)=1.5142[0.4690]

x_i^2 : F(6,58)=1.5142[0.4690]

$x_i \; x_j$: F(9,55)=0.7646[0.6490]

$RESET$: F(1,64)=0.0045[0.8336]

8. This may be surprising since income elasticities of narrow money holdings are often found to be unity and for broad money to exceed unity (Fase(1994)). Presumably, the income elasticities are so low because in the sample chosen, interest rates actually follow a downward trend which explains to some extent the upward trend in money holdings. For longer samples in which interest rates are constant on average the estimated income elasticities are expected to be higher.

cients are significantly different from zero, but also that the uncertainty surrounding the effects is sufficiently small. For example, it appears almost impossible to find an income elasticity of money demand *not* to be significantly different from zero. However, small standard errors for the income elasticity of money demand are required for the choice of an adequate corridor for the monetary target.

Brainard(1967) analyzes the implications of multiplicative uncertainty for stabilization policy. He concludes that the use of policy instruments ought be the more conservative or cautious, the larger the uncertainty about the effects of policy. This means in the case of monetary policy: The lesser the multiplicative stability (or the higher the multiplicative uncertainty) associated with the interest elasticity of money demand, the more conservative ought to be the change of interest rates in the effort to control the money stock.

Multiplicative stability is evaluated on the basis of the estimated standard errors of the cointegration parameters. These standard errors are taken from the Bewley-transformation of the error correction equation. We find for the long-run income elasticity of M1 (M3) a standard error of 0.0063 (0.0071) such that by this criterion the demand for narrow money is found to be more stable.

Dynamic stability in terms of cointegration is found for both money demand functions. By means of the t-statistics belonging to the error correction terms in (15) and in (16) the null hypothesis of no cointegration, *i.e.* $H_0 : \bar{b} = 0$ can be rejected. By this criterion both money demand functions are found to be stable. A narrower interpretation of dynamic stability - given that money demand eventually reaches a long-run equilibrium defined by the cointegrating vector - requires the mean adjustment lag in the money demand function to be reliable. In other words, the standard error of the estimated mean adjustment lag is relatively small. This concept of stability refers to the notion of Friedman (1961) that adjustment lags in monetary policy are long and variable. From the perspective of monetary policy direct estimates of the mean adjustment lag and of the corresponding variance are desirable. In the special case of the Goldfeld equation, the Bewley-transformation not only yields the long-run parameters in money demand and their respective standard errors but also - with a negative sign - an exact estimate

B. Tests for Parameter Constancy

The results of the tests for long-run structural stability are summarized in Table 2. for M1 and in Table 3. for M3.

Table 2
Stability Tests of the M1 Cointegration Relation

Test	M1	Critical values		
		10%	5%	1%
SupF	15.0653	10.6	12.4	16.2
CUSUM	0.9127	1.0477	1.1684	1.4255
LMP	0.2678	0.450	0.575	0.898
LM	0.0278	0.0661	0.1052	0.2422

Table 3
Stability Tests of the M3 Cointegration Relation

Test	M3	Critical values		
		10%	5%	1%
SupF	16.3257	15.3	17.2	21.0
CUSUM	0.4548	0.8381	0.9336	1.1782
LMP	1.0381	0.680	0.834	1.18
LM	0.0978	0.1548	0.2266	0.4320

At a significance level of 5%, the SupF test indicates parameter constancy for M3 but not for M1. The CUSUM test finds the long-run parameters in both money demand equations to be constant over time. The sequences of the CUSUM and SupF test statistics are illustrated in Figure 2.

V. Implications for the European Central Bank

Our results may be summarized as follows: We find cointegrated European money demand functions for M1 as well as for M3. Applying various tests for parameter constancy over time we do not detect suggestive evidence for structural breaks in European money demand. For both monetary aggregates, three out of four tests indicate structural stability. Overall, these results provide support for monetary targeting as a policy strategy of the European Central Bank.

Those prospective EMU member countries which currently monitor monetary aggregates focus in their monetary strategy on broad monetary aggregates (Deutsche Bundesbank(1998)). We do not find the European demand for broad money to be generally more stable than the demand for narrow money. However, it is interesting to note that adjustment lags are substantially longer in the case of broad money. One is tempted to conclude that the broader the chosen monetary aggregate in a monetary targeting regime, the stronger is the case for multi-period monetary targets.

An important question is whether monetary relationships will remain stable after the transition to EMU. Some authors regard empirical studies of European money demand functions before EMU as a fruitless exercise. It may be expected that the transition to EMU constitutes a fundamental structural break altering previous behavioural relationships. Arnold(1994) argues that money demand analyzes prior to EMU are very likely to overestimate the future stability of money demand in Europe. One important reason is that, prior to EMU, money demand shocks in individual member countries are idiosyncratic and tend to cancel each other. After the transition to EMU, these shocks have common sources and tend to be more correlated with each other such that aggregate money demand is likely to be less stable. While these concerns are well founded this does not imply that prior to EMU analyzes of European money demand are useless. After the transition to EMU, at least initially, aggregate European money demand is more likely to turn unstable. If aggregate European money demand was already prior to EMU relatively unstable it can almost be ruled out that after the transition to EMU the ECB chooses monetary targeting as a policy strategy. Furthermore, it is possible to simulate the stability of the European

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