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EU-wide money and currency substitution

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This paper re-addresses the issue of international currency substitution, estimating a money demand equation for the euro-area. By stressing the interdependent nature of the international monetary system, this paper challenges the view that the monetary integration in Europe has favoured a move towards more inward-oriented approaches to price stability.

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1. Introduction

Following the German tradition, the ECB assigns a "prominent role for money" (see Angeloni et al, 1999, ECB, 1999). Money is viewed as the nominal anchor of the Euro-system and the *First Pillar* of the ECB strategy. In accordance, a "reference value" for the rate of monetary expansion is announced. Such reference value does not have, however, the strength of an intermediate target. Lack of controllability of the money supply over the short-run, uncertainty concerning the transmission mechanism in the Euro-system and the recognition that the launch of the euro would represent a significant structural break led the ECB to adopt instead a weak type of money targeting, in which there is no commitment to correct deviations over the short-term. In addition, a *Second Pillar* ("a general assessment of price stability using a broad range of indicators") was formulated, opening a window for less orthodox approaches to price stability. The ECB framework reflects, thus, a balance between continuity with the Bundesbank policy, so as to inherit credibility, and flexibility, as required to operate in the global environment. In any case, either as source of information or as intervention indicator, money has a major role in ECB policy formulation.

Not surprisingly, the stability and information content of European-wide monetary aggregates became a very topical issue in the research agenda (some references along this paper). In general, empirical works addressing this issue have been able to find stable money demand functions for the Euro area. Yet whether such stability is applicable to the post-EMU money demand or if it is instead a statistical artefact is an open question. Indeed, since empirical studies have been based on constructed pre-EMU money aggregates, their validity has been questioned both in light of the Lucas critique and aggregation bias (discussions, for example, in Beyer et al. 2001, Arnold and de Vries, 2000, Fagan and Henry, 1999, Spencer, 1997, Arnold, 1994).

This paper challenges the empirical literature on EU-wide money from a different angle. In a financial environment marked by absence of capital controls and growing international portfolio diversification, the agents' ability to shift the location and the currency denomination of their asset holdings may have a destabilising impact on money demands. Borrowing the arguments put forward by the Theory of Currency Substitution (e.g, Miles,1978, Karaken and Wallace, 1981, McKinnon, 1982, Girton and Roper, 1981, Boyer and Kingston, 1987 and so on), if the money demand in Europe responds to monetary developments abroad, the rate of money growth may become a poor indicator of risks to price stability.

The structure of this paper is as follows. Section 2 reviews the literature on Euro-wide money. Section 3 describes the main empirical models of CS. In Section 4, we estimate a (whatever that is) money demand function for the euro-area under alternative specifications, so as to test for the CS hypothesis. The aim of this exercise is not to defend a particular model or functional form for the euro-area money demand, but simply to argue that the information content of some external variables may be an important input for policy prescription in the Euro-system. Section 5 concludes.

2. Currency Substitution and European-wide money

The phenomenon of International Currency Substitution (CS) became a central topic in monetary economics and one that should increase importance in the future. As recently pointed out by Masson (2000), technology and globalisation are blurring the distinction between national and international uses of money and this phenomenon opens a channel through which the domestic money market is exposed to shocks occurring abroad[1].

In Europe, the CS debate was revived during the transition to the monetary union, giving rise to the so- called "indirect approach" to CS (see Artis, 1996, for a survey). Following the argument, as capital controls were phased out, residents' demand for monetary assets became increasingly influenced by foreign variables, raising the question on whether stable money demand functions could be estimated at the national level. Thus, it was argued that, as long as foreign currency holdings were denominated in European currencies, *internalisation* would be achieved by aggregating up. This question was addressed, among others, by Bekx and Tulio (1989), Kremers and Lane (1990), Bayoumi and Kenen (1993), Cassard et al. (1994) and Spencer (1997), who found that European-wide monetary aggregates are indeed more stable and/or more helpful to predict national inflation rates than the correspondent national aggregates[2]. This evidence revived the

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[1] These shocks can either affect the total demand for international money and its composition among international currencies. The former type of shocks includes, for example, changes in the volume of international trade and financial disturbances in specific countries or areas - as long as they lead to the replacement of the domestic currencies by an international currency, debt emission or intervention. The second type of shocks includes, for example, changes in the relative user costs of international currencies, which induce "international CS".

[2] In a different approach, Monticelli (1996), investigated whether the inclusion of different types of cross border deposits in the definition of money would improve the properties of the estimated money demand equation. Contrary to the evidence found at the national level by Angeloni, Cotarelli and Levi (1994) - that extended monetary aggregates perform consistently better than the standard aggregates for most EU countries - Monticelli (1996) found that at the European level none of the extended measures outperformed the one obtained by the sum of traditional national definitions (see also Fagan and Henry, 1999). These studies however overestimate the amount of foreign currency

confidence on the role of quantitative money targets and favoured the view that the ECB might be able to implement monetary policy more effectively than the individual central banks[3].

A different question is whether CS vis-à-vis the US dollar remains as a potential source of instability[4]. Earlier specifications of the money demand for the euro-area often included a term designed to capture dollar substitution. For money aggregates comprising the EMS7 (Germany, France, Italy, Netherlands, Denmark, Belgium, Ireland), the presence of CS was tested by a long term interest rated differential (Bekx and Tullio, 1989), the dollar-ECU nominal exchange rate (Kremers and Lane, 1990) and the dollar-ECU real exchange rate (Artis et al., 1993, Tullio et al., 1996). For the EMS9 (EMS7 plus UK and Spain), Monticelly and Strauss-Khan (1993) tested the significance the actual exchange rate depreciation. Although none of these studies was devoted directly the CS hypothesis and they all have specification problems, it is remarkable that in all them the term capturing dollar substitution was found to be important. It is thus surprising that the most recent empirical investigation on the Euro-wide money demand (Brand and Cassola, 2000, Coenen and Vega, 1999, Fagan and Henry, 1999, Hayo, 1999, Fase and Winder, 1998) has been entirely devoted to the closed economy portfolio model.

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deposits held inside the euro-area at the cost of those held abroad, because UK (and hence the City) is considered member of the monetary union.

[3] Whether this "indirect approach" provides evidence of intra-European CS is a different question. As noted, for example, by Fagan and Henry (1999) (see Browne et al, 1997 for a survey), the superiority of EU-wide estimates can be attributed either to a statistical averaging effect or to asymmetric shocks that offset each other in the aggregate (of which CS is only a special case). For direct tests suggesting the existence of intra-European currency substitution, see Melvin (1985). Mizen and Pentecost (1994), in contrast, found little evidence of currency substitution in the particular case of the demand for sterlings.

[4] It should be noted that, since foreign currency holdings in the domestic banking system are included in the ECB official aggregate, part of CS was already internalised. Current ECB data suggests that residents' foreign currency deposits inside the EU amounts to 2.5-3.0% of total deposits.

3. Approaches to Currency Substitution

Following Mizen and Pentecost (1994), the CS hypothesis will be tested in the context of the two main theoretical models of CS, the Portfolio Model (PM - Girton and Roper, 1981, Cuddington, 1983, Branson and Henderson, 1985) and the Liquidity Services Model (LSM - Miles, 1978, Liviatan, 1981, Thomas, 1985, Joines, 1985). These two approaches give rise to different specifications of the money demand, as briefly described bellow.

According to the PM, money is a simple asset without any particular feature that makes it distinguishable from other assets. Assuming gross substitutability between money and all other assets, this approach gives rise to a money demand function that depends on wealth and opportunity costs. In the context of a closed economy, where the only available assets are domestic money and domestic bonds, the relevant opportunity cost is the domestic interest rate[5]. In an open economy, if foreign money and foreign bonds are also available, the money demand will also depend on the foreign interest rate and the expected exchange rate depreciation. Cuddington (1983) proposed the following semi-log specification:

$$m_t = a_0 + a_1 i_t + a_2 (i_t^* + \hat{e}_t^E) + a_3 \hat{e}_t^E + a_4 y_t + v_t ,$$

or equivalently,

$$m_t = a_0 + a_1 i_t + a_2 i_t^* + (a_2 + a_3)\hat{e}_t^E + a_4 y_t + v_t , \qquad (1)$$

where *m* is the log of real money balances, i and i^* are the nominal interest rates on domestic and foreign bonds respectively, $\hat{e}_{+1}^E$ is the expected exchange rate depreciation and *y* is the log of the domestic income. The expected signs are $a_1, a_2, a_3 < 0$ and $a_4 > 0$. The term a_2 captures capital flight and a_3 measures the extent of CS.

The LSM motivates the use of money by its means of payment role, thus explaining why it is held in portfolio despite being dominated by interest-bearing assets. According to this theory, portfolio decisions are separable from CS[6]. Currency holdings in each denomination depend only on

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[5] Obviously, the closed economy PM can be extended so as to include a range of domestic assets (see Ericsson, 1999, for a recent survey).

[6] In Miles (1978), such separability was simply postulated. The proof that, in the presence of complete bond markets, portfolio and CS decisions are separable is due to Thomas (1985): *with one hand*, an investor selects his currency holdings based on each currency transaction services and opportunity costs; *with the other hand*, he borrows or

their marginal productivity in the production of liquidity services and user costs. Since a decision to hold more money in one denomination requires reduced holdings in the other, a rise in the relative user cost of the foreign money implies a shift towards the domestic currency. Thus, contrary to the PM, in this theory the domestic money demand depends positively on the foreign interest rate. Joines (1985) proposed the following specification:

$$m_t = b_0 + b_1 i_t + b_2 i_t^* + b_3 y_t + u_t \,. \tag{2}$$

The expected signs are $b_1 < 0$ and $b_2, b_3 > 0$. The coefficient b_2 measures the extent of CS.

Thomas and Wickens (1991) used specification (2) to test simultaneously for the PM and the LSM, arguing that, if the estimated cross interest rate elasticity is positive ($b_2 > 0$), then the later model is more likely to hold[7].

In general, the empirical implementation of the portfolio model (1) is problematic, because under uncovered interest-rate parity the domestic interest rate and the foreign interest rate plus the expected depreciation are co-linear. As others have done, in the next section two restricted versions of the PM model will be also estimated, dropping at the time the foreign interest rate (Equation 1a) and the domestic interest rate (1b). The Closed Economy PM (3) is estimated for comparative purposes.

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lends to achieve the desired overall portfolio composition. An optimal currency hedge is created and the denomination structure of the individual portfolio is independent of the currency holdings.

[7] Conclusions are not so straightforward when $b_2 < 0$. Further investigation on the liquidity services model by Smith (1995), revealed that the sign of the cross interest rate may also be negative, due to inter-temporal substitution effects. Thus, for some parameter values the liquidity services and the portfolio model may be observationally indistinguishable in single equation estimation.

4. Estimation results

This study uses quarterly data from 1982:q2 through 1999:q3[8]. The variables used are the log of the (seasonally adjusted) real M3 in the euro-area (*m*), the log of real GDP in the euro-area (*y*), the 10-year government bonds yields in the euro-area and in US (i and i^*) and a short term interest rate differential, as proxy for the expected exchange rate depreciation ($\hat{e}^E$).

Table 1 displays the results of the unit root tests. Integration of order one was tested against the alternative of trend stationarity for *m* and *y* and the alternative of stationarity in levels for the interest rates and expected depreciation (the Breush-Godfrey LM statistics tests the absence of auto-correlation). In all cases the null was not rejected.

Table 2 reports the estimation results, using the Johansen procedure (PcFiml version 9.10, Dornik and Hendry, 1997). For comparative porpuses, the number of lags was set the same in all equations. Taking into account the usual information criteria, the PCFiml F-tests for system reduction and also the common practice in previous works, the lag-length was set equal to 2.

As in both Brand and Casssola (2000) and Coenen and Vega (1999), residual non-normality was a major estimation problem. Following these authors, cointegration is evaluated only on the basis of the trace test (and the correspondent correction for small samples), because this statistic is likely to be more robust to some forms of non-normality than the maximal eigenvalue test. In all equations the trace test suggests the existence of a unique co-integrating vector (note that in equation 2 the Reimers' statistic is just on the 95% border).

As expected, the residual diagnosis for model (1) reveals major econometric problems, namely non-normality in 3 out of 5 equations, significant vector non-normality and vector auto-correlation. Results are only displayed for comparative purposes.

In Model (1a) - also adopted in some earlier works on European-wide money - the eventual substitutability between money and bonds can only be captured by the domestic interest rate term. In estimation, the expected depreciation term was found negative and significant but the coefficient of

[8] All European-wide variables are from the ECB database, as displayed in Brand and Cassola (2000). The remaining variables are from the IFS. Although consistent data are available from 1980:q1, our experiments revealed better residual diagnosis after removing the first observations from the sample. Coincidentally, both Coenen and Vega (1999) and Brand and Cassola (2000) reported the existence of outliers in the beginning of the sample.

the domestic interest rate was positive and not significant[9]. Residual diagnosis improved significantly in comparison to (1)[10].

As argued by Cuddington (1983), the statistical significance of the expected depreciation term in (1a) is not a valid test for the presence of CS because of capital mobility. To distinguish capital mobility from CS, both the foreign interest rate and the expected depreciation term have to be included among the explanatory variables, as done in (1b).

In (1b) vector autocorrelation is no longer significant, but residual tests still reveal autocorrelation in the equation for *m*, calling for caution in the use of inference. Remarkably, the estimated coefficient of the foreign interest rate term is positive. This, together with the lack of significance of the expected depreciation term, is inconsistent with the PM and suggests that the underlying model may be instead the LSM (although not displayed in Table 2, the significance level of the foreign interest rate declines to 7% when the expected depreciation term is set equal to zero).

Under the LSM, (2), there is no evidence of autocorrelation. Both interest rates are significant at 95% and the respective signs are in accordance to the theory.

The significance of the domestic interest rate in equation (2) contrasts with its lack of significance under the closed economy PM, (3). In the later, the trace statistics still suggests one cointegrating vector, but no cointegration would be obtained if the domestic interest rate were dropped from the model.

Summing up, the estimation results are contradictory in respect to the significance of the expected depreciation term and the domestic interest rate, while a positive and significant coefficient was found on the foreign interest rate[11]. In each equation, either the foreign interest rate or the interest-rate-differential performs at least as well as the domestic interest rate. This evidence is favourable to the CS hypothesis in general.

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[9] In Monticelli and Strauss-Khan (1993) both the domestic interest rate the *actual* depreciation rate were found to be significant. However, an identification problem is likely to have occurred, because the authors misinterpreted the number of cointegrating vectors suggested by the trace statistic.

[10] Although vector autocorrelation cannot be rejected at 90%, similar coefficients and significance levels were obtained in a more reliable (free of auto-correlation) specification, with k=4. As explained above, in Table 2 the lag length is kept equal to 2 for comparative purposes.

[11] A possible explanation, assuming that (2) holds, is that the omission of the foreign interest rate from (1a) renders the exchange rate proxy significant, because its influence is captured by the interest rate differential, while the domestic interest rate becomes redundant. To confirm this explanation, modified versions of equations (1a), (1b) and (2) were estimated, replacing the bond rates by money market rates. The results (available under request) are basically equivalent, except that the domestic money market rate was never significant. This may also explain why the interest rate differential is significant in (1a) but not in (1b).

Being benevolent in respect to the limitations of the empirical exercise, the results suggest that the LSM is more likely to hold (in Appendix 1, stability analysis using recursive estimation also supports this view). If true, this would mean that money in Europe is mainly held for transaction purposes, as is likely to be the case when financial markets are deep and free of controls[12].

As a final exercise, we check how the LSM performs in the presence of the domestic inflation rate. This variable has been included in most empirical works addressing European-wide monetary aggregates and it may be argued that its omission from the model gives rise to a specification problem[13]. The estimation results are displayed in Table 3.

In general, the model has no econometric problems but the usual residual non-normality. The trace tests suggest the existence of two co-integrating vectors (the Reimers' statistic for one or less co-integrating vectors is rejected at 90%). In Table 3, two identifying restrictions were specified, one for the money demand and the other for a cointegrating relationship between the nominal interest rate and the inflation rate, as suggested by both Coenen and Vega (1999) and Brand and Cassola (2000). The significance level of the identifying restrictions is 94%.

The rationale for the second cointegrating vector is still under question. In Coenen and Vega (1999), a simple Fisher condition was identified. In the Brand and Cassola sample (our sample), however, the Fisher condition does not hold as cointegrating vector. Instead, the inflation rate has an estimated coefficient of 1.69 in the normalised vector, suggesting a positive long run relationship between inflation and the real interest rate. According to Brand and Cassola (2000), such relationship may hold in equilibrium due to the impact of taxation. However, a simpler reasoning can be suggested. As shown in Chart 1, the real interest rate, rather than mean reverting, exhibits a declining trend along the sample period[14]. Possible explanations for this sampling behaviour are the debt instability problems faced by some countries in the early 80s and the widespread use of capital

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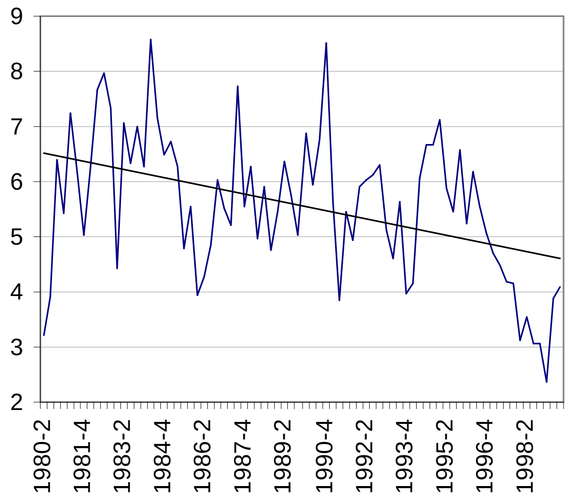
[12] The failure of the PM might be unexpected given the broad concept of money used in the analysis. However, the weight of M2 in M3 is as high as 85%. Although not reported here, similar results were obtained running (1)-(3) for the aggregate M2. For M1, which roughly amounts to 40% of M3, no reliable specification was found.

[13] In some studies, a domestic money market interest rate has been also been specified. However the role of this variable is far from being clarified. It has been already specified as opportunity cost (Cassard et. al, 1994), as proxy for the M3 own return (Fase and Winder, 1998, Coenen and Vega, 1999) and, once recognised its poor performance as proxy for the M3 own rate, simply to capture the influence of the slope of the yield curve (Brand and Cassola, 2000). In general the estimated coefficient was found to be negative when the long-term interest rate is omitted, but it becomes redundant (without a clear sign) when the long-term interest rate is also specified. In this paper, we decided not to include the money market rate in the estimation so as to reduce the complexity of the model and to overcome potential econometric problems resulting from multicollinearity.

[14] From the picture, it easy to see that the downward trend becomes more pronounced when the first observations are dropped, as implied by estimation with lags.

controls, coupled with high interest rates to fight inflation. During the convergence process, progressive elimination of capital controls and healthier public finance translated into a declining real interest rate, on average. Since both the real interest rate and the inflation rate exhibit declining trends, a co-integrating relationship between these two variables holds naturally in this particular sample. This does not mean that such relationship should be used to forecast inflation or interest rates in the future.

Chart 1: Real interest rate in the euro-area (1980:2-1999:3)



The results obtained for the money demand equation in Table 3 are similar to those obtained in equation (2), above. Basically, the signs of both interest rates are in accordance to the LSM and the t-ratios (3.3 for the domestic rate and 2.7 for the foreign rate) suggest statistical significance.

In Table 3, two estimates for the loading vectors are displayed. The first estimate is the one that results directly from the Johanson procedure. The second (two-step) estimate was obtained using the residuals of the co-integrating relationships in an unrestricted OLS in differences. The advantage of the second procedure is that zero restrictions on each loading factor can be tested separately.

The loading factor for *m* in respect to the first co-integrating vector is significant and positive, meaning that a monetary overhang (translated into a negative residual) causes a fall in real money supply (though it is impossible to say if this is due to a rise in the price level or a policy response). The results obtained also suggest that output, inflation and the domestic interest rate are weakly exogenous in respect to money but, interestingly enough, the US interest rate is not. This evidence stresses the idea that the euro-area is a large player in the international monetary system.

5. Concluding remarks

Since the euro-area is a larger and relatively more closed economy than any of the participating countries, there is a view that it should be mainly affected by internal shocks, rather than by monetary developments abroad. By stressing the influence of foreign variables in the demand for domestic money, the results obtained in this paper challenge this "de-coupling effect" view of the European monetary unification.

Being benevolent to the limitations of the empirical exercise, the results obtained also suggest that the LSM is likely to produce a better fit than the PM. If true, this conclusion challenges the previous literature on EU-wide money, which has been exclusively devoted to the PM.

In light of the "Arnold critique", the coefficients estimated above may have little value for forecasting and policy prescription[15]. Whatever the limitations are, the aim of this exercise is not do defend a particular model or functional form for the euro-area money demand. Simply, by stressing the interdependent nature of the international monetary system, we add an argument to the general case for caution in the interpretation of the information content of EU-wide monetary aggregates.

[15] For example, it has been argued that the emergence of the euro as international currency will enhance its substitutability vis-à-vis the dollar. Of course, in that case the coefficients estimated above would be underestimating the extent of CS, but the conclusion that interdependency matters would be reinforced. The concerns that the emergence of the euro as international currency may increase the unpredictability of exchange rates and reduce the effectiveness of monetary policies are likely to be reviving the debate on the architecture of the international monetary system (see, for example, Mundell, 2000, Mckinnon, 2000, Cooper, 2000).

References

Angeloni, I., C. Cotarelli and A. Levy (1994), "Cross border deposits, aggregation and money demand in the transition to EMU", *Journal of Policy Modelling* 16 (1), 27-54.

Angeloni, I. , V. Gaspar and O. Tristani (1999), "The monetary policy strategy of the ECB", manuscript presented at the conference, "The ECB and its Watchers", held by the Centre for Financial Studies.

Arnold, I., C de Vries (2000), "Endogeneity in European Money Demand", *European Journal of political Economy* 16, 587-609.

Arnold, I. (1994), "The myth of a stable European money demand", *Open Economies Review*, 5, 249-259.

Artis, M. (1996), "Currency Substitution in European Financial Markets", in P. Mizen and E. Pentecost (eds), *The Macroeconomics of International Currencies: Theory, policy and Evidence*, Cheltenham: Edward Elgar.

Artis, M.J., R. Bladen-Hovelll and W. Zhang (1993), "A European money demand function" in P.R. Masson and M.P.Taylor (eds), *Policy Issues in the Operation of Currency Unions*, Cambridge, UK: Cambridge University Press, 240-263.

Bayoumi, T.A, and P.B. Kenen (1993), "Using an EC-wide monetary aggregate in the stage two of EMU", *Review of International Economic*, 1, 209-20.

Bekx, P. and G. Tullio (1989), "A note on the European Monetary System and the determination of the DM-dollar exchange rate", *Caiers Economiques de Bruxelles* 123, 329-43.

Beyer, A. , J. Doornick and D. Hendry (2001), "Constructing historical euro-zone data", *The Economic Journal*, 111, 102-121.

Boyer, R. and G. Kingston (1987), "Currency substitution under financial constraints", *Journal of International Money and Finance,* 6, 235-50.

Branson, W.H. and D.W. Henderson (1985), The specification and influence of asset markets, in: R. W. Jones and P. B. Kenen, eds., Handbook of international economics, Vol. II (North Holland, Amsterdam).

Brand, C. and N. Cassola (2000), "A money demand system for euro area m3", European Central Bank, mimeo.

Browne, F. , G. Fagan and J. Henry (1997), "Money Demand in EU Countries: a Survey", European Monetary Institute Staff Paper Nº 7, March.

Cassard, M., T. D. Lane and P.R. Masson (1994), "ERM money supplies and the transition to EMU", IMF Working paper Nº 94/1.

Coenen, G. and J-L Vega (1999), "The Demand for M3 in the Euro Area, European Central Bank Working Papers 6.

Cooper, R. (2000), "Toward a Common Currency?", *International Finance* 3:2, 287-308.

Cuddington, J. (1983), "Currency Substitutability, Capital Mobility and Money Demand", *Journal of International Money and Finance*, 2, 111-133.

Dornick, J. and D. Henry (1997), *Modelling Dynamic Systems Using PcFiml 9 for Windows*, International Thomson Business Press, London.

ECB (1999), "The stability oriented monetary policy strategy of the Eurosystem", *ECB Monthly Bulletin*, January.

Ericsson, N.R. (1999), "Empirical modelling of money demand", in H. Lutkepohl and J. Wolters (eds.), *Money demand in Europe*, Heidelberg: Physica Verlag, 29-49.

Fagan, G. and J. Henry (1999), "Long run money demand in the EU: evidence for area-wide aggregates", in H. Lutkepohl and J. Wolters (eds.), *Money demand in Europe*, Heidelberg: Physica Verlag,, 217-240.

Fase, M. and C. Winder (1998), "Wealth and the demand for money in the European Union", Empirical Economics 23, 507-524.

Girton, L. and Don Roper (1981), "Theory and Implications of Currency Substitution", *Journal of Money, Credit and Banking* , 13, 12-30.

Hayo, B. (1999), "Estimating a European Demand for Money" (1999), *The Scottish Journal of Political Economy* 46 (3), 221-244.

Joines. D. (1985), "International Currency Substitution and the Income Velocity of Money", *Journal of International Money and Finance*, 4, 303-316.

Kareken, J. and N. Wallace (1981), "On the indeterminacy of equilibrium exchange rates", *Quarterly Journal of Economics* 96, 207-22.

Kremers, J., and T. Lane (1990), “Economic and monetary Integration and the aggregate demand for money in the EMS”, *International Monetary Fund Staff Papers* 37 (4), 777-805.

Liviatan, Nissan (1981), “Monetary Expansion and the Real Exchange Rate Dynamics”, *Journal of Political Economy,* 89 (6), 1218-1227.

McKinnon, R. I. (2000), “Mundell, the Euro and the World Dollar standard”, *Journal of Policy Modeling* 22 (3), 311-324.

Masson, P. (2000), Remarks on "One World, One Currency: Destination or Delusion?" Speech at the IMF Economic Forum, November 8. Transcript available in www.imf.org/external/np/tr/2000/tr001108.htm.

McKinnon, R. I. (1982), “Currency substitution and the instability in the world dollar standard”, *American Economic Review* 72, 320-333.

Melvin, M. (1985), “Currency substitution and Western European Monetary unification”, *Economica* 52, 79-92.

Miles, M. A. (1978), "Currency Substitution, Flexible Exchange Rates, and Monetary Independence", *American Economic Review,* 68, 428-436.

Mizen, P. and E. Pentecost (1994), "Evaluating the Empirical Evidence for Currency Substitution: A Case Study of the Demand for Sterling in Europe", *The Economic Journal*, 104 (426), 1057-1069.

Monticelli, C (1996), “EU-wide money and cross border holdings”, *Weltwirtschaftliches Archiv* 132, 215-235.

Monticelli, C. and M.O. Strauss-Khan (1993), “European Integration and the Demand for Broad Money”, Machester School of Economics and social Studies”, 61, 345-66. Bank of International Settlements Working Paper Nº 18, 1992.

Mundell, R. (2000), “Currency areas, volatility and intervention”, *Journal of Policy Modeling* 22 (3), 281-299.

Smith, C., "Substitution, Income and Intertemporal Effects in Currency-Substitution Models.” *Review of International Economics* 3(1995), 53-59.

Spencer, P. (1997), “ Monetary Integration and Currency Substitution in the EMS: the case for a European Monetary Aggregate”, *European Economic Review* 41, 1403-1419.

Tullio, G., E. de Souza and P.Giucca (1996), “The demand for money functions in Europe and in Germany before and after the fall of the Berlin Wall”, in P. de Grawe, S. Micossi and G. Tullio (eds), *The control of inflation in the transition to EMU*, Oxford: Oxford University Press.

Thomas, L. (1985), "Portfolio Theory and Currency Substitution", *Journal of Money, Credit and Banking*, 17 (3), 347-357.

Thomas, S. and M. Wickens (1991), "Currency Substitution and Vehicle Currencies: Tests of Alternative Hypotheses for the Dollar, DM and Yen", CEPR Discussion Paper Nº 507, January.

Table 1: Unit roots tests

	Lags	LM (4)	Trend	ADF
m3r	6	2.79	yes	2.03
y	1	7.70	yes	1.89
l	6	1.70	no	1.69
l$	7	6.25	no	1.48
exp	8	6.00	no	1.36

TABLE 2: TESTING ALTERNATIVE MODELS OF CS

Sample: 1982:q2-1999:q3

Unrestricted Portfolio

Trace test	**m**	**y**	$\hat{e}^E$	**i**	**i***	**Residual tests**
Standard Ho:rank=r	Co-integrating vector:					**AR 1- 5 F(5, 54)** m : 0.995 [0.43] y : 0.357 [0.88]
$r=0$ 83.72** $r\leq 1$ 39.74	-1	1.46 (0.04)	-0.0013 (0.0018)	0.0004 (0.0034)	0.0044 (0.0038)	i : 1.717 [0.15] i* : 0.958 [0.45]
$r\leq 2$ 22.26 $r\leq 3$ 7.72	Loading factors:					$\hat{e}$: 1.801 [0.13] **Normality Chi^2(2)** m : 1.829 [0.40]
Reimer's (T-nm) Ho:rank=r $r=0$ 71.76* $r\leq 1$ 34.06 $r\leq 2$ 19.08 $r\leq 3$ 6.62	0.077 (0.027)	-0.055 (0.037)	20.65 (3.88)	-3.72 (2.58)	-11.03 (3.94)	y : 9.362 [0.01] ** i : 0.968 [0.62] i* : 6.189 [0.05] * $\hat{e}$: 8.521 [0.01] * **Multivariate tests:** AR 1-5 F(125,152) = 1.726 [0.00]** Normality Chi^2(10)= 33.138 [0.00]** Xi^2 F(300,332) = 0.861 [0.91]

Restricted Portfolio (1a)

Trace test	**m**	**y**	$\hat{e}^E$	**i**	**i***	**Residual tests**
Standard Ho:rank=r	Co-integrating vector:					**AR 1-5 F(5,56)** m : 2.186 [0.07] y : 0.252 [0.94]
$r=0$ 65.69** $r\leq 1$ 25.15 $r\leq 2$ 9.59	-1	1.42 (0.037) [0.00]**	-0.0031 (0.0012) [0.03]*	0.0029 (0.0019) [0.25]		i : 2.656 [0.03] * $\hat{e}$: 1.588 [0.18] **Normality Chi^2(2)**
Reimer's (T-nm) Ho:rank= r	Loading factors:					m : 1.112 [0.57] y : 7.139 [0.03] * i : 1.743 [0.42] $\hat{e}$: 6.708 [0.03] *
$r=0$ 58.19** $r\leq 1$ 22.27 $r\leq 2$ 8.50	0.087 (0.027) [0.01]**	-0.041 (0.038) [0.32]	20.4 (3.95) [0.00]**	-3.02 (2.69) [0.27]		**Multivariate tests** AR 1-5 F(80,152) = 1.327 [0.07] Normality Chi^2(8)= 17.465 [0.03]* Xi^2 F(160,318) = 1.014 [0.46]

Restricted Portfolio (1b)

Trace test	m	y	$\hat{e}^E$	i	i*	Residual tests
Standard Ho:rank=r	Co-integrating vector:					**AR 1- 5 F(5, 56)** m : 2.642 [0.03] * y : 1.175 [0.33]
$r = 0$ 64.92** $r \leq 1$ 28.26 $r \leq 2$ 10.60	-1	1.46 (0.048) [0.00]**	-0.0014 (0.0012) [0.37]		0.0053 (0.0024) [0.13]	i* : 0.407 [0.84] $\hat{e}$: 1.703 [0.15] **Normality Chi^2(2)**
Reimer's (T-nm)	Loading factors:					m : 1.089 [0.58] y : 8.176 [0.02] * i* : 5.006 [0.08]
Ho:rank=r $r = 0$ 57.5** $r \leq 1$ 25.03 $r \leq 2$ 9.39	0.075 (0.027) [0.03]*	-0.050 (0.037) [0.23]	20.4 (3.73) [0.00]**		-11.3 (3.79) [0.012]*	$\hat{e}$: 8.812 [0.01] * **Multivariate tests** AR 1-5 F(80,152) = 1.247 [0.12] Normality Chi^2(8)= 20.981 [0.01]** Xi^2 F(160,318) = 1.051 [0.35]

Liquidity Services Model (2)

Trace test	m	y	$\hat{e}^E$	i	i*	Residual tests
Standard Ho:rank=r	Cointegrating vector:					**AR 1- 5 F(5, 56)** m : 0.902 [0.49] y : 0.335 [0.89]
$r = 0$ 53.2* $r \leq 1$ 25.34 $r \leq 2$ 10.9	-1	1.40 (0.056) [0.00]**		-0.0083 (0.0028) [0.03]*	0.0098 (0.0035) [0.04] *	i : 2.112 [0.08] i* : 0.847 [0.52] **Normality Chi^2(2)**
Reimer's (T-nm)	Loading factors:					m : 1.824 [0.40] y : 8.229 [0.02] * i : 1.034 [0.60]
Ho:rank=r $r = 0$ 47.12 $r \leq 1$ 22.44 $r \leq 2$ 9.66	0.094 (0.025) [0.01]**	-0.024 (0.036) [0.58]		-1.80 (2.52) [0.51]	-11.80 (3.77) [0.02]*	i* : 6.098 [0.05] * **Multivariate tests** AR 1-5 F(80,152) = 1.139 [0.25] Normality Chi^2(8)= 24.893 [0.00]** Xi^2 F(160,318) = 0.827 [0.91]

Closed economy (3)

Trace test	m	y	$\hat{e}^E$	i	i*	Residual tests
Standard Ho:rank= r $r = 0$ 33.33*	Cointegrating vector:					**AR 1- 5 F(5, 58)** m : 1.203 [0.32] y : 0.431 [0.82]
$r \leq 1$ 13.55 $r \leq 2$ 1.03	-1	1.30 (0.048) [0.01]**		-0.0057 (0.0023) [0.16]		i : 2.429 [0.05]* **Normality Chi^2(2)** m : 0.467 [0.79]
Reimer's (T-nm) Ho:rank= r	Loading factors:					y : 9.360 [0.01]** i : 0.669 [0.72] **Multivariate tests**
$r = 0$ 30.47* $r \leq 1$ 12.39 $r \leq 2$ 0.94	0.127 (0.029) [0.01]**	-0.018 (0.043) [0.77]		0.041 (3.08) [0.99]		AR 1-5 F(45,137) = 1.188 [0.22] Normality Chi^2(6)= 11.674 [0.07] Xi^2 F(72,250) = 0.827 [0.83]

Notes: * = 95% significance. ** = 99 % significance. Standard errors are in common brackets. Significance levels are in square brackets. Significance levels for each coefficients and loading factor were obtained testing for the correspondent zero restriction, leaving all the other coefficients unconstrained.

TABLE 2: THE LSM AND THE INFLATION RATE

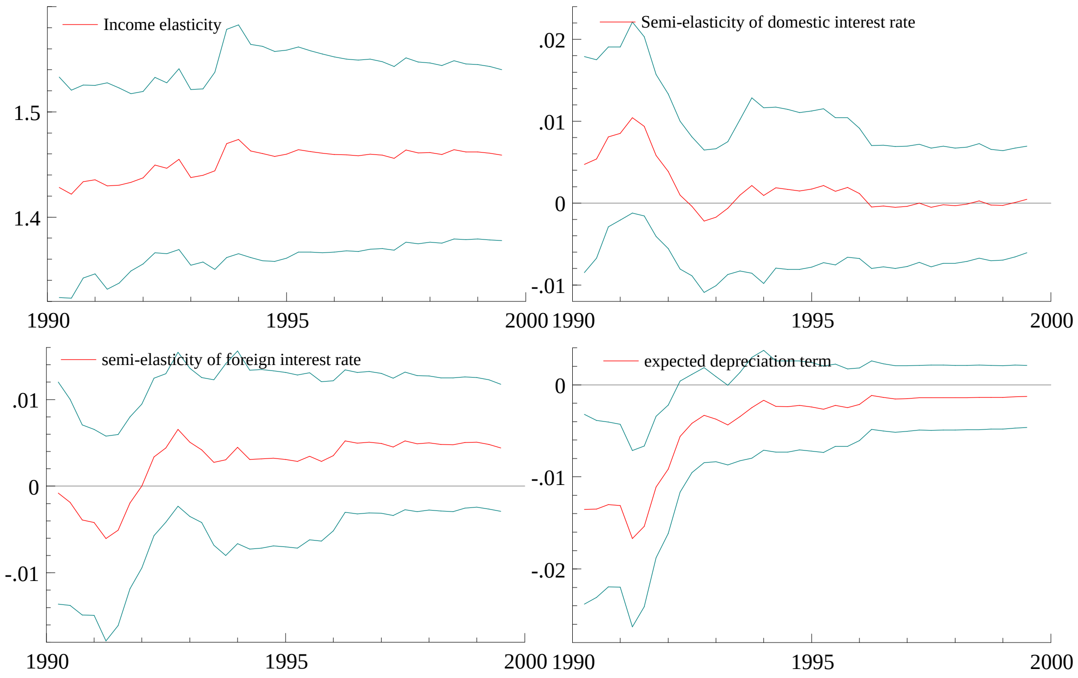
SAMPLE: 1982 (2) to 1999 (3)

Trace test	**m**	**y**	**π**	**i**	**i***	**Residual tests**
K=2 Standard Ho:rank= r $r = 0$ 92.89** $r \le 1$ 52.36* $r \le 2$ 26.47 $r \le 3$ 12.31 Reimer's (T-nm) Ho:rank= r $r = 0$ 79.62** $r \le 1$ 44.88 $r \le 2$ 22.69 $r \le 3$ 10.55	**Significance of the identifying restrictions:** Chi^2(2) = 0.135 [0.94] **Co-integrating vectors:**					**Portmanteau 8 lags** m : 8.20 y : 2.22 i : 17.42 π : 3.28 i* : 5.14 **AR 1- 5 F(5, 54)** m : 0.907 [0.48] y : 0.227 [0.95] i : 2.342 [0.054] π : 0.613 [0.69] i* : 1.070 [0.39] **Normality Chi^2(2)** m : 1.230 [0.54] y : 7.932 [0.02] * i : 3.044 [0.22] π : 4.537 [0.10] I* : 6.978 [0.03] * **ARCH 4 F(4, 51)** m : 1.529 [0.21] y : 0.949 [0.44] i : 0.579 [0.68] π : 1.884 [0.13] i* : 1.313 [0.28] **Xi^2 F(20, 38)** m : 0.836 [0.66] y : 1.236 [0.28] i : 0.738 [0.76] π : 0.833 [0.66] i* : 0.931 [0.56] **Vector tests:** Portmanteau 8 lags= 188.96 AR 1-5 F(125,152) = 1.11 [0.27] Normality Chi^2(10)=25.6 [0.0044]** Xi^2 F(300,332)= 0.742 [0.996]
	-1	1.37 (0.05)		-0.0085 (0.0025)	0.0083 (0.0031)	
			1.69 (0.11)	-1		
	Loading factors:					
	0.099 (0.027)	-0.016 (0.039)	-1.99 (5.73)	-2.40 (2.67)	-11.94 (4.12)	
	0.0003 (0.0004)	0.0001 (0.0005)	-0.410 (0.078)	0.071 (0.036)	0.056 (0.056)	
	Loading factors, Two-step OLS in differences k=1 Sample: 1982 (3) to 1999 (3)					
	0.101 (0.027) [0.0004]** 	-0.013 (0.039) [0.74]	-1.65 (5.80) [0.78]	-2.15 (2.69) [0.43]	-11.73 (4.17) [0.0067]**	
	0.0003 (0.0004) [0.3741]	0.0002 (0.0005) [0.68]	-0.397 (0.083) [0.00]**	0.082 (0.038) [0.037]*	0.065 (0.060) [0.2822]	

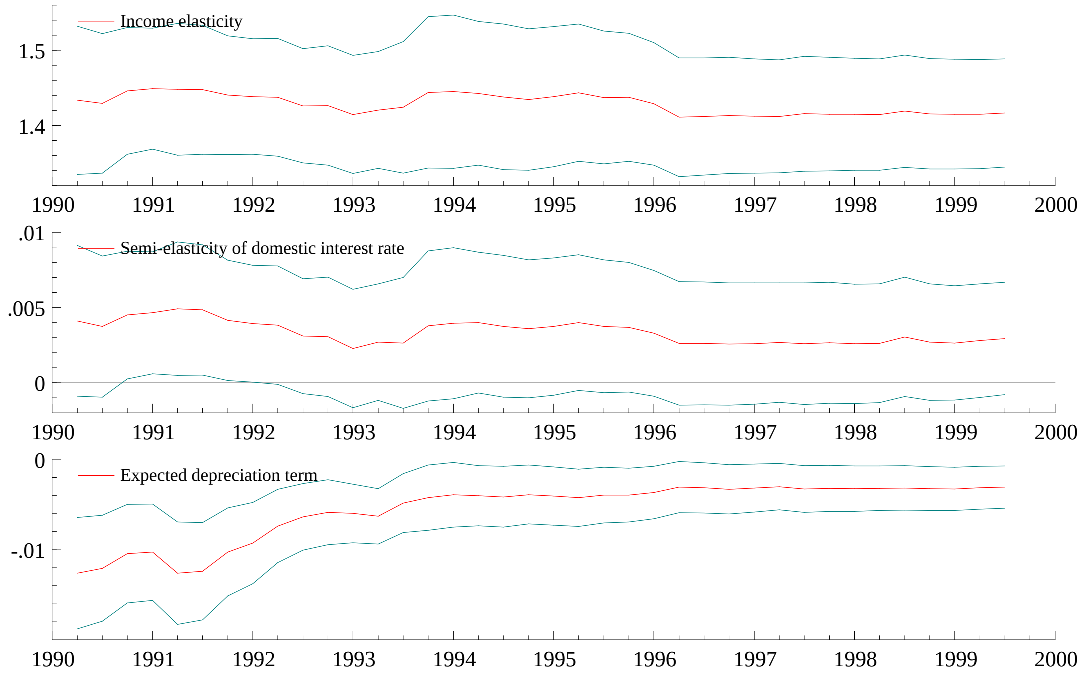
Notes: * = 95% significance. ** = 99 % significance. Standard errors are in common brackets. Significance levels are in square brackets.

Appendix 1: Recursive estimation

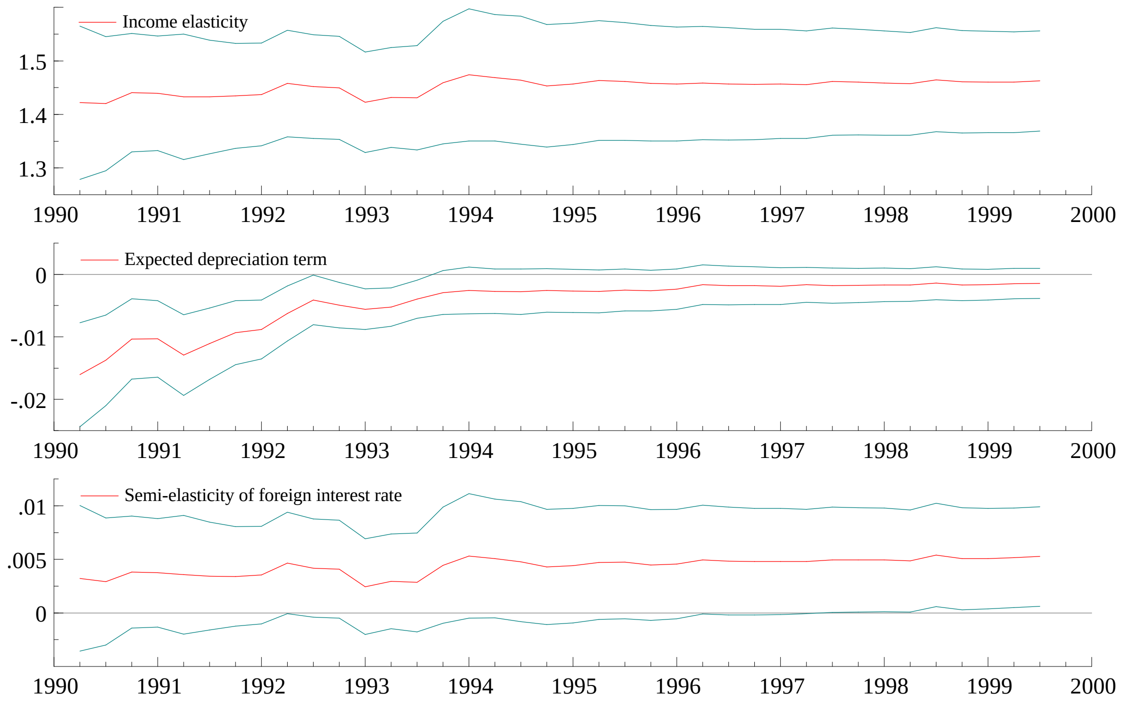
- Unrestricted PM (1)



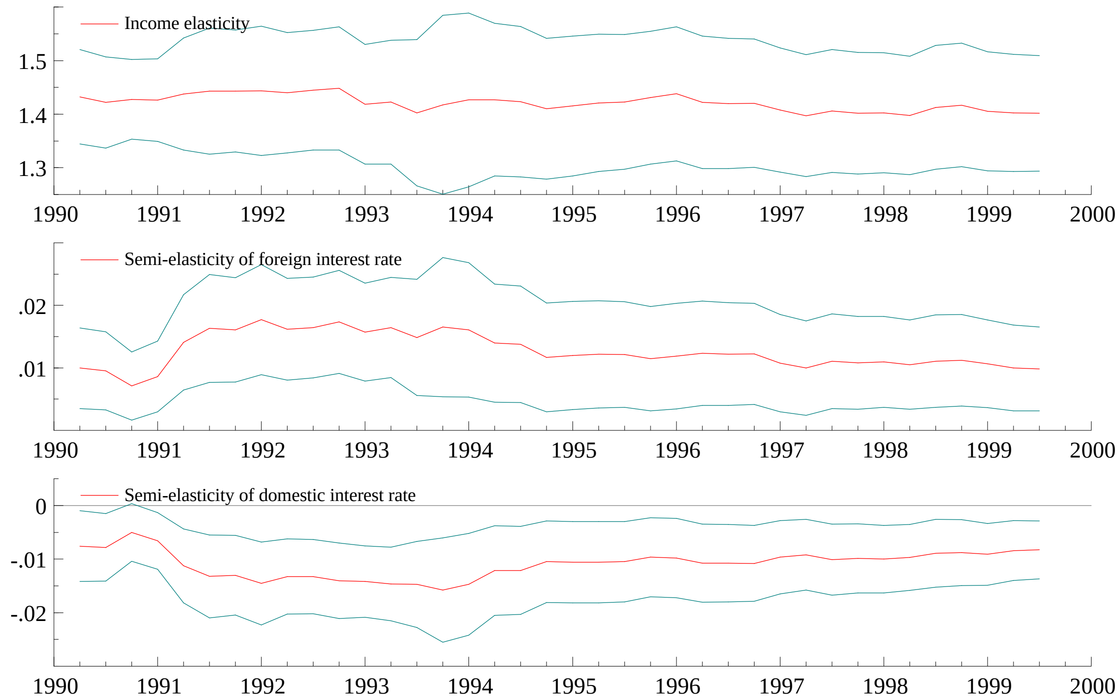
- Restricted PM (1a)



- Restricted PM (1b)



- Liquidity services (2)



- Closed economy PM (3)