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Dimitrios Sideris

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BANK OF GREECE
Economic Research Department – Special Studies Division
21, E. Venizelos Avenue
GR-102 50 Athens
Tel: +30210-320 3610
Fax: +30210-320 2432

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OPTIMUM CURRENCY AREAS, STRUCTURAL CHANGES AND THE ENDOGENEITY OF THE OCA CRITERIA: EVIDENCE FROM SIX NEW EU MEMBER STATES

Dimitrios Sideris
Bank of Greece and Panteion University

ABSTRACT

The present paper has two aims. The first aim is to test whether six new member states of the European Union (the six Central and Eastern European Countries) form an optimum currency area (OCA) with the eurozone, in an attempt to assess their readiness for euro adoption. The second aim is to examine whether the introduction of the euro in 1999 and the decision of the countries to seek to join the euro area created any forces fostering their convergence, evidence which would be in line with the theory on the endogeneity of the OCA criteria. Our findings indicate that the introduction of the euro did promote integration of the six new member states and that, at present, they are quite well aligned with the eurozone.

Keywords: EU enlargement; OCA; real exchange rates; cointegration; GPPP.
JEL classification: C32; F33; F36; F42.

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Correspondence:
Dimitrios Sideris
Economic Research Department
Bank of Greece, 21, El. Venizelou Ave.,
10250 Athens, Greece,
Tel. +30210-3203607,
Fax +30210-3233302
e-mail: dsideris@bankofgreece.gr

1. Introduction

Since May 2004, twelve new countries have joined the European Union (EU). Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, the Slovak Republic and Slovenia joined the EU in May 2004; Bulgaria and Romania in January 2007. The twelve new member states (NMS) are now participating in the single European market with free exchange of goods and services and free movement of capital. At present, eight of the NMS have a currency other than the euro – the three Baltic countries and five Central and Eastern European Countries (CEEC). However, all of these countries are required by their Accession Treaties to join the eurozone and thus they have turned their attention to the next step in their integration with Europe: replacing their national currencies with the euro. Thus, at some future date the eight countries will share a common currency and monetary policy with that of the euro area, which can be considered as the only real world approximation of an optimal currency area (OCA) in the sense defined by Mundell (1961). The question that naturally arises is: to which extent are the NMS aligned with the eurozone, or, in other words, do they constitute an OCA with the rest of the eurozone members?

The main objective of the present study is to investigate this issue, thus contributing to the existing empirical literature on the assessment of the alignment of the NMS with the eurozone. The study focuses on the countries: Bulgaria, the Czech Republic, Hungary, Poland and Romania, which now operate independent monetary policies and have some way before they achieve policy convergence with the euro area (see, *inter alia,* Schadler *et al.*, 2005). The Slovak Republic is also included in the group of countries under examination, given that it adopted the euro very recently- in January 2009. The theoretical literature on OCA does not provide any formal criterion to evaluate whether timing of implementation of a currency can be considered optimal (Eichengreen, 1990). However, in the relevant empirical literature, two main approaches have been used to evaluate whether or not a group of countries constitute an OCA. The first approach is based on the theory of the Generalized Purchasing Power Parity (GPPP) and was introduced by Enders and Hurn (1994). This approach analyses the behavior of the real exchange rates of the economies with respect to a base currency. The second approach is introduced by Bayoumi and Eichengreen (1998). It advocates the construction of an index

which is based on the forecasted values of exchange rate variability, assuming that the exchange rate is determined by economic fundamental variables.

To date, there is one paper by Horvath (2007) which has examined if the six CEECs form an OCA, using the Bayoumi and Eichengreen index for the period following the introduction of the euro in 1999. It indicates that the six economies are relatively well aligned with the euro area for the years 1999-2004. In the present paper we extend this literature by applying the first approach, the theory of GPPP, to assess the potential for an OCA of the six countries with the eurozone. The GPPP theory proposes testing whether the real exchange rates of a group of economies with respect to a base currency form a cointegrating vector or not. The theory is based on the following idea: it could be that the real exchange rates of a number of economies are not themselves stationary, as a result of the non stationarity of the fundamental economic variables; nevertheless, if the fundamentals are sufficiently integrated as in a currency area, the real exchange rates will share common trends and therefore, will form a cointegrating relationship.

In the study, we use data since the start of the transition phase of the six economies at the beginning of the 1990s. In order to make use of all available observations, we approximate the eurozone by Germany given that Germany has been the reference country for all European countries during the pre-euro years of the European Monetary System and its central bank pursued an anti-inflationary monetary policy similar to that pursued by the European Central Bank. Besides, Germany still weights for roughly one-third of the euro area GDP.[1]

Even though the main task of the paper is to test for GPPP with the eurozone, analysis of the joint behavior of the real exchange rates of the six CEECs vis-à-vis the US dollar is also performed. This is done based on the argument that internal foreign exchange markets were mostly dollar denominated during the initial period of the transitional phase of the economies under consideration. In addition, funds for economic reconstruction were being provided by US sponsored institutions.

An additional issue of interest is whether the introduction of the euro and the decision of the six NMS to join the euro area have facilitated their route towards the

[1] A number of empirical studies use Germany as the base country of the European Union; see *inter alia* Antonucci and Girardi, 2006.

formation of an OCA with the euro area members. Evidence in favor of this hypothesis would be in line with the endogenous OCA theory. The endogenous OCA theory was first introduced by Frankel and Rose, (1998) and supports that countries joining a currency union may satisfy the criteria of an OCA *ex post*, even if they do not *ex ante*.[2] The Frankel and Rose argument was based on the experience of the first wave of euro area participants which has shown that some of the criteria for a successful currency area, such as trade openness and the correlation of business cycles, are endogenous. The idea underlying the endogenous OCA theory is that the introduction of a single currency eliminates exchange rate risk and raises price transparency, facilitates foreign direct investment, and the building of long-term relationships and thus promotes trade, growth and economic and financial integration (see, *inter alia*, Mongelli, 2002; Dellas and Tavlas, 2008).

In the present study we extend this idea and claim that the decision to seek to participate in a currency area and the policy measures that follow such a decision may enhance the economic integration of the participants. The introduction of the single currency in non-physical form in January 1999 can be considered as a significant structural change that affected trade of the six CEECs with their main trading partners, the euro area members.

The decision of the countries to seek to join the eurozone also resulted in a number of structural and institutional changes in the economies. More importantly, in the years 1997-2007 the monetary authorities of the six economies changed their exchange rate policies, with most of the economies moving from a peg which had the US$ in it to one more concentrated on the DM/euro.[3]

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[2] On the other hand, an opposite view states that economic integration creates incentives to exploit economies of scale, resulting in greater exposure to asymmetric shocks (Krugman and Venables, 1996).

[3] In detail: Bulgaria had a flexible exchange rate regime until 1997, when it moved to a hard peg against the DM/euro. The Czech Republic had a fixed exchange rate to a DM-US$ basket (65%-35%) until 1997 when it moved to a managed floating regime, with a view to smooth volatility with the DM/euro. Hungary chose a crawling peg to a 50%-50% DM-US$ currency basket until March 1995, then to a DM- US$ currency basket with weights 70%-30%. It was pegged to the euro for most of 2001 and is in a euro target zone since October 2001. Poland introduced a crawling peg in 1991, anchoring its currency to a basket of five currencies –US$, DM, GBP, FRF and CHF- until the end of 1998. It then moved to a crawling band against a DM-US$ basket (55%-45%). It pursues a free float since April 2000. Romania had a flexible exchange rate regime with the US$ as a reference currency until 2001 when it moved to a crawling peg. The Slovak Republic had a fixed exchange rate to a DM-US$ basket with weights 60%-40% until 1998, when it moved to a managed floating with no preannounced path. It entered ERM2 in 2005.

To analyze the effects of the introduction of the single currency and investigate whether there has been any endogeneity effect following the European integration we test for GPPP for both periods before and after January 1999. In other words, we test whether the introduction of the euro and the decision of the CEEC6 to join the European Monetary Union had any impact on the behavior of the real exchange rates and the fundamentals of the economies, as is suggested by the endogenous OCA theory.

The empirical work entails univariate stationarity analysis of the individual real exchange rate series and then testing for cointegration in a multivariate setting. The model specification used for cointegration allows for different long-run relations and short-run dynamics. As evidenced in the relevant literature, if the short-run dynamics are different from the long-run relations, the specification of the short-run dynamics turns out to be crucial for the estimation of the equilibrium relationships.

The rest of the paper is organized as follows. Section II presents briefly a review of the GPPP theory and its relevance to the OCA theory. Section III presents the empirical results. The final section summarizes and concludes.

2. The economic background

The GPPP theory is based on the following idea: It could be that the fundamental economic variables determining real exchange rates of a group of economies are non-stationary, and consequently the real exchange rates of the economies are non-stationary. However, the fundamental variables can still be sufficiently integrated; in such an event, the real rates will share common trends and form a cointegrating relationship (Enders and Hurn, 1994). If this holds true, the economies constitute an optimal currency area in the sense of Mundell (1961) who argues that two economies constitute a currency area if they present similar real disturbances. Following this rationale, the existence of an equilibrium path for a linear combination of real exchange rates rules out the presence of real asymmetries and implies long-run sustainability of a monetary area.

The theory also suggests that, when economic interdependence in a group of economies is high, an economy's bilateral real exchange rate is influenced by the exchange rates of the other economies in the group and the fundamentals of the other economies. The theory thus questions the validity of the standard bilateral tests for the

validity of the Purchasing Power Parity (PPP) hypothesis as they ignore the influence that outside countries may have on bilateral exchange rates.[4]

Following the notation of Enders and Hurn (1994), GPPP can be described as follows: given an *n*-country world, an *m*-country ($m \leq n$) currency area exists such that a long-run equilibrium relationship exists between the m - 1 bilateral exchange rates, of the form:

$$r_{21t} = a + b_{31t}\, r_{31t} + b_{41t}\, r_{41t} + b_{51t}\, r_{51t} + \ldots.. + b_{m1t}\, r_{m1t} + e_t \qquad (1)$$

where r_{i1t} is the log of the bilateral real exchange rate in period t between country 1 and country i; a is the intercept term; b_{i1}s are the parameters of the cointegrating vector, which represent the degree of comovement of the real exchange rates; and e_t is a stationary stochastic disturbance term.

It is clear that if all b_{i1}s are equal to zero, then the traditional PPP -between countries 1 and 2- is valid. GPPP holds when the combination of the non-stationary bilateral real exchange rates is shown to be itself stationary. The b_{i1} parameters reflect the economic interdependencies within the group of economies. Enders and Hurn (1994) show that the estimated b_{i1}s are closely linked to the aggregate demand functions of a goods market-clearing relationship. They also indicate that the more similar the aggregate demand functions in each country of the group, the lower the b_{i1}s in magnitude.

The GPPP method has been used in a large number of papers, in order to test whether a group of countries form an OCA or not and, consequently, whether a group of economies, considered as a whole, is suitable for monetary integration.[5]

[4] The idea that third country effects should be taken into account when testing for bilateral PPP is further developed in Sideris (2006a).

[5] In particular: Enders and Hurn (1994) test for GPPP using the exchange rates of a group which includes industrialized countries and countries of the Pacific Rim. Sarno (1997) tests for cointegration of the real exchange rates of a number of EMS countries for the period before the introduction of the euro. Bernstein (2000) assesses cointegration of the real exchange rates of a group of European countries. Antonucci and Girardi (2006) use the real exchange rates of eleven EMU countries and examine the effects of structural changes on the behavior of the real exchange rates. Ahn et al. (2006), Aggarwal and Mougoue (1993), Choudry (2005), Kawasaki and Ogawa (2006), Ogawa and Kawasaki (2003) and Wilson and Choy (2007) use the concept of GPPP in order to provide insights on whether East Asian countries should proceed to a monetary union. Neves et al. (2007) examine whether the Mercosur economies form an OCA.

3. The empirical evidence

3.1 The data set

The econometric work entails initially univariate analysis of each real exchange rate series.[6] In other words, we first test for stationarity of the series, applying a number of unit root tests. Then, and in the event that the real exchange rates turn out to be non stationary, we test whether there holds a GPPP relationship among them, using a cointegration technique.

In the study we use monthly observations for the domestic currencies of the six countries against the German mark and the US dollar. The price variables are measured by the consumer price index (CPI), given that CPIs are the indices published for all involved countries and are broadly similar as far as coverage is concerned. The sample period varies in the different economies, depending on the period when the reforms started and the availability of the data. Reforms started in 1990 in all six countries but data observations are available for the period after 1993 for the Czech and Slovak Republics. All data are taken from the International Financial Statistics electronic database. To investigate any possible effects coming from the introduction of the euro, analysis is performed: (i) for the whole period 1993.1-2007.12, (ii) for the pre-euro period 1993.1-1998.12 and (iii) for the post-euro period 1999.1-2007.12.

3.2 Univariate analysis- Unit root tests

Time series plots of the six real exchange rate series vis-à-vis the German mark and the US dollar are given in Graphs 1 and 2, respectively. Real exchange rate series against the mark and the dollar are denoted as r_{ig} and r_{ius}, respectively. The subscript i takes the values *b, cz, h, p, r* and *slk,* which stand for Bulgaria, the Czech Republic, Hungary, Poland, Romania and the Slovak Republic, respectively. The series exhibit trending behaviour and provide evidence against stationarity. The time plots also indicate that time changes may exist in the drift of the corresponding series. As indicated in the

[6] Analysis of the behavior of the real exchange rates is essential in the international economics literature. Stationarity of a bilateral real exchange rate implies that PPP holds between the two economies, evidence which, in turn, indicates that the two economies are well integrated. The real exchange rate offers also a measure of competitiveness between the two countries and can provide an equilibrium value for the nominal exchange rate.

plots, the volatility of the rates is quite high for most of the currencies –mainly the currencies of Bulgaria, the Czech Republic and Romania- in the period until 1999 and declines after 2000, possibly as a result of pegs.

We apply two different sets of unit root tests. The first set entails standard ADF tests, whereas the second set entails the Lanne *et al.* (2001, 2002) tests which analyse the unit root properties of the series after taking into account the effect of possible structural shifts. The detailed results of the unit root tests are presented in the Appendix. Overall, the ADF and the Lanne *et al.* tests provide evidence for a unit root in all real exchange rate series. The results thus imply that there is no evidence for PPP linking any of the economies under consideration with Germany and/or the US. [7]

The Lanne *et al.* tests also provide evidence of possible structural breaks in the series. The tests indicate a regime change somewhere at the end of 1998 for the case of three out of the six economies- the Czech Republic, Poland and the Slovak Republic. The change is possibly related to the Russian crisis occurring in August 1998.

3.3 Testing for GPPP using cointegration analysis

The cointegration rank

Based on the results of the unit root tests, we then investigate whether the six real exchange rates with respect to the mark cointegrate in a GPPP relationship. We test for cointegration using the Johansen methodology on Vector Auto-Rregressive (VAR) models (Johansen, 1995). Within this framework, and given that the unit root tests provide some evidence for structural breaks in the series, we also perform the Saikkonen and Lütkepohl (S&L) tests (2000a; 2000b), which test for the cointegration rank allowing for structural shifts in the VAR systems. The analysis is performed for the three different periods. To this end, we estimate three unrestricted VARs for the vector $x_t' = (r_{bg}, r_{czg}, r_{hg}, r_{pg}, r_{rg}, r_{slkg})$ using multivariate least squares. The VAR systems are estimated assuming a constant in the deterministic variable set. The number of included lags in the VARs is

[7] These results are in line with the findings on studies examining the behavior of real exchange rates and the validity of PPP in Central and Eastern European economies for the recent period (see, *inter alia*, Christev and Norbakhsh, 2000; Dibooglu and Kutan, 2001; Hsing, 2008; Sideris, 2006b, 2008).

determined on the basis of the Akaike information criterion and is set equal to two. The diagnostic statistics are satisfactory for all three systems.

The cointegration results for the full sample are reported in Table 1, Panel A. The maximum eigenvalue tests developed by Johansen (1995) indicate evidence for one cointegrating vector at the conventional 5% level, but the trace test does not reject the hypothesis of no cointegration.[8] The results from the S&L tests provide evidence for *r=1*. Overall, the results are inconclusive.

However, cointegration analysis performed in the two subsamples shed further light on the behavior of the mark real exchange rates of the six CEECs. No cointegration is found for the period 1993.3 -1998.12, as evidenced by all three tests. The results indicate that these countries were not a part of an OCA with the eurozone before the introduction of the euro. However, the results for the post–euro period, presented in Table 1, panel C, provide evidence for one cointegrating vector: The real exchange rates are closely integrated and form a GPPP relation during this period.

According to the results, the six countries have been operating as an optimal currency area in the post euro-period, but not before.[9] This change in the findings possibly reflects the impact of the trade increase between the six economies and the euro zone, as a result of the introduction of the euro and the change in the exchange rate regimes of most of the six economies towards regimes which use the euro as the reference currency (see Angeloni *et al.* (2007) for a report on the trade rise between the NMS and the EU in 1995-2004). It may also reflect the higher level of coordination in their economic policies, once they decided to join the EU. In fact, the monetary policy institutions, the goals and institutional settings of the central banks of the economies have converged to some degree in the recent years (for similar arguments, see *inter alia* Angeloni *et al.*, 2007).

[8] Following Juselius (2006), the trace test is more robust than the maximum eigenvalue test.

[9] These findings are in line with those of the relevant literature: Angeloni *et al.* (2007) report that the real exchange rates of ten NMS –which include the six CEECs- tend to converge in the post-1999 period. Candelon *et al.* (2007) provide estimates of fundamental-based real exchange rates of eight NMS and indicate that their differences from the observed rates tend to disappear in the period 1999-2003. Horvath (2007) finds out that a group of NMS -including the six CEECs- are well aligned with the euro area for the period 1999-2004. Crespo-Cuaresma *et al.* (2005) report that equilibrium exchange rates -estimated using the monetary model - tend to be relatively stable in the period 1994-2002.

The pattern of the six real exchange rates with respect to the US dollar is interestingly different. The cointegration results are presented in Table 2. The tests indicate that there is a cointegrating relationship among the series, characterizing the period 1993.4-1998.12, which nevertheless disappears, once the euro is introduced. The results probably reflect changes in trade and finance links with the US in the pre- and post- euro period. They may indicate that the dollar lost importance in the financial and goods markets of the six countries as a result of the increasing trade of these countries with the EU and of the new and dominant role of the euro in the European markets. They may also reflect the change in the exchange rate policies of these countries, which targeted alignment with the euro area countries, in view to the upcoming membership.

The estimated cointegrating relationships. The long-run coefficients

Table 3 presents the estimated vectors of the two systems for which there was evidence for cointegration: the first describes the GPPP relationship between the six real mark rates for the period 1999.1-2007.12, whereas the second describes the GPPP between the dollar rates for the period 1993.3-1998.12.

The first cointegrating vector is normalized on the Czech koruna/ German mark rate. Actually, any real exchange rate could have been applied to create the normalized equations and the koruna/mark rate is picked randomly. The normalized vector reflects the interrelationship among these real exchange rates. The estimated coefficients can be interpreted as long-run elasticities. In the vector, all coefficients except that of the Polish zloty/ mark rate are significant at the 5% level; the Polish zloty/ mark rate is significant at the 10% level. All but the Bulgarian lev coefficients are lower than unity, implying a small size affect. For example, the estimated coefficients show that a 1% rise (fall) in the zloty/mark real exchange rate will induce a 0.17 % rise (fall) in the koruna/ mark real exchange rate. According to Ender and Hurn (1994), if the real exchange rates are only influenced by real output processes of the various nations, the normalized vector coefficients will be smaller the more similar are a country's aggregate demand parameters.

The estimated coefficients of the second long-run relationship normalized on the Czech koruna/ US dollar rate, are also presented in Table 3. In the relationship, the

Slovakian koruna/ US dollar rate turns out non-significant.[10] The size of the coefficients is relatively small –less than unity in most cases, indicating high financial and trade links with the US during the pre-euro period.

The estimated adjustment coefficients

The Johansen maximum likelihood approach also estimates the adjustment coefficients of each variable in the VARs. The adjustment coefficients indicate the speed at which the variables adjust towards their long-run equilibrium. The speed of adjustment shows how quickly any deviation from GPPP tends to correct itself. According to Johansen (1995), if a certain variable adjustment coefficient is insignificantly different from zero, then the variable is known to be weakly exogenous, as the dynamics of this variable are not influenced by the long-run equilibrium relationship.

Table 4 presents the speed of adjustment coefficients for the two cointegrated vectors. For the mark rate system, the largest coefficients are found in the case of real exchange of the Czech koruna and the Romanian leu against the mark. The coefficient 0.185 for the Romanian leu implies that the leu/mark real exchange rate adjusts at the rate of 18,5 percent per month toward the long-run equilibrium. The adjustment coefficients of the Slovakian koruna, the Polish zloty and the Hungarian forint are not found to be significant when tested individually, indicating possibly that these real rates are weakly exogenous, i.e. the equilibrium GPPP relationship does not influence their short-run dynamics. Nevertheless, weak exogeneity of these three real exchange rates may be due to frequent interventions in the foreign exchange markets of Hungary, Poland and Slovakia, by the monetary authorities who targeted the real exchange rate at a predetermined level.[11] The weak exogeneity test results may also reflect the effects of regulations in prices in these countries.[12] Nevertheless, these results should be interpreted as indicative of the dynamics of the system, given that the hypotheses tested do not identify the whole cointegrating space and are not tested jointly.

[10] This may cause some doubts on the necessity of this rate for the GPPP relationship; still, the cointegrating space is not fully specified, so we do not investigate further this issue.
[11] For the effects of interventions on the behaviour of the nominal and real exchange rates of a number of CEEC economies see, *inter alia* Egert, (2007); Sideris, (2008).
[12] The role of regulated prices is shown to be significant for the behaviour of the real exchange rates of Hungary and the Slovak Republic in MacDonald and Wojcik (2004).

In the GPPP relationship of the dollar real rates, the largest coefficients are found for the Bulgarian lev and the Romanian leu. The adjustment coefficients of the Hungarian forint and the Polish zloty do not turn out significant when tested individually, indicating that these two rates may be weakly exogenous. This again may be the result of frequent interventions by the monetary authorities in the exchange rate markets of the two economies and the effects of price regulations.[13]

4. Conclusions

The present study has two aims. The first aim is to analyze the degree of convergence of six new member states of the European Union with the eurozone, in an attempt to evaluate their readiness to adopt the euro. The work examines whether these countries form an OCA with the eurozone by using the GPPP theory. The second aim is to investigate whether the introduction of the euro and the decision of the six countries to join the eurozone had any impact on fostering their integration with the euro area. We argue that the decision of the six economies to join the monetary union and the policy steps made towards convergence with it, have already promoted their integration. This idea is in line with the endogenous OCA theory which supports that countries joining a currency union may satisfy the criteria of an OCA *ex post* even if they do not *ex ante*.

In the empirical work, cointegration analysis is employed to test the GPPP hypothesis –whether the real exchange rates converge in the long run– after an initial assessment of the stationarity of each real exchange rate series. The cointegration analysis examines the joint behavior of the rates, in three different periods: the full period and the periods before and after the introduction of the euro. The results provide evidence in favor of an OCA with the euro area only for the period following the introduction of the euro. The results indicate that the group of the six economies has enjoyed a reduction in their real exchange rate instability in the post-euro period. This could be due to increased trade integration of the six economies with the EU caused by the introduction of the euro and the swift of the exchange rate policies of most of the six CEECs towards euro-based

[13] A summary of the exchange rate policy measures pursued in Hungary and Poland in the period 1990-1999 is presented in, *inter alia,* Dibooglu and Kutan (2001).

exchange rate regimes. They also indicate that a significant increase in policy convergence has been achieved.

For indicative purposes, a similar analysis with respect to the US economy is also performed. It indicates that alignment of the countries with the US is supported by the data for the period before the introduction of the euro but not for the period following it. These results probably reflect the weakening role of the dollar in the European markets and the change in the policies of the six countries.

Overall the findings imply that the convergence process with the eurozone has been promoted in recent years probably as a result of the convergence of the economic policies of the countries under consideration, the structural changes that took place in the economic systems of the countries, the increased trade integration with the European Union and the significant role of the euro on the European markets. Thus, at present, the six economies are quite well aligned with the euro area members. It could also be argued that the OCA endogeneity effect may further enhance integration with the eurozone, once the euro is adopted by all six economies; however, we expect this effect to be quite small given that trade is already largely oriented to the eurozone.

Table 1: Cointegration analysis for the German mark real exchange rates.

Testing for the cointegration rank						
Johansen tests					S&L tests	
Panel A: Full sample						
Rank	Max eigen.	c.v. (95%)	Trace	c.v. (95%)	LR	c.v. (95%)
0	**41.13***	40.07	94.60	95.75	**93.85***	83.80
1	22.95	33.87	53.46	69.81	56.08	59.95
2	13.68	27.58	30.51	47.85	38.62	40.07
3	10.32	21.13	16.82	29.79	19.66	24.16
4	6.49	14.26	6.50	15.49	9.73	12.26
5	0.02	3.84	0.02	3.84	2.84	4.13
Panel B: 1993.4-1998.12						
Rank	Max eigen.	c.v. (95%)	Trace	c.v. (95%)	LR	c.v. (95%)
0	40.02	40.07	91.56	95.75	80.34	83.80
1	25.88	33.87	51.25	69.81	40.29	59.95
2	14.86	27.58	25.37	47.85	20.57	40.07
3	5.52	21.13	10.50	29.79	14.22	24.16
4	4.29	14.26	4.98	15.49	5.13	12.26
5	0.68	3.84	0.68	3.84	0.03	4.13
Panel C: 1999.1-2007.12						
Rank	Max eigen.	c.v. (95%)	Trace	c.v. (95%)	LR	c.v. (95%)
0	**40.48***	40.07	**101.88***	95.75	**95.49***	83.80
1	27.02	33.87	61.40	69.81	57.58	59.95
2	17.93	27.58	34.37	47.85	33.64	40.07
3	9.18	21.13	16.43	29.79	20.98	24.16
4	6.86	14.26	7.25	15.49	9.93	12.26
5	0.39	3.84	0.39	3.84	3.13	4.13

Notes: The S&L tests include a constant and seasonal dummies. The S&L tests are performed with JMulTi 4.2. The remaining computations are performed with PcFiml 9.0. * denotes rejection of the hypothesis at the 0.05 level

Table 2: Cointegration analysis of the US dollar real exchange rates

Testing for the cointegration rank						
Johansen tests					S&L tests	
Panel A: Full sample						
Rank	Max eigen.	c.v. (95%)	Trace	c.v. (95%)	LR	c.v. (95%)
0	40.03	40.07	94.60	95.75	69.58	83.80
1	20.92	33.87	54.03	69.81	49.69	59.95
2	13.78	27.58	33.10	47.85	29.05	40.07
3	10.73	21.13	19.32	29.79	14.14	24.16
4	7.89	14.26	8.58	15.49	3.34	12.26
5	0.69	3.84	0.69	3.84	1.45	4.13
Panel B: 1993.4-1998.12						
Rank	Max eigen.	c.v. (95%)	Trace	c.v. (95%)	LR	c.v. (95%)
0	34.37	40.07	**102.88***	95.75	**83.87***	83.80
1	28.45	33.87	68.50	69.81	53.40	59.95
2	23.35	27.58	40.05	47.85	25.13	40.07
3	10.77	21.13	16.69	29.79	11.55	24.16
4	4.66	14.26	5.92	15.49	2.90	12.26
5	1.25	3.84	1.25	3.84	0.10	4.13
Panel C: 1999.1-2007.12						
Rank	Max eigen.	c.v. (95%)	Trace	c.v. (95%)	LR	c.v. (95%)
0	30.30	40.07	90.61	95.75	70.94	83.80
1	24.06	33.87	60.30	69.81	42.62	59.95
2	21.62	27.58	36.23	47.85	24.36	40.07
3	8.15	21.13	14.60	29.79	11.09	24.16
4	6.32	14.26	6.45	15.49	5.64	12.26
5	0.12	3.84	0.12	3.84	0.26	4.13

Notes: The S&L tests include a constant and seasonal dummies. The S&L tests are performed with JMulTi 4.2. The remaining computations are performed with PcFiml 9.0.
* denotes rejection of the hypothesis at the 0.05 level

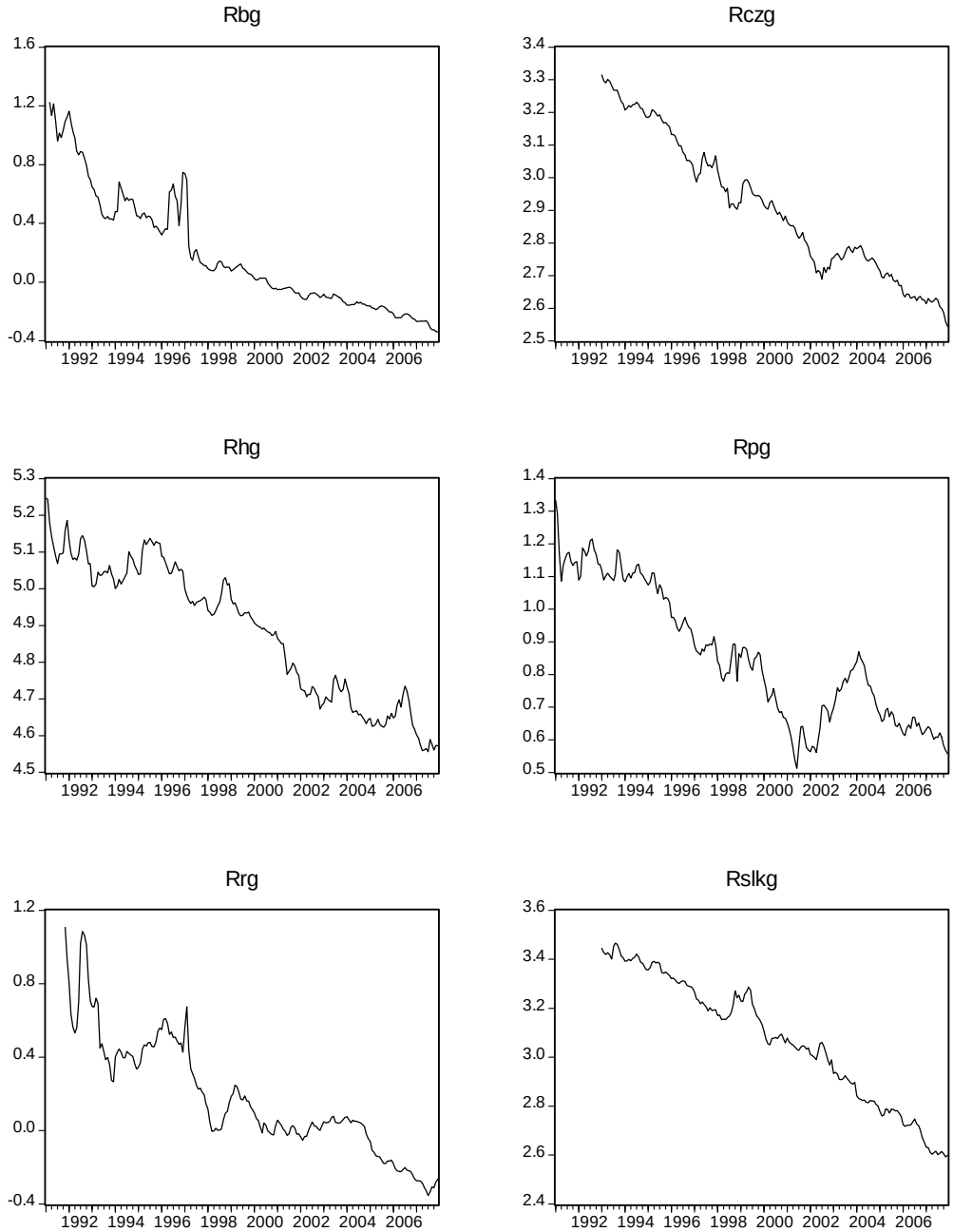
Table 3: Estimated cointegrating vectors

German mark real exchange rates: 1999.1-2007.12						
	r_{czg}	r_{bg}	r_{hg}	r_{pg}	r_{rg}	r_{slkg}
Coefficients	1	-2,041	-0,272	0,177	-0,294	0,953
t-stats		-8.056	-2,209	1,709	-2,617	5,724
US dollar real exchange rates: 1993.3.-1998.12						
	r_{czus}	r_{bus}	r_{hus}	r_{pus}	r_{rus}	r_{slkus}
Coefficients	1	0,166	-0,335	-1,069	-0,253	0,187
t-stats		3,513	-1,574	-5,257	-4,203	0,670

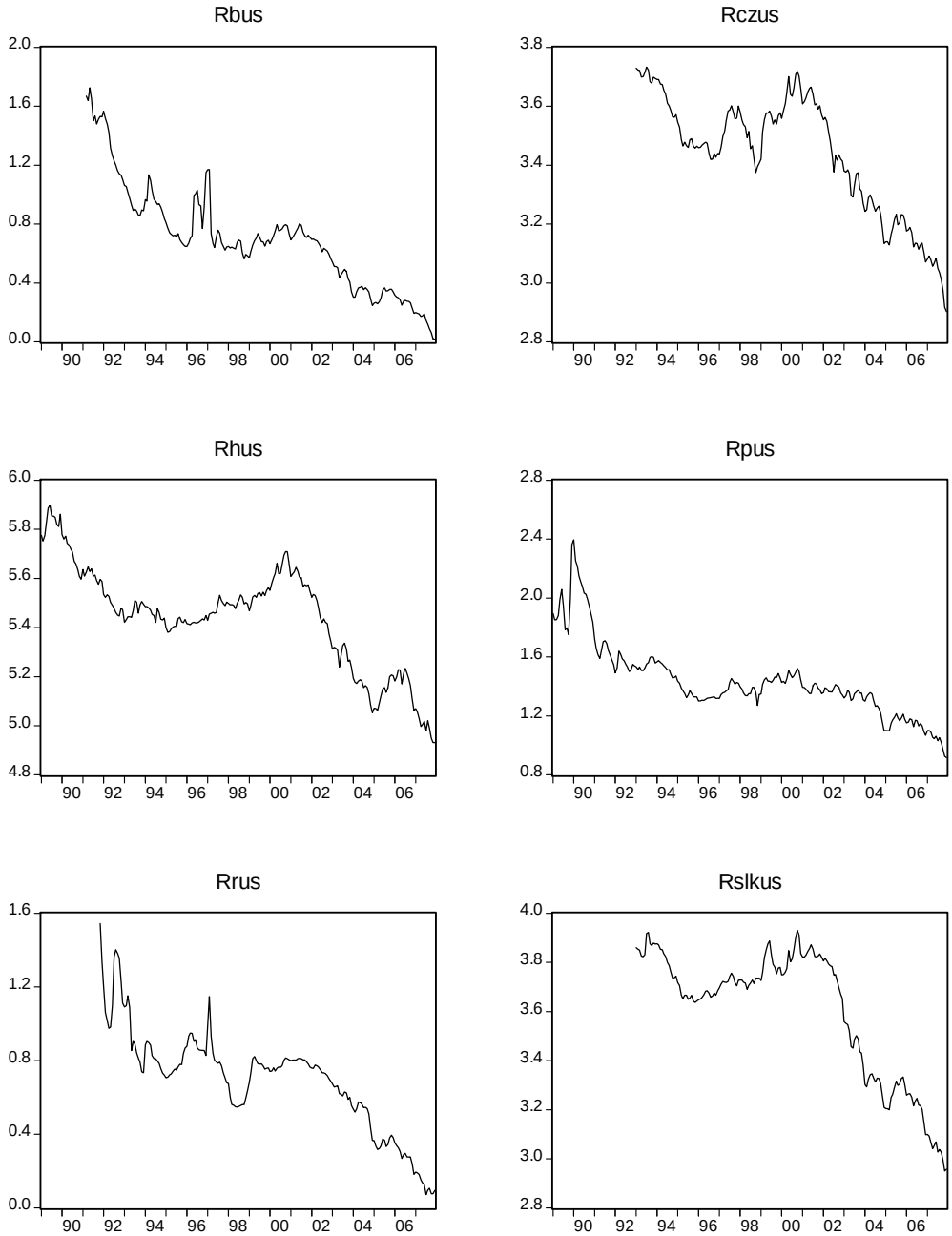
Table 4: Estimated loading coefficients

German mark rates: 1999.1-2007.12			**US dollar rates: 1993.3-1998.12**		
	loadings	t-stats		loadings	t-stats
Δr_{czg}	-0,168	3,711	Δr_{czus}	-0,258	2,537
Δr_{bg}	0,055	1,402	Δr_{bus}	-0,608	1,426
Δr_{hg}	-0,058	0,985	Δr_{hus}	0,045	0,525
Δr_{pg}	-0,071	0,905	Δr_{pus}	0,137	1,345
Δr_{rg}	0,185	2,821	Δr_{rus}	-0,743	2,973
Δr_{slkg}	-0,006	0,102	Δr_{slkus}	-0,116	1,535

Graph 1: Real exchange rates vis-à-vis the German mark



Graph 2: Real exchange rates vis-à-vis the US dollar



APPENDIX

The results of the ADF tests for the real exchange rate series vis-à-vis the German mark are reported in Table A1, Panel A. In the regressions of the series, we include a constant, a trend and seasonal dummies, based on tests for their statistical significance. No trend appears in the tests for the first differences. Given that the lag length is known to have an impact on the results of the unit root tests, we perform tests with different lag lengths as suggested by different lag selection criteria. The maximum lag length is set equal to 12. Overall the ADF test results provide evidence for a unit root in all real exchange rate series vis-à-vis the mark. The Lanne *et al.* (2001, 2002) tests are unit root tests with an unknown break date. The test results are reported in Table 1: Panel B. They suggest that all series are I(1). The tests indicate a regime change somewhere in the second half of 1998 for the case of the Czech Republic, Poland and Slovakia. The change is possibly related to the Russian crisis in August 1998 and the introduction of the euro in non-physical form in January 1999. The structural breaks identified in the remaining three countries are related to internal policy measures taken by the domestic governments. In particular: the break in 1997.3 identified in Bulgaria is related to the 1996-97 economic crisis, which led to a severe depreciation of the lev vis-à-vis the US dollar in March 1997. In the Romanian rate, the 1997 break is related to the stabilisation program, which was launched in January 1997 and included full liberalisation of prices. The break in 1995.3 in Hungary reflects the large devaluation of the fiorint in March 1995 and the subsequent change in the currency basket to which the fiorint was pegged.

The results of the unit root tests for the real exchange rate series against the US dollar are reported in Table A2. They provide evidence that the series are I(1). The Lanne *et al.* tests further indicate the effect of a regime change at the end of 1998 for three out of the six cases.

Table A1. Unit root tests: Real exchange rates vis-à-vis the German mark

Panel A: Augmented Dickey-Fuller tests							
Var.	Lags		Det. terms	Test statistic	Critical values		
					10%	5%	1%
r_{bg}	AIC:	7	*c, t, SD*	-3.36	-3.13	-3.41	-3.96
	HQ, SBC:	3	*c, t, SD*	-2.81			
r_{czg}	AIC, HQ:	1	*c, t, SD*	-2.71			
	SBC:	0	*c, t, SD*	-2.49			
r_{hg}	AIC, HQ, SBC:	1	*c, t, SD*	-3.13			
r_{pg}	AIC, HQ:	1	*c, SD*	-1.10	-2.57	-2.86	-3.43
	SBC:	0	*c, SD*	-1.17			
r_{rg}	AIC, HQ:	3	*c, t, SD*	-3.02	-3.13	-3.41	-3.96
	SBC:	2	*c, t, SD*	-2.71			
r_{slkg}	AIC, HQ, SBC:	1	*c, t, SD*	-2.81			
Δr_{bg}	AIC, HQ:	4	*c, SD*	-9.30	-2.57	-2.86	-3.43
	SBC:	2	*c, SD*	-8.64			
Δr_{czg}	AIC, HQ, SBC:	0	*c, SD*	-7.03			
Δr_{hg}	AIC:	1	*c, SD*	-9.01			
	HQ, SBC:	0	*c, SD*	-10.1			
Δr_{pg}	AIC, HQ, SBC:	0	*c, SD*	-11.2			
Δr_{rg}	AIC:	2	*c, SD*	-6.72			
	HQ, SBC:	1	*c, SD*	-9.91			
Δr_{slkg}	AIC, HQ, SBC:	0	*c, SD*	-10.9			

Panel B : Unit root tests allowing for structural breaks								
Var.	Lags		Det. terms	Possible break	Test statistic	Critical values		
						10%	5%	1%
r_{bg}	AIC, HQ:	4	*c, SD*	1997M3	-0.42	-2.58	-2.88	-3.48
	SBC:	3	*c, SD*		-0.82			
r_{czg}	AIC:	1	*c, SD*	1998M7	-0.62			
	HQ, SBC:	0	*c, SD*		-0.67			
r_{hg}	AIC, HQ:	2	*c, SD*	1995M3	-0.28			
	SBC:	1	*c, SD*		-0.26			
r_{pg}	AIC, HQ:	1	*c, SD*	1998M12	-1.22			
	SBC:	0	*c, SD*		-0.98			
r_{rg}	AIC, HQ:	3	*c, SD*	1997M3	-0.94			
	SBC:	2	*c, SD*		-1.08			
r_{slkg}	AIC, HQ:	1	*c, SD*	1998M10	0.33			
	SBC:	1	*c, SD*		-0.54			
Δr_{bg}	AIC, HQ:	4	*c, SD*	1997M2	-6.99			
	SBC:	2	*c, SD*		-12.1			
Δr_{czg}	AIC, HQ, SBC:	0	*c, SD*	1998M1	-11.7			
Δr_{hg}	AIC, HQ:	1	*c, SD*	2003M6	-9.19			
	SBC:	0	*c, SD*		-10.3			
Δr_{pg}	AIC, HQ, SBC:	0	*c, SD*	1998M11	-9.54			
Δr_{rg}	AIC, HQ:	1	*c, SD*	1997M3	-9.14			
	SBC:	0	*c, SD*		-10.6			
Δr_{slkg}	AIC, HQ, SBC:	0	*c, SD*	1999M7	-11.5			

Notes: c, t and *SD* stand for a constant, a linear trend and seasonal dummies, respectively. AIC=Akaike's Information Criterion; HQ=Hannan-Quinn Criterion; SBC=Schwarz Bayesian Criterion. The unit root tests with one break point and the corresponding critical values (Panel B) are those proposed by Lanne *et al.* (2001, 2002). Computations are performed with JMulTi, Version 4.2.

Table A2. Unit root tests: Real exchange rates vis-à-vis the US$

Panel A: Augmented Dickey-Fuller tests							
Var.	Lags		Det. terms	Test statistic	Critical values		
					10%	5%	1%
r_{bus}	AIC:	5	*c, SD*	-2.55	-2.57	-2.86	-3.43
	HQ, SBC:	3	*c, SD*	-2.07			
r_{czus}	AIC, HQ, SBC:	1	*c, SD*	-0.01			
r_{hus}	AIC:	5	*c, SD*	0.17			
	HQ, SBC:	0	*c, SD*	1.02			
r_{pus}	AIC, HQ, SBC:	4	*c, SD*	-1.31			
r_{rus}	AIC:	8	*c, t, SD*	-2.93	-3.13	-3.41	-3.96
	HQ, SBC:	0	*c, t, SD*	-4.33			
r_{slkus}	AIC:	2	*c, SD*	-0.47	-2.57	-2.86	-3.43
	HQ, SBC:	1	*c, SD*	-0.76			
Δr_{bus}	AIC:	4	*c, SD*	-6.69	-2.57	-2.86	-3.43
	HQ, SBC:	2	*c, SD*	-10.4			
Δr_{czus}	AIC, HQ, SBC:	0	*c, SD*	-9.89			
Δr_{hus}	AIC:	4	*c, SD*	-4.12			
	HQ, SBC:	0	*c, SD*	-11.2			
Δr_{pus}	AIC, HQ, SBC:	1	*c, SD*	-11.3			
Δr_{rus}	AIC, HQ:	7	*c, SD*	-4.78			
	SBC:	0	*c, SD*	-15.2			
Δr_{slkus}	AIC:	1	*c, SD*	-9.11			
	HQ, SBC:	0	*c, SD*	-9.83			

Panel B : Unit root tests allowing for structural breaks								
Var.	Lags		Det. terms	Possible break	Test statistic	Critical values		
						10%	5%	1%
r_{bus}	AIC, HQ, SBC:	3	*c, SD*	1997M3	-2.32	-2.58	-2.88	-3.48
r_{czus}	AIC, HQ, SBC:	1	*c, SD*	1999M2	0.16			
r_{hus}	AIC:	7	*c, SD*	1991M1	-1.30			
	HQ, SBC:	0	*c, SD*		0.01			
r_{pus}	AIC, HQ, SBC:	4	*c, SD*	1998M11	-1.21			
r_{rus}	AIC:	8	*c, SD*	1997M3	-1.20			
	HQ, SBC:	0	*c, SD*		-2.58			
r_{slkus}	AIC:	2	*C, SD*	2000M5	-1.26			
	HQ, SBC:	1	*c, SD*		-1.42			
Δr_{bus}	AIC:	3	*c, SD*	1997M3	-2.46			
	HQ, SBC:	2	*c, SD*		-2.55			
Δr_{czus}	AIC, HQ, SBC:	0	*c, SD*	2002M8	-3.35			
Δr_{hus}	AIC, HQ:	4	*c, SD*	1990M1	-5.12			
	SBC:	0	*c, SD*		-8.37			
Δr_{pus}	AIC, HQ, SBC:	1	*c, SD*	1998M12	-4.11			
Δr_{rus}	AIC, HQ:	6	*c, SD*	1997M3	-2.96			
	SBC:	0	*c, SD*		-4.98			
Δr_{slkus}	AIC, HQ:	1	*c, SD*		-3.15			
	SBC:	0	*c, SD*	2000M6	-2.96			

Notes: c, t and *SD* stand for a constant, a linear trend and seasonal dummies, respectively. AIC=Akaike's Information Criterion; HQ=Hannan-Quinn Criterion; SBC=Schwarz Bayesian Criterion. The unit root tests with one break point and the corresponding critical values (Panel B) are those proposed by Lanne *et al.* (2001, 2002). Computations are performed with JMulTi, Version 4.2.

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