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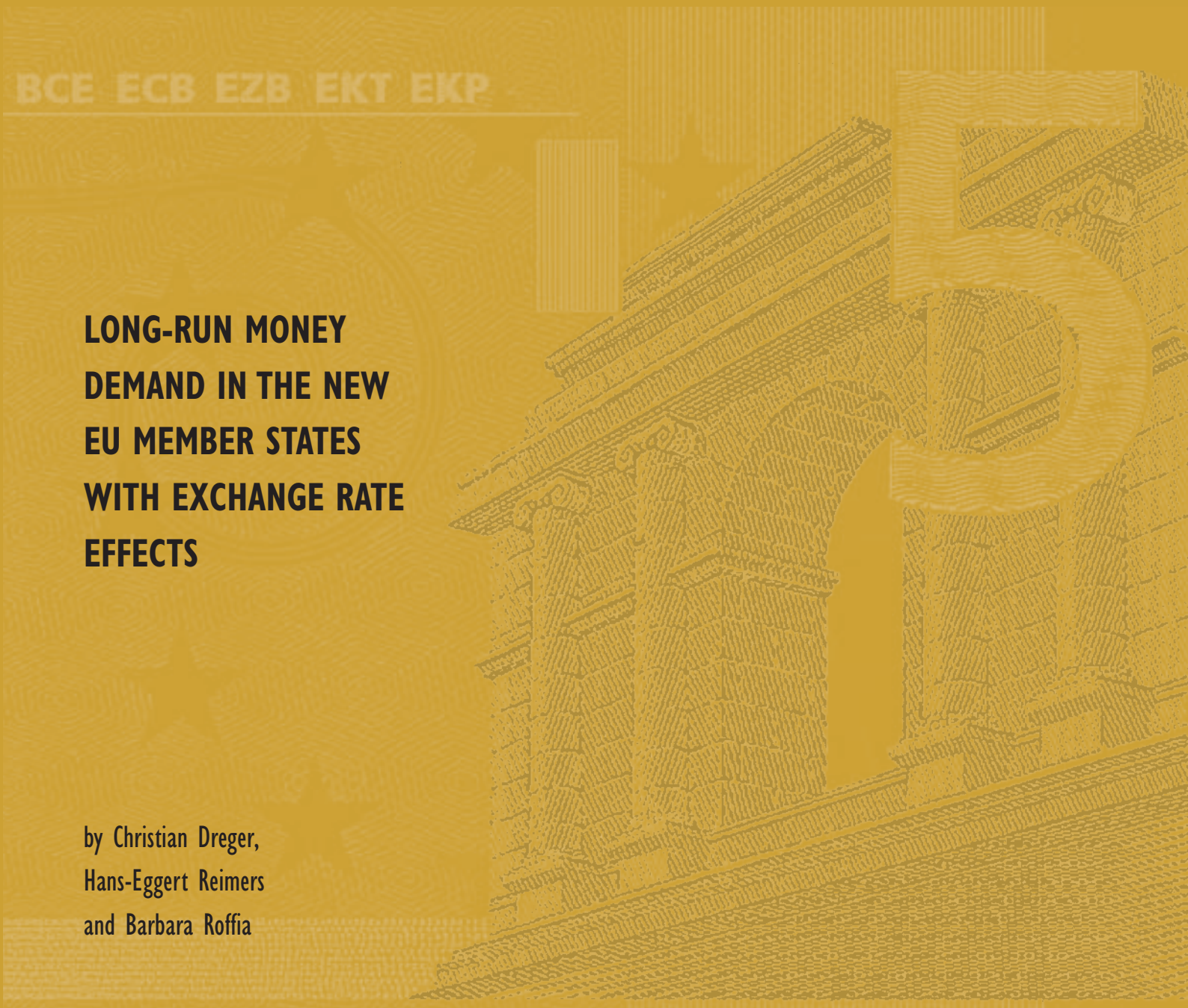

LONG-RUN MONEY DEMAND IN THE NEW EU MEMBER STATES WITH EXCHANGE RATE EFFECTS

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In 2006 all ECB publications will feature a motif taken from the €5 banknote.

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Abstract: Generally speaking, money demand models represent a natural benchmark against which monetary developments can be assessed. In particular, the existence of a well-specified and stable relationship between money and prices can be perceived as a pre-requisite for the use of monetary aggregates in the conduct of monetary policy. In this study a money demand analysis in the new Member States of the European Union (EU) is conducted using panel cointegration methods. A well-behaved long-run money demand relationship can be identified only if the exchange rate as part of the opportunity cost is included. In the long-run cointegrating vector the income elasticity exceeds unity. Moreover, over the whole sample period the exchange rates vis-à-vis the US dollar turn out to be significant and a more appropriate variable in the money demand than the euro exchange rate. The present analysis is of importance for the new EU Member States as they are expected to join in the future years the euro area, where money is deemed to be highly relevant − within the two-pillar monetary strategy of the European Central Bank (ECB) − in order to detect risks to price stability over the medium term.

Key words: Money demand; new EU Member States; exchange rate; panel cointegration

JEL classification: C23, E41, E52

Non-technical summary

Generally speaking, money demand models represent a natural benchmark against which monetary developments can be assessed. Therefore, having a stable long-run money demand is very important, as the existence of a well-specified and stable relationship between money and prices can be perceived as a prerequisite for the use of monetary aggregates in the conduct of monetary policy. The stability of this relationship is usually assessed in a money demand framework, where money demand is linked to other macroeconomic variables, like income and interest rates.

In this study, a money demand analysis in the new Member States of the European Union (EU) is conducted using panel cointegration methods. Given the history of these countries which, during periods of high inflation, have been experiencing a partial replacement of domestic by foreign currencies, we also include in the money demand equation − in addition to standard macroeconomic variables such as money, income, prices and interest rates − the exchange rate variable.

The results from the empirical analysis show that a well-behaved long-run money demand relationship can be identified only if the exchange rate − as part of the opportunity cost − is included. In the long-run cointegrating vector, the income elasticity exceeds unity. Moreover, the exchange rates vis-à-vis the US dollar turn out to be significant (with a negative sign) and tends to be a more appropriate variable in the money demand than the exchange rates vis-à-vis the euro. The importance of the US dollar exchange rate is in line with previous findings in the literature focusing on individual new Member States. Moreover, it might be possibly due to the fact that the launch of the euro exchange rate in January 1999 seems to have affected only a few exchange rate regimes in the new Member States (although sometimes at a later stage), while before 1999 it was constituted by its legacy currencies.

The present analysis is of importance for the new EU Member States as they are expected to join in the future years the euro area, where money is deemed to be highly relevant − within the two-pillar monetary strategy of the European Central Bank (ECB) − in order to detect risks to price stability over the medium term.

1. Introduction

Money demand models represent a natural benchmark against which to assess monetary developments. As a matter of fact, they can provide a framework which helps to distinguish between those changes in money which are explained by developments in macroeconomic variables and those changes which are specific to the situation at hand. Therefore, having a stable long-run money demand is very important, as the existence of a well-specified and stable relationship between money and prices can be seen as prerequisite for the use of monetary aggregates in the conduct of monetary policy. The stability of this relationship is usually assessed in a money demand framework, where money demand is linked to other macroeconomic variables like income and interest rates.

The present analysis focuses on estimating a long-run money demand function for the ten new Member States − eight Central and Eastern European countries and two mediterranean countries − which, in May 2004, have entered the European Union (EU). In addition to the variables which are usually considered within money demand analysis (e.g. income, prices and a measure of the opportunity costs), in the period of transition foreign determinants can also play a crucial role in explaining money demand. In the specific case at hand, during periods of high inflation, the Central and Eastern European countries experienced a partial replacement of domestic by foreign currencies, either as a store of value or a medium of exchange. Therefore, the exchange rate is likely to be an important factor explaining money demand behaviour in these states. As the euro was not introduced before 1999, the euro and US dollar exchange rates are therefore considered alternatively in the analysis.

In order to estimate long-run money demand functions for the new EU Member States, cointegration techniques are employed (see, for example, Engle and Granger, 1987). As most countries are transition economies, they have to manage enormous structural changes. Hence, it is difficult to obtain data for a long sample period. The estimated parameters, which are based on a short period, are not very reliable. Evidently, estimates for long-run parameters require data for a long period. Alternatively, the sample can be extended, if the information of all countries is pooled. This is done by panel integration and cointegration techniques (see Banerjee, 1999). Specifically, the procedures of Pedroni (2000), Mark and Sul (2002) and Breitung (2002) are used to get efficient estimates of the cointegration parameters.

The results indicate that a well-behaved money demand function can be justified only if the exchange rate is allowed to enter the specification. In reduced systems containing money, income and interest rates, a long-run relationship cannot be detected at all. This principal finding is confirmed when the exchange rates vis-à-vis the euro are part of the variables set, possibly due to the late introduction of this currency. Only if the exchange rates vis-à-vis the US dollar are considered, cointegration can be found. Moreover, the income elasticity seems to be significantly larger than 1.

The present analysis is of importance for the new Member States of the European Union (EU). As a matter of fact, they have joined the EU as Member States with a derogation. This means that, while not yet adopting the euro, they will be committed to striving towards the eventual adoption of the euro after having at some point following accession, joined the exchange rate mechanism (i.e. ERM II). The adoption of the euro will occur upon fulfilment of the convergence criteria laid down in the Maastricht Treaty. These conditions include ceilings for inflation and long-term interest rates, budget deficits and government debt and exchange rate stability. After the introduction of the euro, the Governing Council of the European Central Bank (ECB) will also take over the responsibility of the monetary policy for these countries.

Given that these countries are expected to join in the future years the euro area, money demand analysis of the new EU Member States will soon become more relevant as money is deemed to be highly relevant − within the two-pillar monetary strategy of the ECB − in order to detect risks to price stability over the medium term.[2]

The rest of the paper is organised as follows. Section 2 gives the specification of the long-run money demand function. Section 3 illustrates the macroeconomic developments in these countries and describes the set of variables used in the analysis. The following two sections present the econometric methods and the corresponding results for the unit root testing and the cointegration analysis respectively. Finally, concluding remarks are presented in Section 6.

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[2] In 1998, the Governing Council of the ECB (1998) announced the main elements of its monetary policy strategy, which is based on a two-pillar framework. Within the first pillar, the monetary aggregate M3 was attributed a prominent role. On 8th May 2003 the Governing Council of the ECB reviewed and confirmed the two-pillar monetary policy strategy (ECB 2003), whereby one pillar is based on the economic analysis of price risks in the short term, while the other pillar includes the monetary analysis of risks to price stability in the medium term and long run, with the monetary aggregate M3 still having a prominent role.

2. Money demand of transition countries

In the literature there are only a few studies which analyse money demand functions in transition countries (see Buch, 2001). Earlier investigations cover only a short period of reform years (Dzwonik-Wrobel and Zieba, 1994, International Monetary Fund, 1998). Based on a correlation analysis, Antczak (2003) and Jarocinski (2003) have stressed the importance of money growth for stabilizing inflation rates. More recently, Buch (2001) has specified money demand functions for Hungary and Poland, which account for the transition situation of these countries. Her money demand function includes an income variable, domestic and foreign interest rates and changes of exchange rate expectations as well as inflations rates. Hence, this implies more than one variable measuring opportunity costs of money holding. The importance of exchange rates is also stressed by Orlowski (2004) for Hungary, Poland and the Czech Republic as well as by Komarék and Melecký (2001) for the Czech Republic.

The analyses of money demand functions for the euro area do not contain more than two opportunity cost variables (see, for example, Görgens et al., 2004, Bruggemann et al., 2003). Those studies suggest the following functional form for the money demand function:

$$(1) \qquad M / P = f(Y, oc)$$

where M represents a broad monetary aggregate, P is the consumer price index (which may be either the HICP for the euro area or, more generally, the CPI or the GDP deflator), Y is income proxied by the real GDP, and oc represents an opportunity cost indicator. According to textbook presentations, the income variable should have a positive effect on money holdings. Conversely, if the opportunity cost measures the earnings of alternative assets, its coefficient should be negative.[3] The interest rate variable includes via the Fisher effect the inflation rate of these countries (see Orlowski, 2004). At least for most industrial countries, Crowder (2003) finds evidence in favour of the Fisher effect using panel cointegration methods.

With the exception of Poland, all the other new EU Member States are "small" open economies. The foreign trade liberalisation during the transition process has, therefore, af-

[3] As will be explained later, due to the developments of the financial markets of the new EU member states, the opportunity costs are approximated by the short-term interest rate.

fected agents' behaviour with respect to their demand of foreign and domestic financial assets. Agents could switch more easily between foreign and domestic currencies. This may have affected money holdings in these economies. In order to account for this effect (which is usually denoted as "direct currency substitution" effect), the exchange rate (i.e. its rate of appreciation/depreciation) may be used as a proxy for the rate of return on foreign money.[4] In the literature on money demand, many studies (e.g. Buch, 2001 and Orlowski, 2004) include in the money demand function of some of the new EU Member States also the exchange rate against the euro. However, the overall effect of the exchange rate on money holdings is not entirely clear-cut. On the one hand, in a monetary model of the exchange rate, a depreciation of the domestic currency is likely to induce extra demand for domestic goods from abroad and the induced rise in domestic production implies higher domestic inflation rate and a need for more money in the economy as the amount of transactions increases (see, for example, Bilson, 1979 and Komárek and Melecký, 2001). Hence, being the exchange rate denoted as units of domestic currency per unit of the foreign currency, its coefficient should be positive. On the other hand, according to the currency substitution approach (see. e.g., Calvo and Rodriguez, 1997), a depreciation reduces the confidence in the domestic currency, thereby lowering money demand via a substitution effect with foreign money. Hence, its coefficient should be negative. This is also true if the exchange rate variable reflects the main source of returns in the foreign currency holdings. Selcuk (2003) presents evidence that some of the new EU Member States have a considerable proportion of foreign currency holdings.[5]

Moreover, devoting some attention to the analysis of the effect of the exchange rate on money demand is also important as these countries − in view of the fact that they are expected to join the euro area some time in the future − are likely to focus on minimising the volatility of the domestic currency value against the euro. As a matter of fact, some of the new EU Member States have already given the exchange rate policy a prominent role in implementing their monetary policy aims; therefore, its importance should be taken into account in the study (see Backé et al., 2004). For example, Estonia introduced a currency board to the euro in 1992. Malta followed a currency basket peg since 1971, where the

4 As an example, the expected rate of return non-foreign money can be represented by the expected depreciation of the domestic currency relative to the foreign currency.

5 In the present analysis we follow the direct currency substitution approach.

weights in the basket were trade-weighted, with the value of the euro being 70%. Hungary has a peg to the euro (for a more detailed description of the exchange rate strategies adopted by these countries, see Table 1). However, it is important to keep in mind that the euro was only introduced in January 1999 (and in circulation only in January 2002). Therefore, for many of the new EU Member States either the US dollar and/or the German mark (DEM) have been the most important currencies for the domestic market and the foreign trade (see, for instance, Komárek and Melecký, 2001 and Beguna, Skorohoda, Sloka and Tkačevs, 2002). For this reason, we also consider in our analysis the exchange rates of these countries vis-à-vis the US dollar.

-Table 1 about here-

3. Data description

The analysis is carried out using quarterly data for the following countries: Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithunia, Malta, Poland, Slovak Republic and Slovenia. The sample ranges over the period 1995 Q1-2004 Q2. Data include broad money, the consumer price index (CPI), the three-month money market interest rate, real GDP and nominal exchange rates (denoting the units of national currencies against the euro or the US dollar, respectively). It is worth noting that, in theory, a capital market or a long-term bond yield rate would be better proxies of the opportunity costs of holding broad money. However, these series are either not available or only start very late (around 2000) for most of the countries.[6] As a consequence, in our analysis the opportunity cost of holding money is proxied by the short-term interest rate. Money, prices, interest rates and exchange rates are generally taken from the International Financial Statistics of the IMF, the EBRD and the ECB. As an exception, Hungarian money has been obtained from the OECD Main Economic Indicators. Nominal money stocks are deflated by the CPIs. Real GDP series are from Eurostat. In case of missing values, national central bank information is used to generate these data points. All variables (apart from the interest rates) enter the analysis in their logs. Real GDP and real money are seasonally adjusted. The evolution of the individual time series is depicted in Figure 1.

[6] As an example, up to end-2004 in Estonia no harmonised and comparable long-term interest rate is available, while for the other countries comparable series are not available before 2002.

-Figure 1 about here-

From the charts it can be noticed that all countries experienced an increase in the real money stock over the period under consideration, with the rise being the most pronounced in Estonia and Slovenia. In these two countries, at the end of the sample the series exceed their initial values by a factor of 2.5 and 3.5, respectively. Real GDP has grown in all countries, and the strongest acceleration is observed in the Baltic states (Estonia, Latvia, Lithuania). Interest rates (as well as inflation rates) have declined in all economies, especially after 1999. However, the decrease was not steadily, as phases of rising interest rates are also apparent for some countries (Estonia, Czech Republic, Slovak Republic). Compared to the starting level, interest rates are lower at the end of the sample for all countries, with the strongest decline being experienced by Lithuania.

Finally, Hungary, Poland and Slovenia were characterised by a remarkable depreciation of their currencies relative to the euro and the US dollar. In contrast, Lithuania experienced a strong appreciation against these currencies. With respect to the exchange rate, it is worth noting that the new Member States have been characterised, in some cases, by different exchange rate regimes. For instance, exchange rate policy had a prominent role in achieving monetary goals in some Member States, e.g. especially in those countries which adopted currency boards (Estonia and Lithuania) and pegged exchange rates (Latvia and Malta). In other countries instead, the exchange rate regime (based on either pegged or floating exchange rate) was combined (or subordinated to) with an inflation targeting policy (e.g. Hungary, Slovak Republic, Czech Republic and Poland, see Table 1). These differences may have also affected monetary policy and money demand functions.[7] However, notwithstanding these differences in the exchange rate regimes, we deemed it useful to base our analysis on all countries developments, as all these countries are expected to join the euro area at some point in the future and also as a larger cross-section sample help to overcome the shortness of the sample period.[8]

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[7] With regard to stability, previous studies do not seem to find evidence of structural breaks (see, e.g., Buch, 2001).

[8] For a robustness check, we have also run the estimations on a sub-set of countries which excludes the three Baltic States as well as Malta, e.g. those countries that were characterised by a currency board/fixed exchange regime. The results are not affected, as most of the tests still show cointegration when the US dollar (instead of the euro) exchange rate is used (the results are available from the authors upon request).

-Table 2 about here-

4. Panel unit root tests

The integration and cointegration properties of the variables involved in the analysis determine the specification of the money demand. If the series are cointegrated, equation (1) should be viewed as a long-run relationship. However, it has been widely acknowledged that standard unit root and cointegration tests can have low power against stationary alternatives for the important cases, see for example Campbell and Perron (1991). As an alternative, recently developed panel unit root and cointegration tests are applied. Since the time series dimension is enhanced by the cross section, the results rely on a broader information set. Therefore, gains in power are expected, and more reliable evidence can be obtained.

In the paper, the LLC (Levin, Lin and Chu, 2002), the IPS (Im, Pesaran and Shin, 2003) and the HD (Hadri, 2000) tests are applied. These procedures allow for deterministic and dynamic effects differing across the panel members. The first two tests are generalizations of the ADF principle. The null of a unit root is investigated against the alternative of a stationary process for all (LLC) or at least for one (IPS) cross section. The hypotheses are interchanged by the HD procedure, which adapts the KPSS test to panels. For the LLC and IPS tests, the optimal lag length is selected using the general-to-simple procedure proposed by Campbell and Perron (1991). The consistent estimator of the long-run residual variance relevant for the LLC and HD statistics is obtained using the Bartlett kernel and the automatic bandwidth parameter suggested by Newey and West (1994).

The stationarity hypothesis of the variables considered in the analysis is, therefore, checked via the IPS test, the LLC test, Breitung test and the HD test. Table 2 includes the results for the levels and for the first differences of the variables. Only the LLC test indicates stationarity for the exchange rate levels against the US dollar. The nonstationarity of the first differences is always rejected at the five percent level for the LLC, IPS and Breitung test. The HD test rejects the stationarity hypothesis for broad money and the exchange rate. In sum, it seems sensible to conclude that all variables are stationary in first differences. These results allow to test for cointegration among the variables and to estimate money demand functions.

5. Cointegration tests

In the light of the evidence from the panel unit root tests, we proceed with our panel cointegration analysis, for which the tests suggested by Pedroni (1999) are employed. They extend the Engle and Granger (1987) two-step procedure to panels and rely on ADF and PP principles. First, the cointegration equation is estimated separately for each panel member. Second, the residuals are examined with respect to the unit root feature. If the null hypothesis is rejected, then a long-run equilibrium exists, although the cointegration vector may be different for each cross section.

In addition, the Kao and McCoskey (1998) LM test for the null of cointegration is applied. The long-run relationship is estimated by efficient methods carried out separately for the panel members. Then, the cointegration residuals are pooled, and the test statistic is asymptotically Gaussian with a right-hand side rejection area.

To obtain efficient estimates of the long-run relationship, the fully modified (FM) (Phillips, 1995, Pedroni, 2001) and dynamic OLS (DOLS) methods (Saikkonen, 1991) are used.

In the DOLS framework, the long-run regression is augmented by lead and lagged differences of the explanatory variables to control for endogeneous feedback (Saikkonen, 1991). Lead and lagged differences of the dependent variable can be included to account for serial correlation (see Stock and Watson, 1993). In particular, the equation:

$$(2) \qquad y_{it} = \alpha_i + \beta_i x_{it} + \sum_{j=-p_1}^{p_2} \delta_j \Delta y_{it-j} + \sum_{j=-q_1}^{q_2} \lambda_j \Delta x_{it-j} + u_{it}$$

is run for the *i*-th panel member, where the appropriate choice of leads and lags is based on data-dependent criteria (Westerlund, 2003). Standard errors are computed using the long-run variance of the cointegration residuals.

In a panel setting, the cointegration relationship is homogeneous. Heterogeneity is limited to fixed effects, time trends and short-run dynamics. The panel FM estimator is the average of the individual parameters (see Pedroni, 2001). According to Mark and Sul (2002), a panel DOLS estimator is obtained using a two-step procedure. First, individual dynamic and deterministic components are regressed out separately for the panel members. Then, the residuals are stacked and a pooled regression is run. As an alternative to these methods, Breitung (2002) has suggested a two-step procedure based on a cointegrated VAR model.

According to simulation evidence provided by Breitung (2002), his estimator is preferable to FMOLS and DOLS alternatives, as it is characterised by a smaller finite sample bias.

As a major shortcoming, the panel tests for integration and cointegration presume that the cross sections are independent. However, this requirement is not met in the analysis presented here. For example, the economic development in new EU Member States may be subject to common shocks. In particular, the presence of cross section cointegration can distort the panel results, see Banerjee, Marcellino and Osbat (2001) and Urbain (2004). In these cases, either the endogeneous variable or specific regressors cointegrate across the panel members. To control for this problem, cointegration tests based on nonstationary common factors are proposed (see Bai, 2004), where factors are obtained as principal components. Compared to the individual country analysis, the procedure is likely to be more robust, because idiosyncratic (country-specific) parts cancel out.

Table 3 presents the panel cointegration tests. The first system includes real money, real GDP and the interest rate. The second system additionally contains the exchange rate against the US dollar.

The upper part of Table 3 shows that the tests indicate that no cointegration exists among real broad money, real GDP and the interest rate for the period under consideration. All tests do not reject the null hypothesis of no cointegration in this panel. For the system including the euro-exchange rates only one test rejects the null of no cointegration. The results are instead more favourable if the system contains the US dollar exchange rate. Six out of seven Pedroni tests reject the null hypothesis of no cointegration. This is a strong evidence for the existence of a cointegrating relationship among the variables.[9]

-Table 3 about here-

Table 4 shows the results of the FM, DOLS and the two-step approach. The values of the DOLS method are determined under the assumption of one lead and two lags of the changes in the regressors. The income elasticity of the money demand function is signifi-

[9] Vice versa, we have additionally tested whether some of the variables introduced in the long-run cointegrating vector are redundant. The results based on the Pedroni tests (available from the authors upon request) indicate that the exchange rate variable and real broad money are not cointegrated and that, in addition, the statistics are even wrong-signed.

cantly above unity in all cases (in the literature, an elasticity exceeding one implies a declining trend in velocity and is usually interpreted as suggesting the relevance of wealth effects in the demand for money).[10] The panel income coefficient is generally higher than the corresponding value for the euro area money demand function (see Bruggemann et al. 2003, Görgens et al. 2004, p. 179). It is worth noting that all methods lead to a higher income elasticity if the system includes the exchange rates vis-à-vis the US dollar rather than vis-à-vis the euro. The interest rate elasticity is significantly negative and relatively small, which may reflect the fact that it is difficult to control money holdings. The exchange rate elasticity is also negative as expected, but is not significantly different from zero, if the exchange rates vis-à-vis the euro area considered. All methods find a significant impact of exchange rates vis-à-vis the US dollar. These results confirm to some extent the results of Buch (2001), Komarék and Melecký (2001) and Orlowski (2004) in the sense that the US dollar exchange rate is an important variable to be considered in money demand analysis for these countries. This is in line with the fact that euro coins and notes have only entered into circulation in January 2002. The period of less than four years seems to be too short to recover a significant currency substitution effect in favour of the euro. Moreover, while the launch of the euro exchange rate in January 1999 seems to have affected only few exchange rate regimes in the new Member States, although in some cases at a later stage (e.g. Estonia, Lithuania and Cyprus which moved to a peg to the euro before joining ERM II), before 1999 it was constituted by its legacy currencies. In contrast to Orlowski (2004), the exchange rates vis-à-vis the US dollar is necessary to obtain a cointegration relationship. Hence, the specification of money demand function for the new EU Member States differs from the specification for the euro area.

-Table 4 about here-

Finally, a cointegration analysis is performed using common factors (see Table 5). Principal components are estimated separately for real money, income, interest and exchange rates. For each variable, the first principal component is considered. Then, the cointegration test is performed using standard methods. In carrying out this exercise, the ADF type cointegra-

[10] On this, see also Calza, Gerdesmeier and Levy (2001). An income elasticity higher than one is a quite well-established result for money demand functions estimated for the euro area.

tion test (MacKinnon, 1991) is considered. The cointegrating regression is estimated by the DOLS, and the residuals are checked for stationarity.

-Table 5 about here-

The cointegration result can be confirmed at the 5 percent significance level. In addition, the variables enter the long-run money demand relation with the correct sign. However, the elasticities seem to be different from the panel evidence. Most strikingly, the income elasticity is not significantly larger than 1.

6. Conclusions

In this paper the long-run coefficients of a money demand function for the new Member States of the European Union are estimated. The estimation is conducted with means of panel cointegration methods for the period from 1995 Q1 to 2004 Q2 for the 10 European countries under consideration. The panel income elasticity is around 1.70 while the interest rate elasticity is negative. Moreover, in order to obtain a long-run money demand function, the variable of the exchange rate of each country vis-à-vis the US dollar has to be taken into account.

In terms of future developments, a sudden introduction of the euro in all new EU Member States may introduce problems for the stability of the euro area money demand function. However, in this respect, it should be taken into account that the introduction of the euro requires that the Maastricht convergence criteria are fulfilled and the probability that all countries would achieve the criteria at the same time is small. Moreover, the number of inhabitants in these countries is small and their GDP is markedly less than the average of actual EU. Hence, their weights inside the euro area are relatively small. Nevertheless, as future research it might be useful to analyse the stability of the euro area money demand function when accounting for new EU Members States.

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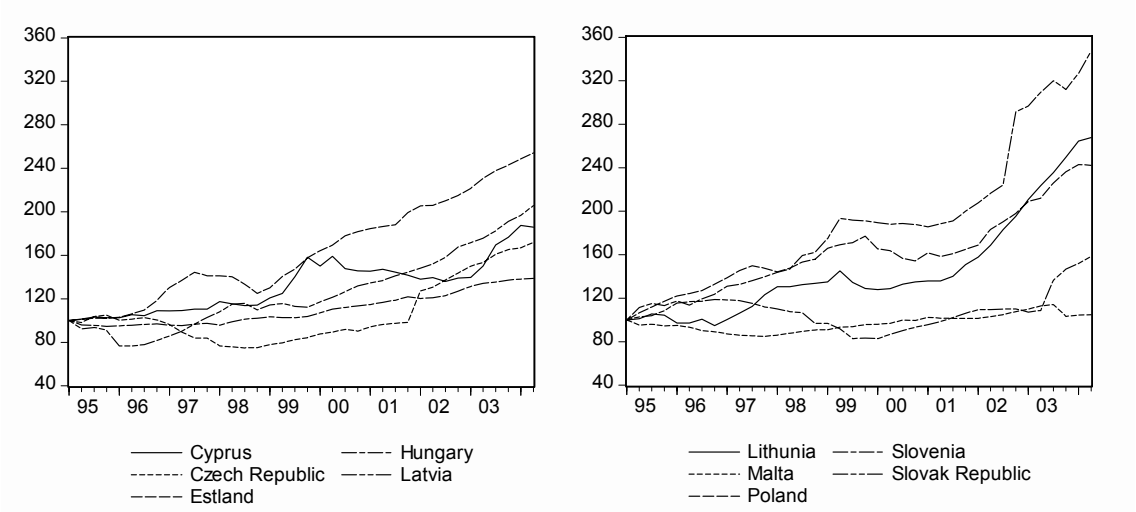
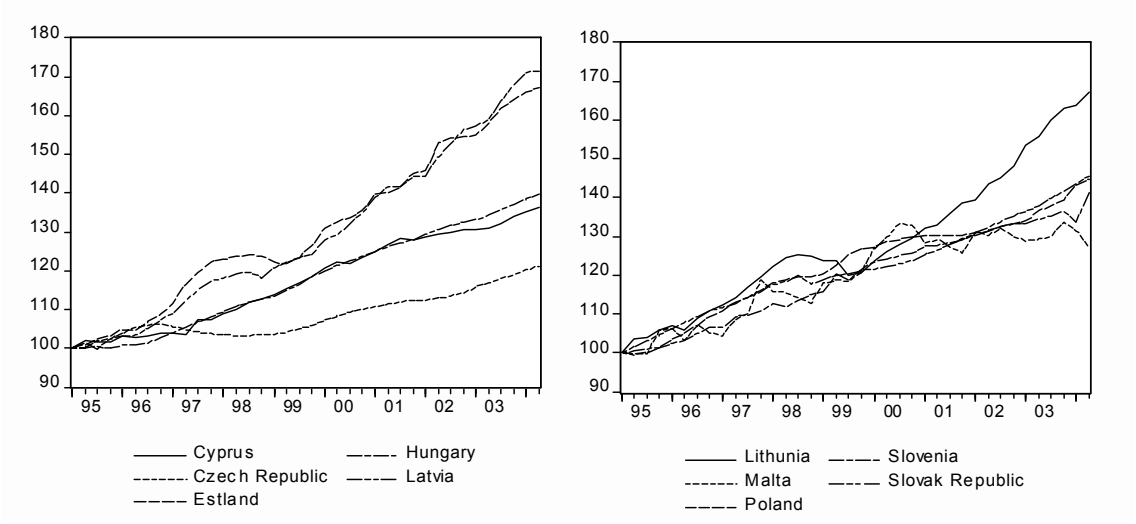
8. Appendix: figures and tables

Figure 1: Broad money, GDP, interest rates and exchange rates in the new EU Member States (1995 Q1)

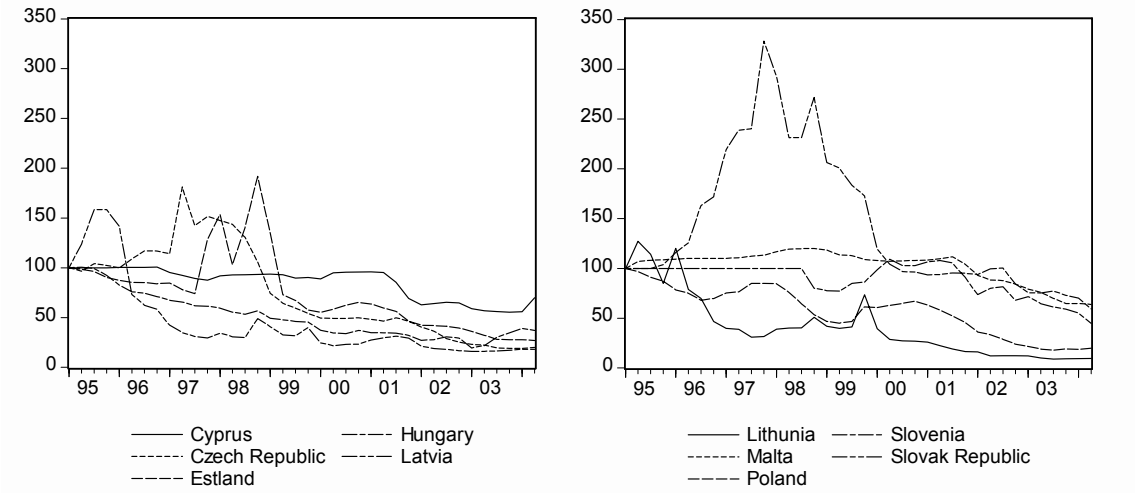
A Real broad money (deflated by CPI)



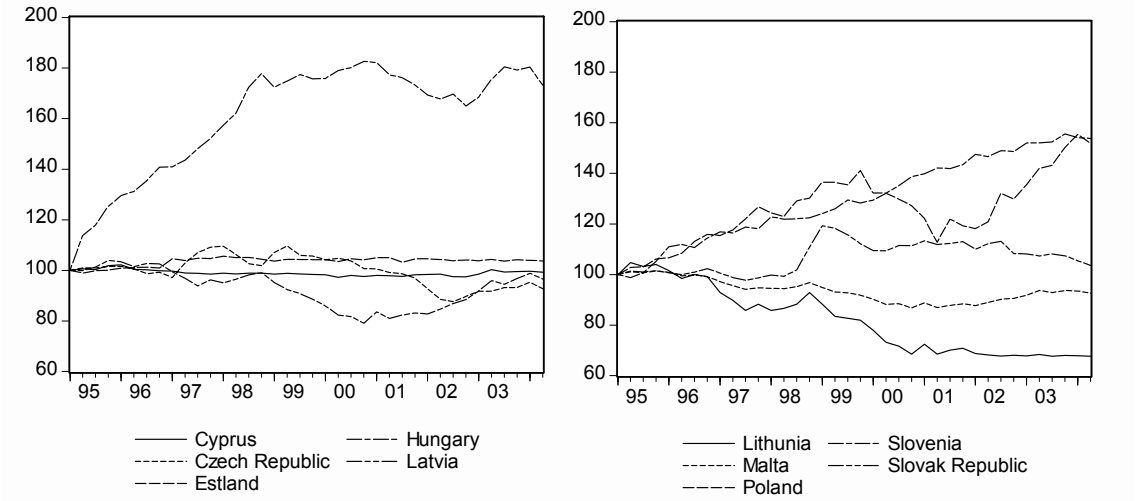
B Real GDP



C Nominal interest rates



D Exchange rate: domestic currency units per euro



E Exchange rate: domestic currency units per US- dollar

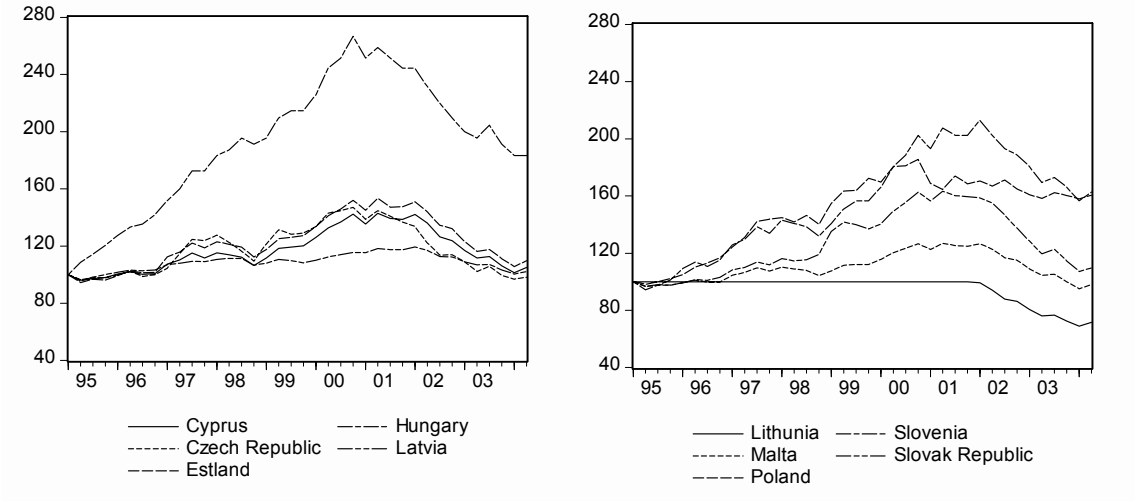


Table 1: Monetary and exchange rate strategies in new EU Member States

(as of October 2004, with indications of the entry to ERM II)

	Exchange rate Strategy	Currency	Additional features
Currency board			
Estonia	Currency board to the euro	Estonian kroon	Introduced in 1992, with the exhcnage rate fixed vis-à-vis the DEM; joined ERM II with effect from 28 June 2004
Lithuania	Currency board to the euro	Lithuanian litas	Introduced in 1994; re-pegged from the US dollar to the euro on 2 February 2002; joined ERM II with effect from 28 June 2004
Conventional fixed peg			
Latvia	Peg to the Special Drawing Right (SDR). From 1 January 2005 pegged to the euro	Latvian lat	Exchange rate fluctuation band ± 1%; joined ERM II with effect from 2 May 2005
Malta	Peg to a basket (70% for the euro, 10% for the US dollar, 20% for the pound sterling)	Maltese lira	Maintaining price stability is achieved through a fixed exchange rate regime. Exchange rate RM II (+/- 15% fluctuation bands); joined ERM II with effect from 2 May 2005
Unilateral peg to the euro with ± 15% fluctuation band			
Cyprus	Peg to the euro	Cyprus pound	Exchange rate fluctuation band ± 15%; joined ERM II with effect from 2 May 2005
Hungary	Peg to the euro	Hungarian forint	Exchange rate fluctuation band ± 15%. Exchange rate regime combined with inflation targeting: 3.5% ± 1% for 2004, 4% ± 1% for 2005, 3.5% ± 1% for 2006, and 3% ± 1% afterwards.

Managed float			
Slovak Republic	Managed float	Slovakian koruna	Inflation targeting: 3.5% ± 0.5% for 2005, <2.5% for 2006, <2% for December 2007 and 2008
Slovenia	Managed float	Slovenian tolar	Prominent role for monetary aggregates (two-pillar monetary policy framework); the euro was used informally as reference currency, exchange rate policy guided by the uncovered interest parity; joined ERM II with effect from 28 June 2004
Independent float			
Czech Republic	Free float	Czech koruna	Inflation targeting: 2%-4% by end-2005, 3.5% ± 1% from January 2006
Poland	Free float	Polish zloty	Inflation targeting: medium-term CPI inflation target of below 4% by end-2003, from 2004 of 2.5% ± 1%

Sources: ECB Annual report 2002 and ECB Convergence Report 2004.

Note: Cut-off date October 2004. As of 2 May 2005 the following countries had joined the ERM II: Estonia, Lithuania and Slovenia on 28 June 2004, and Cyprus, Latvia and Malta on 2 May 2005.

Table 2: Panel unit root test of the variables in the money demand function

A: Levels				
	LLC	Breitung	IPS	HD
Broad Money	-0.931	0.322	-1.491	6.769*
Income	0.591	0.739	1.026	5.834*
Interest rate	1.508	2.248	3.269	9.748*
Exchange rate against euro	-5.088*	2.064	-1.998	9.431*
Exchange rate against US dollar	-2.767*	6.763	-0.149	7.151*
B: First differences				
Broad Money	-9.980*	-5.096*	-11.021*	2.026*
Income	-9.863*	-5.856*	-13.664*	-0.141
Interest rate	-8.894*	-5.070*	-9.273*	0.207
Exchange rate against euro	-15.901*	-6.336*	-15.578*	2.622*
Exchange rate against US dollar	-10.693*	-5.530*	-9.588*	6.632*

LLC=Levin, Lin, Chu (2002), IPS=Im, Pesaran, Shin (2003). The other statistics are described in detail in Breitung (2000) and Hadri (2000). The statistics are asymptotically distributed as standard normal with a left hand side rejection area, except of the Hadri test, which is right sided. A * indicates the rejection of the null hypothesis of nonstationarity (LLC, Breitung, IPS) or stationarity (HD) at least on the 0.05 level of significance.

Table 3: Panel cointegration tests

Model without exchange rate		
	Pedroni (1999)	
Method:	Panel Statistics	Group Statistics
Variance ratio	0.881	
Rho statistic	0.078	0.327
PP statistic	-0.725	-1.005
ADF statistic	0.247	-0.315
	Kao and McCoskey (1998)	
LM statistic	FM: 0.202	DOLS: 1.548

Models including the exchange rate				
	Pedroni (1999)			
	US- dollar exchange rate		Euro exchange rate	
	Panel Statistics	Group Statistics	Panel Statistics	Group Statistics
Variance ratio	2.542*		1.402	
Rho statistic	-0.790	0.117	-0.153	0.402
PP statistic	-1.831*	-1.666*	-1.129	-1.460
ADF statistic	-2.246*	-2.400*	-1.483	-2.802*
	Kao and McCoskey (1998)			
LM statistic	FM: -1.966*	DOLS: -0.695	FM: -1.638	DOLS: -0.471

Statistics are asymptotically distributed as normal. The Pedroni statistics are described in detail in Pedroni (1999). The variance ratio test is right-sided, while the other Pedroni tests are left-sided. The LM test from Kao and McCoskey (1998) is right-sided and carried out using either FM or DOLS residuals. A * indicates the rejection of the null hypothesis of no cointegration (Pedroni) or cointegration (Kao and McCoskey) at least on the 0.05 level of significance.

Table 4: Panel cointegrating parameter estimates

Test result: No cointegration vector

Model including *m-p, y, R*		
	Income	Interest rate
FM (Pedroni, 1999)	1.67 (0.08)	-0.09 (0.02)
DOLS (Mark and Sul, 2002)	1.46 (0.13)	-0.12 (0.03)
2-Step (Breitung, 2002)	1.46 (0.14)	-0.17 (0.04)

Test result: No cointegration vector

Model including *m-p, y, R, euro*			
	Income	Interest rate	Euro
FM (Pedroni, 1999)	1.54 (0.08)	-0.10 (0.02)	0.13 (0.16)
DOLS (Mark and Sul, 2002)	1.38 (0.12)	-0.14 (0.03)	0.01 (0.09)
2-Step (Breitung, 2002)	1.48 (0.10)	-0.12 (0.03)	0.11 (0.08)

Test result: One cointegration vector

Model including *m-p, y, R, US Dollar*			
	Income	Interest rate	US dollar
FM (Pedroni, 1999)	1.73 (0.08)	-0.09 (0.02)	-0.28 (0.04)
DOLS (Mark and Sul, 2002)	1.94 (0.13)	-0.07 (0.03)	-0.22 (0.06)
2-Step (Breitung, 2002)	1.78 (0.10)	-0.06 (0.02)	-0.16 (0.04)

Elasticities of real money demand with respect to real income, interest and exchange rates are reported. Standard errors in parentheses.

Table 5: Cointegration analysis of common factors

	Euro	US Dollar
Income	0.959 (0.106)	1.047 (0.051)
Interest rate	-0.279 (0.070)	-0.160 (0.036)
Exchange rate	-0.355 (0.061)	-0.278 (0.023)
ADF	-2.427	-4.797*

ADF-test for stationarity of residuals obtained by DOLS methods. Elasticities of money demand with respect to real GDP, interest and exchange rates. Standard errors in parentheses.

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