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Structural Breaks and Purchasing Power Parity in the CEE and Post-War former Yugoslav States

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Abstract

In this paper we investigate purchasing power parity in the CEE and post-War former-Yugoslav states during EU integration process 1994-2006. This work stems from longer term tests of real exchange rate convergence in the former Yugoslavia. This period is of interest on two fronts: First, it investigates real exchange dynamics in the aftermath of war financed in part through seignorage; and second, we investigate the level of economic integration with the European Union following the break up of the former Yugoslavia. Given the short run nature of the available data we use panel unit root tests with and without structural breaks. Preliminary results suggest that real exchange rates between the former Yugoslav states and Germany are stationary when breaks are accounted for. Given the size of nominal shocks in the region, particularly in the early 1990s, preliminary results indicate that convergence to the long run equilibrium is relatively quick.

Keywords
purchasing power parity, Economic Integration, panel unit root tests

JEL classification
E31, F22

1. INTRODUCTION

The goal of this paper is to investigate convergence to PPP during transition and EU accession process in Croatia, Macedonia, Serbia and Slovenia (former Yugoslav countries) and Czech Republic, Hungary, Poland, and Slovakia (remaining non Yugoslav Central European countries) employing Im, Lee and Tieslau (2005) two break LM panel unit test.[1] The research originates from the vast literature on long-run validity of the PPP hypothesis (Rogoff 1996) and on growing literature that has emerged investigating the unprecedented appreciation of real exchange rates in transition countries during the last 18 years (Egert, Macdonald, Halpern 2006).

In addition to testing for PPP in transition countries, we hope to shed light on the way in which war and dissolution of the former Yugoslavia affects convergence to the PPP in the post war period. Our data set allows to analyze how economic forces function in an environment of war, trade redirection and post-war normalization. Until now the lack of data presented serious problems for inclusion of Serbia and even Macedonia in PPP or any other studies. This is an opportunity to test the economic theory in countries that were until recently excluded from empirical research.

The power problem of the standard unit root test to reject a null hypothesis when applied to float data has been circumvented with panel study approach.[2] Given the long run nature of real exchange rate behavior, examining a single real exchange rate over a period of twenty-five years or so may not yield enough information to detect slow mean-reversion towards PPP (Froot and Rogoff 1995). Using panel methods allows us to circumvent the relatively short time frame associated with the available data for the transition countries in our sample. The longest data series in our sample spans sixteen years and it would be quite optimistic to expect rejection of a null hypothesis in such a short sample.

In addition to the power problem, the environment of transition countries is even more challenging due to strong appreciation trends in central European and Baltic countries and the huge instability of real exchange rates in former Yugoslav countries. One of the stylized facts of transition is the initial undervaluation of transition countries in terms of absolute PPP. At the beginning of transition - due to economic planning and isolation form global trade patterns and capital movements - price levels in the Czech Republic, Hungary, Poland and Slovakia were much lower compared to equally developed market economies. Accompanying economic transition, real exchange rates experienced strong appreciation trends (Egert, Halpern and MacDonald 2006).

On the other hand, real exchange rates in the former Yugoslav countries were not undervalued, if at all. The "self-management" version of communism in the former Yugoslavia was more open to global economic forces and price levels at the beginning of transition were more closely aligned to similarly developed market economies. Clearly, the abandonment of central planning in favor to self-management (as early as 1948) resulted in much earlier (pre-transition) price level convergence (Pertot 1971, Egert, Halpern and MacDonald 2006). In addition, much higher price levels in former Yugoslavia over the period of 1990-94, due to hyperinflation resulted in unprecedented real exchange rate volatility.

In the late 1990s, after the initial period of transition, strong appreciation trends in central European countries were also attributed to Harrod-Balassa-Samuelson (HBS) related phenomena. Several studies have even claimed that it is not going to be possible for transition countries to simulationiously converge in terms of GDP per capita and in terms of European Monetary Union (EMU) inflation targets (Halpern and Wyplosz 2001, De Broeck and Slok 2001; Lojschova 2003).

[1] Czech Republic, Hungary, Poland, Slovakia and Slovenia are European Union members and Croatia is expected to finish negotiation process by 2009.

[2] Artificially generated processes have indicated that for the speed of mean-reversion typically recorded in the literature (half-life of 2.5-7.3 years), the probability of rejecting the null hypothesis of a random walk real exchange rate, in the case when the real exchange rate is mean reverting, would only be between 5 and 7.5% for 15 years of data (Sarno and Taylor 2002).

In the former Yugoslav countries there is less evidence if favor of a HBS effect. Data for Serbia and Macedonia are not available for much of the period, but several studies managed to find evidence of HBS effect in Slovenia, however, there is little evidence of HBS in Croatia (Mihaljek and Klau 2004). Throughout the entire period of transition Croatia, Macedonia, Serbia and Slovenia have had much smaller (if any) appreciation trend of relative real exchange rates and during the war period and dissemination of the Yugoslavia (1991-1995) real exchange rates experienced unprecedented volatility - when compared to the other four transition countries.

With this in mind, it is clear that the economic environment of transition economies presents a challenge for real exchange rate stationarity. Therefore, a panel Lagrangian multiplier (LM) unit root test, formulated by Im, Lee and Tieslau (2005), with two endogenously estimated level shifts is employed to accommodate structural shifts and the strong appreciation trends in real exchange rates during transition. The test is a multivariate generalization of the Schmidt and Phillips (1992) LM approach to the unit root testing combined with Zivot and Andrews (1992) endogenous break determination, extended to two endogenously determined breaks by Lumsdaine and Pappell (1997) and Lee and Strazicich (2003). The panel approach increase the power problem of univariate tests, and the LM approach with two structural breaks should reinforce the power of the test in a volatile economic environment which includes various institutional shocks.

In order to highlight the effect of economic disintegration in former Yugoslavia, two panels are employed. One including all countries during 1994:1 2006:12 and other including only four former Yugoslav countries during 1996:1 2006:12. Early 1990s exhibited quite turbulent behavior of variables, especially during record high hyperinflation in Serbia and much smaller but still chronic hyperinflation in Croatia, Macedonia and Slovenia. Therefore, testing of PPP assumption in former Yugoslav countries is performed for the after war period only.

Overall, we find strong evidence of PPP convergance in four former-Yugoslav countries during post-war period and slightly weaker evidence of convergance for sample of eight countries.

The remainder of the paper is divided in four sections. Section 2 provides a theoretical justification for real exchange rate convergence and the econometric methodology. Section 3 discusses the data and provides an overview of the two unit root break tests. Section 4 presents and discusses the results and Section 5 concludes.

2. PPP IN TRANSITION COUNTRIES

Analyzing PPP in transition countries is much more complex and less analyzed due to data availability problems. Using sufficiently long sample periods to overcome power shortcomings in most countries is impossible due to the length of data series (mostly starting in the early 1990s). Therefore, most research is restricted to using panel methods. Using Jöhansen VECM cointegration tests Mahdavi and Zhou (1994) find evidence for PPP in high inflation countries, including the former Yugoslavia. The results with quarterly data indicated existence of relative or absolute PPP in former Yugoslavia and seven other non-European countries.

Choudhry (1999) investigated PPP between USA and Poland, Romania, Russia and Slovenia, and provided evidence of relative PPP only in Slovenia and Russia. Christev and Noorbakhsh (2000) investigated long-run PPP in Bulgaria, Czech Republic, Hungary, Poland, Romania and Slovakia. Moderate evidence has been found to support long-run equilibrium, although the estimated cointegrating vector did not yield easily interpreted results and violates the symmetry and proportionality conditions.[3]

[3] Kocenda (2005) performed test with endogenous determination of breaks in nominal exchange rate movements in transition countries. Although methodology is in line with one used in this study, exclusion of inflation data makes it difficult to fit in within the survey of PPP assumption papers.

Besides panel data tests, several authors performed tests for individual countries with the expected result given the low power of these tests. Thacker (1995) did not reject the null hypothesis of the unit root in Hungary and Poland. Barlow (2005) employed cointegration methodology in order to test for PPP in Poland, Czech Rep. and Romania, without evidence of PPP vis a vis developed economies. Payne, Lee and Hofler (2005) employed a battery of unit root tests with structural breaks in order to test short-span PPP in Croatia. As expected, their findings do not demonstrate a mean-reverting process in Croatian real exchange rates. Giannellis and Papadopoulos (2006) managed to reject the null hypothesis in 6 out of 8 real exchange rates in four transition economies.

On the other hand, long span approach was more successful. Tica (2006) managed to reject null hypothesis of random walk after compiling 51 years of annual data for the Croatian real exchange rate vis-á-vis Germany, the United States, and Italy. Sideris (2006) performed long-run PPP test for each of seventeen transition economies together with panel cointegration test. The analysis provided support for long-run equilibrium, but the cointegrating vectors violated the symmetry and proportionality hypotheses suggested by PPP.

Recently, several papers with nonlinear econometric tests increased the power of the stationarity tests and resulted with stronger evidence in favor of the PPP theory. Cuestas (2007) employed two tests to control for the sources of nonlinearities in eight transition countries. Results have indicated that PPP holds in most of these countries once account has been taken of nonlinear deterministic trends and smooth transition. Bahmani-Oskooee, Kutan and Zhou (2008) tested the null of non-stationarity versus an alternative hypothesis of non-linear stationarity in 88 developing countries including transition economies. The nonlinear model supported the PPP theory in twice as many developing countries compared to the ADF test.

2.1. Transition economy idiosyncrasies

Real exchange rate behavior in transition countries is quite specific and peculiar compared either to developed or developing countries. Strong transitional appreciation trend in most of the transition countries became vehemently discussed topic as early as 1997 (Grafe and Wyplosz 1997). Early empirical studies on real exchange rate noticed that real exchange rates appreciated between 7.5% in Slovenia and 800% in Latvia since the beginning of transition (Halpern and Wyplosz 1997), though the data samples are very incomplete. Apparently, such strong appreciation of real exchange raised questions about sustainability of transitional exchange rate policies in most of the countries. As a consequence, many new theories appeared in a quest to explain appreciation as a stylised fact of the transition, and two theories have received most of the attention.[4]

First, is the theory of initial undervaluation in terms of absolute PPP in transition countries (Grafe and Wyplosz 1997; Coricelli and Jazbec 2001). According to this theory of initial undervaluation, at the beginning of transition process - due to autarchy of soviet bloc countries - the absolute price level was much lower than in comparably developed market economies. The process of liberalization, deregulation and stabilization resulted with strong appreciation trend towards comparable price levels in equally developed market economies.

The second theory of transitional real exchange rate determination is the HBS effect. The process of absolute PPP convergence were accompanied with income convergence of new member countries, which have fuelled appreciation even more through the productivity channel. Empirical studies show that it is quite difficult to find evidence of cointegration between relative productivity and relative prices in the early nineties. Due to initial undervaluation and strong price level convergence, the observed appreciation appears to be systematically much stronger than HBS effects could justify. However, for the period after mid-nineties the HBS effect manages to explain most of the appreciation in new EU member countries (Egert 2002).

[4] See Egert, Macdonald, Halpern (2006) for a comprehensive list of transition specific theories of real exchange rate determination.

The empirical research on HBS culminated with the debate on the feasibility of conforming to the Maastricht rules for entry into the European Monetary Union (EMU). According to Maastricht inflation criterion, a country that adopts Euro is required to target inflation at no more than 1.5 percentage points higher than three lowest inflation member states. Abiding to the Maastricht criterions might prove to be difficult for the transition economies as in the accession process rising income might put additional pressures on inflation. The literature on the conflict between Maastricht inflation criteria and income convergence induced inflation (HBS effect) in the new EU member states has been quite controversial topic and even today researchers are quite divided on the issue of the strength of HBS effect in the new member countries. [5]

2.2. Former Yugoslavia

Theory of initial depreciation and HBS effect, together with several other transition theories, dominated discussion about real exchange rate movements during transition in Baltic countries, the Czech Republic, Croatia, Hungary, Poland, Slovakia and Slovenia. However, most studies of relative price behavior have excluded Bosnia and Herzegovina, Serbia, or Serbia-Montenegro, and Macedonia due to data availability problems.

Most of the central European and Baltic countries fit mainstream stylized facts of transition. On the other hand, Slovenia experienced mild appreciation trend and did not experienced initial undervaluation (Halpern and Wyplosz 1997). Croatia has been depicted as an exception in terms of initial undervaluation and in terms of HBS effect. Researchers have had difficulties in finding proof of HBS and there is no proof of initial undervaluation (Egert, Macdonald, Halpern 2006, Mihaljek and Klau 2004). Heretofore employed data for Serbia and Macedonia also provide evidence that former Yugoslav countries demonstrated peculiar real exchange rate movements during transition process.

The best way to notice idiosyncratic behavior of the former Yugoslav countries is to analyze the movements of eight analyzed transition countries within PPP vs. GDP per capita loci during 1990-2004 and movements of their relative real exchange rate during 1990-2006. In the early nineties, the Czech Republic, Hungary, Poland and Slovakia experienced convergence in terms of GDP per capita and price levels, while in former Yugoslav countries price levels behaved in an opposite direction (Figure 1). Also, even relative real exchange rates of Croatia, Macedonia, Serbia and Slovenia (Figures 2-5) shows much smaller (if any) appreciation trends compared to former soviet block planned economies Czech Republic, Hungary, Poland and Slovakia (Figures 6-9).

The most probable explanation of peculiarity of the former Yugoslavia might be found in the peculiarity of Yugoslav self-managed and non-aligned communist system. Due to self-management system in former Yugoslavia, former Yugoslav countries were much more open to international trade, international capital movements and even international labor movements. As early as 1948 the former Yugoslav type of communism diverged from soviet type of communism. The planned economy was abandoned and economic decisions were decentralized at the level of companies, which were run by employees (self-management) and controlled by the party. Price liberalization and abandonment of multilateral exchange rate as a last part of early reforms happened in 1965. As a consequence, price levels at the beginning of transition were much higher in Yugoslavia compared to other Central European former soviet bloc planned economies (Pertot 1971).

In addition, the former Yugoslav countries are idiosyncratic due to the war and disintegration of Yugoslav tariff, monetary and economic integration, followed by the European integration processes.[6] Yugoslav

[5] See Tica and Družić (2006) for a survey of the empirical evidence of the HBS effect.

[6] EU integration process occurred parallel with war and disintegration of former Yugoslavia. Presently, Slovenia is a member of European Monetary Union (EMU) and European Union (EU). Croatia is in the process of negotiating for integration into European Union (EU), while EMU integration will follow. Bosnia and Herzegovina, Kosovo, Macedonia and Serbia lagged behind in EU integration processes, but they have joined trade liberalization agreement (CEFTA). New CEFTA agreement includes Croatia, Macedonia, Bosnia and Herzegovina, Serbia, Montenegro, Moldova, Albania and Kosovo.

disintegration resulted with a war in Slovenia (summer 1991), Croatia (1991-1995), Bosnia and Herzegovina (1992-1996) and Kosovo (1999). Together with dynamics of EU integration, transition of former Yugoslavia was coupled with monetary (economic) disintegration, trade redirection and war. It might be suggested that such environment might have resulted with specific behavior macroeconomic variables.

3. THE DATA AND STATISTICAL ANALYSIS

3.1. Data and descriptive statistics

The set of monthly data on inflation and nominal exchange rate has been collected going back in time to the begging of transition (January 1990) when possible. Inflation is represented as consumer price index for most of the countries and majority of the period. The problem is that some of the transition countries did not switch to consumer price index (CPI) and some of them switched quite late in transition. In such cases retail price index (RPI) has been used instead of consumer price index.

Inflation data for Serbia are represented by RPI during the entire period 1990:1-2006:12. In the case of Croatia, CPI was introduced in January 1998 and inflation is represented by RPI during 1990:1-1997:12. There is a similar situation in Slovenia and Macedonia. In Slovenia, CPI was introduced in January 1992 and RPI is used as an inflation indicator before that period. In Macedonia, CPI introduction occurred in January 1997 which means that RPI is used as an inflation indicator during 1990:1-1996:12. In Poland and Hungary CPI is available for the entire period 1990:1-2006:12. In the case of Czech Republic and Slovakia inflation data are unavailable for the 1990-91 and CPI indices start in January 1992. In the case of Germany inflation is represented with CPI during 1991:1-2006:12 period and West Germany cost of living index is used for 1990 (Table 1).

Compilation of the end of monthly nominal exchange rates vis-á-vis Germany is also complex due to introduction of Euro. The German mark nominal exchange rate is used prior to introduction of Euro and in the period after January 1999 the nominal exchange rate vis-á-vis Euro is used. In the construction of the series, nominal exchange rate determined at the end of December 1998 is used for conversion of nominal exchange rates of German mark and Euro (Table 1).

The data for Czech Republic, Hungary, Poland, Slovakia and post-independence Croatia and Slovenia were acquired from The Vienna Institute for International Economics Studies (WIIW 2007). Datasets for Slovenia prior to independence and for Macedonia and Serbia for the entire period were acquired from their national central banks. Nominal exchange rates data for the period prior to independence in Croatia are acquired from Tečajevi i tečajne liste (1993) and RPI data from Anušić et. al. (1995). Compilation of data series for Serbia and Macedonia represented the biggest problem. The data for both countries are not easily available and most of the data has been received through direct communication with national banks. The collapse of Yugoslav monetary system between October 1991 and April 1992 and hyperinflation made it quite hard to construct meaningful real exchange index for the entire period. Furthermore, even today Serbia uses an anachronistic statistic methodology and Macedonia implemented modernization in late nineties, which makes it quite impossible to extend our sample with additional variables.

Figures 2-9 show the real exchange rate (dashed) and inflation (solid) in each of the sample countries. All the former Yugoslav countries experienced sharp inflation beginning in summer 1990 – monthly inflation in Serbia hit 3 million percent while in the remaining countries it was more moderate -- before dramatically slowing in early 1994.[7] In the other four countries, price levels moderately increased over the entire sample. As can been seen, after the initial inflationary shock, Slovenian prices track closely with the non-Yugoslav economies.

[7] In October 1991 Slovenia introduced its own money and started with its own stabilization program. It was followed by Croatia in December 1991 and Macedonia in April 1992. Throughout the entire period inflation accelerated in Serbia and hyperinflation peeked in January 1994 with one of the highest monthly inflation rates in monetary history: 3 million percent.

The real exchange rate is defined as:

$$q_t \equiv e_t + p_t^D - p_t^i \quad (1)$$

where q_t is the real exchange rate, e_t is the nominal exchange rate of euro in terms of countries *i* currency, p_t^D is the price level in numeraire country (Germany), and p_t^i is the price level in country *i* (lower case indicating natural logarithms).

In terms of real exchange rate movements former Yugoslav countries exhibited much smaller appreciation trends during the post war period and much higher - almost unprecedented - volatility of real exchange rate during the period prior to independence of new nations. Other four Central European countries slowly tamed inflation and their real exchange rates exhibited strong appreciation trends due to initial undervaluation of absolute price levels.

Tables 3 and 4 show inflation and real exchange rate correlations respectively. As can be seen, and perhaps unexpectedly, inflation within the former Yugoslavian countries exhibits low correlation, with the exception of the prices between Serbia and Macedonia, which might be expected given the close relations between these two countries over the sample period. Also of interest is the negative correlation between Croatian and Serbian inflation rates. On the other hand, Slovenia appears to be more closely aligned to the four non-Yugoslav countries than it is with its former co-states. The four non-Yugoslav economies display much higher correlation compared to the former-Yugoslav countries. Obviously, disintegration and war created divergent price behaviors.

Similar results pop out of the correlations with respect to real exchange rates. In non-Yugoslav countries real exchange rates exhibit higher correlation compared to the rest of the sample. Real exchange rate correlation rates between CEE and former-Yugoslav and within four FYC countries are low and in some cases even negative. In terms of real exchange rate movements former-Yugoslav countries are heterogeneous and moderately high correlation might be found between Croatia and Serbia and between Macedonia and Slovenia (Table 4).

3.2. Univariate two break lm test

As discussed above, most of the Eastern European and former Yugoslavian economies have undergone dramatic shifts in their structure. We have seen that there is some evidence for long term productivity changes, via the HBS effect, and deterministic preference changes, as discussed in Kravis and Lipsey (1988). Given the exposure to foreign capital and rising incomes over the sample period, especially in post-war Yugoslavia, both of these effects are likely to play a role in price dynamics and a good test case for understanding price behavior under, sometimes, a less than ideal environment.

Perron (1989) was the first to demonstrate that structural breaks in the data might be misinterpreted as a permanent stochastic process. He considered three models which explain changes in the deterministic process. In Model "A" the time series undergoes a single level shift; Model "B" exhibits a change in the slope; and Model "C" nests both processes. While his test was successful at rejecting unit roots in the standard Nelson and Plosser (1982) data, the test itself requires rather savvy use of the eyeball metric by the econometrician to exogenously choose the break point. The Zivot and Andrews (1992) test, on the other hand, allows the data to endogenously choose the break using a ``minimum" t-test, checking for a break in each period.

Perron and Vogelsang (1992) model tests for *innovation* outliers (IO) for long term changes in the series, say due to real structural changes in the economy, analogous to ZA's Model "B". And the second, the *additional* outliers (AO) version, allows for a sudden break in the series, Model "A".

The standard single break tests have been extended to include breaks Lumsdaine and Pappell (1997), extending the Zivot-Andrews test, and Clemente, Montañés, and Reyes (1998), which adds an additional break to the Perron-Vogelsang test.

Lee and Strazicich (2003) extend the single break LM test of Amsler and Lee (1995) to allow for two breaks under both the null and alternative hypotheses, thus increasing the power of the test. Consider the following DGP:

$$y_t = \delta' Z_t + e_t,\ e_t = \beta e_{t-1} + \varepsilon_t,\ t = 0,...,T \quad (2)$$

where Z is vector of exogenous variables. In Model A we allow for two level shifts, $Z_t = (1, t, D_{1t}, D_{2t})'$ for $D_{jt} = 0$ for $t < TB_j$ and 1 otherwise. In Model C $Z_t = (1, t, D_{1t}, D_{2t}, DT_{1t}, DT_{2t})'$ where D_{jt} is defined as above and $DT_{jt} = t - TB_j$ for $t \geq TB_j$ and 0 otherwise, a change in the slope coefficients. With this specification, the DGP breaks under the null, $\beta = 1$, and the alternative, $\beta < 1$, hypotheses.

The two break test is estimated using the LM specification

$$\Delta y_t = \delta' \Delta Z_t + \phi \tilde{S}_{t-1} + \sum_{j=1}^{p} \rho_j \Delta \tilde{S}_{t-j} + u_t \quad (3)$$

where $\tilde{S}_t = y_t - \hat{\psi} - Z_t \hat{\delta}$; $\hat{\delta}$ is the estimated coefficients from the regression of Δy_t on ΔZ_t and $\hat{\psi}$ is given by $y_1 - Z_1 \hat{\delta}$, y_1 *and* Z_1 are the first period observations of y and Z. Under the null, $\phi = 0$ which is tested using as the Studentized $t-$statistic τ. The number of lagged $\tilde{S}$ is chosen using the standard method of starting with a p_{max} (6 months) and working backwards. As is standard in the literature, the two breakpoints are chosen from the interval $[0.1T, 0.9T]$ to avoid endpoints. The single break LM unit root test of Amsler and Lee (1995) is a special case of the two break test with $D_{2t} = DT_{2t} = 0$.

3.3. Panel LM tests

The panel LM unit root test is simply a panel analog of the tests described above. Panel unit root tests were first introduced by Levin, Lin and Chu (LLC, 2002) and Im, Pesaran and Shin (IPS, 2003) to overcome the power problem associated with shorter data sets. Both of these tests are based on the Augement Dicky-Fuller (ADF) representation of the DGP. However, they differ in their treatment of the first AR parameter (β above). In the LL test $\hat{\beta}_i = \hat{\beta}\ \forall i = 1, \ldots, N$ univariate series whereas the IPS allows β_i to vary across all of the N series. Additional tests have since been introduced by Maddala and Wu's (1999) Fisher test, the Harris and Tzavalis (1999) test, the SUR based ADF test of Sarno and Taylor (Sarno and Taylor, 1998, Taylor and Sarno, 1998) and the Hadri (2000) who uses a panel LM test with the null of stationarity.

The panel LM break test takes as its starting point a regression of the form

$$\Delta y_{it} = \gamma + \delta_i Z_{it} + \beta_i \tilde{S}_{t-1} + \sum_{j=1}^{p_i} \rho_{i,j} \Delta \tilde{S}_{i,t-j} + \nu_{it} \quad (4)$$

where $\tilde{S}_t = y_{it} - \tilde{\gamma} t - \tilde{\delta} D_{it}$ and $Z_t = [1, t, D_{1t}, D_{2t}, DT_{1t}, DT_{2t}]'$. The variable Z for the two break test defined nests an additional two models, the no break test $Z_t = [1, t]'$, and one with a single break $Z_t = [1, t, D_{1t}, DT_{1t}]'$. The LM Studentized $t-$statistic is calculated under the null hypothesis of $\beta_i = 0$, that is a unit root, denoted $\tau_{LM,i}$ for each i series, and its average as $\bar{\tau}_{LM}$. Defining t_{LM} as the $t-$statistics with *no* structural shifts, then the panel LM statistic with breaks is given by

$$\Gamma_{LM} = \frac{\sqrt{N}(\bar{\tau}_{LM} - 1N\sum_{i=1}^{N} E[\mathrm{t}_{LM}])}{\sqrt{1N\sum_{i=1}^{N} Var[\mathrm{t}_{LM}]}} \Rightarrow N(0,1) \quad (5)$$

unless N/T diverges as $N,T \to \infty$.

In the cases which contain breaks the minimum LM test uses a `grid search' to endogenously find the each of the breaks, defined by $\lambda_j = T_{Bj}/T,\ j = 1,2$ given by

$$LM_{\tau} = \inf_{\lambda} \tilde{\tau}(\lambda)$$

4. RESULTS

In total, 4 panel LM test are estimated in the paper: Panel LM tests with no breaks, panel LM with a break in intercept, panel LM test with a break in trend and panel LM test with two breaks in intercept. Each test is estimated for the entire sample of eight countries during 1990:1-2006:12 and for former Yugoslav countries during 1996:1-2006:12. The results indicate that it is not possible to reject null hypothesis in the panel LM test without breaks (Table 5). One break panel LM test rejects null hypothesis for four former Yugoslav countries, but not for all eight countries. Null hypothesis is rejected at 5% level of significance in the model with a break in the intercept, and at 1% level of significance in the model with break in trend (Table 6). Two breaks panel LM test rejects null hypothesis in both sample of countries. Null hypothesis of joint nonstationarity is rejected at the 1% level of significance for both samples of countries (Table 7).

Endogenously estimated breaks can be partly attributed to the numerous institutional shifts, exchange rate regime changes and political shocks (especially in Serbia). In Serbia breaks are dominated by nominal shocks. The nominal exchange rate devaluations might explain breaks in 1995:11, 1998:3 and in 2000:11. Also, the end of war in Croatia might explain the estimated break at the end of 1995. In the case of Croatia most of the shocks from 1998 might be attributed to the VAT introduction and following depreciation. Latter shocks are much more of institutional nature. Institutional reforms speeded up after change in government in 2000 and WTO and EU accession followed. In Slovenia most of the breaks are estimated in mid nineties during gradual stabilization program, while membership in ERM-II in June 2004 is not captured as a shock. Most of the breaks in Macedonia were estimated in 1997 due to the fact that earliest reforms can be traced in that period. The short war of 2001 did not have any major effects on real exchange rate movements.

In CEE countries reforms and institutional changes were much more homogenous. In Poland switch to floating exchange rate regime explains the break in 2000:12. In Hungary change in basket composition explains break in 1997:6 and last official devaluation rate is accountable for 2001:12. Late 2003 breaks in the Czech Republic might be connected with EU accession in 2004, although Czech Rep. is not in the EMU process yet. Breaks in Slovakian real exchange rate at the end of 1997 are probably connected with introduction of managed float and 1999:1 break corresponds with the creation of Euroland.

5. CONCLUSION

The paper uses real exchange rates of eight transition countries in order to test for PPP hypothesis during 16 years of transition. Im, Lee and Tieslau (2005) panel LM unit root test is employed in order to circumvent problems associated with power problem, initial undervaluation of absolute price levels, strong appreciation trends and volatility of former Yugoslav countries prior to dissemination of the common country. Results imply that real exchange rates between the former Yugoslav states and Germany are stationary when breaks are accounted for. Furthermore, stationarity of real exchange rates of former Yugoslav countries is implied

even in the test with one break. Such a strong evidence of stationarity in the 10 years long sample of four countries is obviously a proof of rather fast post-war convergence of real exchange rates to the long run equilibrium. Economic meaning of these purely econometrical findings implies a strong proof of quite rapid recovery of international economic relationships in central and south east Europe vis a vis EU.

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TABLES

Table 1: Data series used in compilation of real exchange rates

Country	Retail price index	Consumer price index	The nominal exchange rate of the German mark	The nominal exchange rate of Euro
Serbia	1990:1-2006:12	N.A.	1990:1-1998:12	1999:1-2006:12
Croatia	1990:1-1997:12	1998:1-2006:12	1990:1-1998:12	1999:1-2006:12
Slovenia	1990:1-1991:12	1992:1-2006:12	1990:1-1998:12	1999:1-2006:12
Macedonia	1990:1-1996:12	1997:1-2006:12	1990:1-1998:12	1999:1-2006:12
Poland	N.A.	1990:1-2006:12	1994:1-1998:12	1999:1-2006:12
Hungary	N.A.	1990:1-2006:12	1990:1-1998:12	1999:1-2006:12
The Czech Republic	N.A.	1992:1-2006:12	1991:1-1998:12	1999:1-2006:12
Slovakia	N.A.	1992:1-2006:12	1991:1-1998:12	1999:1-2006:12
Germany	1990:1-1990:12*	1991:1-2006:12	Numeraire country	

Note: Data for West Germany only.

Table 2: Descriptive Statistics

		Inflation				Real Exchange Rate			
	Obs	Mean	SD	Min	Max	Mean	SD	Min	Max
Serbia	203	28.376	128.843	7.689	1492.328	1.161	80.203	693.865	520.319
Croatia	203	3.448	7.423	1.410	32.714	0.177	10.490	22.157	130.153
Slovenia	203	1.674	3.122	1.009	19.473	0.090	6.365	15.706	72.051
Macedonia	168	1.235	4.027	9.326	28.179	0.251	5.616	27.498	54.353
Poland	155	0.719	0.907	0.908	4.388	0.298	2.629	5.283	9.936
Hungary	203	1.154	1.145	0.404	7.219	0.389	2.238	8.935	8.620
Czech	179	0.494	0.874	0.802	8.170	0.500	1.972	7.743	7.337
Slovakia	179	0.658	1.043	0.401	8.529	0.536	1.921	6.640	8.467

Note: All data × 100

Table 3: Inflation Correlation

	Serbia	Croatia	Slovenia	Macedonia	Poland	Hungary	Czech	Slovakia
Serbia	1.000							
Croatia	-0.227	1.000						
Slovenia	0.116	0.103	1.000					
Macedonia	0.702	-0.155	0.328	1.000				
Poland	0.059	0.211	0.613	0.287	1.000			
Hungary	0.073	0.282	0.539	0.187	0.786	1.000		
Czech	-0.015	0.259	0.275	0.038	0.462	0.428	1.000	
Slovakia	0.010	0.309	0.269	0.069	0.230	0.322	0.373	1.000

Table 4: Real Exchange Rate Correlation

	Serbia	Croatia	Slovenia	Macedonia	Poland	Hungary	Czech	Slovakia
Serbia	1.000							
Croatia	0.211	1.000						
Slovenia	0.046	0.093	1.000					
Macedonia	0.431	0.134	0.211	1.000				
Poland	-0.028	0.158	0.067	0.079	1.000			
Hungary	-0.104	0.172	0.061	0.067	0.429	1.000		
Czech	0.028	0.104	-0.054	-0.019	0.344	0.173	1.000	
Slovakia	0.067	0.052	0.149	0.047	0.327	0.311	0.274	1.000

Table 5: Unit Root Tests: No Break

	1996-2006	1994 -2006
Serbia	-0.117	-0.045
	(-2.857)	(-1.995)
Croatia	-0.104	-0.113
	(-2.375)	(-2.827)
Slovenia	-0.014	-0.029
	(-0.608)	(-1.890)
Macedonia	-0.044	-0.007
	(-1.718)	(-0.759)
Poland		-0.049
		(-2.198)
Hungary		-0.044
		(-1.874)
Czech		-0.122
		(-3.062)
Slovakia		-0.124
		(-3.523)
Panel LM	0.209	-1.327

Table 6: Unit Root Tests: One Break

	1996-2006				1994-2006			
	Model 1		Model 2		Model 1		Model 2	
	β	Break	β	Break	β	Break	β	Break
Serbia	-0.022	2000.11	-0.024	2000.11	-0.057	2000.11	-0.059	2000.11
	(-1.215)	(1.598)	(-1.263)	(27.205)	(-2.123)	(5.984)	(-2.161)	(5.953)
Croatia	-0.095	2001.07	-0.024	2000.11	-0.079	2001.07	-0.039	2000.11
	(-2.253)	(4.483)	(-1.253)	(-22.799)	(-2.402)	(4.718)	(-1.746)	(-5.947)
Slovenia	-0.022	2001.11	-0.025	2000.11	-0.027	2001.11	-0.056	2000.11
	(-0.841)	(2.388)	(-1.373)	(-23.423)	(-1.379)	(2.384)	(-2.110)	(-5.545)
Macedonia	-0.050	1997.06	-0.038	2000.11	-0.001	1997.06	-0.137	2000.11
	(-1.507)	(14.460)	(-1.359)	(-21.636)	(-0.140)	(12.749)	(-3.379)	(-6.815)
Poland					-0.039	1998.07	-0.053	2000.11
					(-2.005)	(4.223)	(-2.061)	(-5.322)
Hungary					-0.038	2003.05	-0.006	2000.11
					(-1.728)	(3.717)	(-0.524)	(-10.146)
Czech					-0.087	1998.07	-0.056	2000.11
					(-2.632)	(4.715)	(-2.116)	(-4.901)
Slovakia					-0.049	1996.06	-0.056	2000.11
					(-1.965)	(-3.526)	(-2.113)	(-4.681)
Panel LM	1.623**		2.190***		0.796		-0.287	

Note: ***, **, and * represent rejection of the null hypothesis at the 1%, 5%, and 10% level respectively.
The panel *LM* statistics are ~ *N(0,1)*

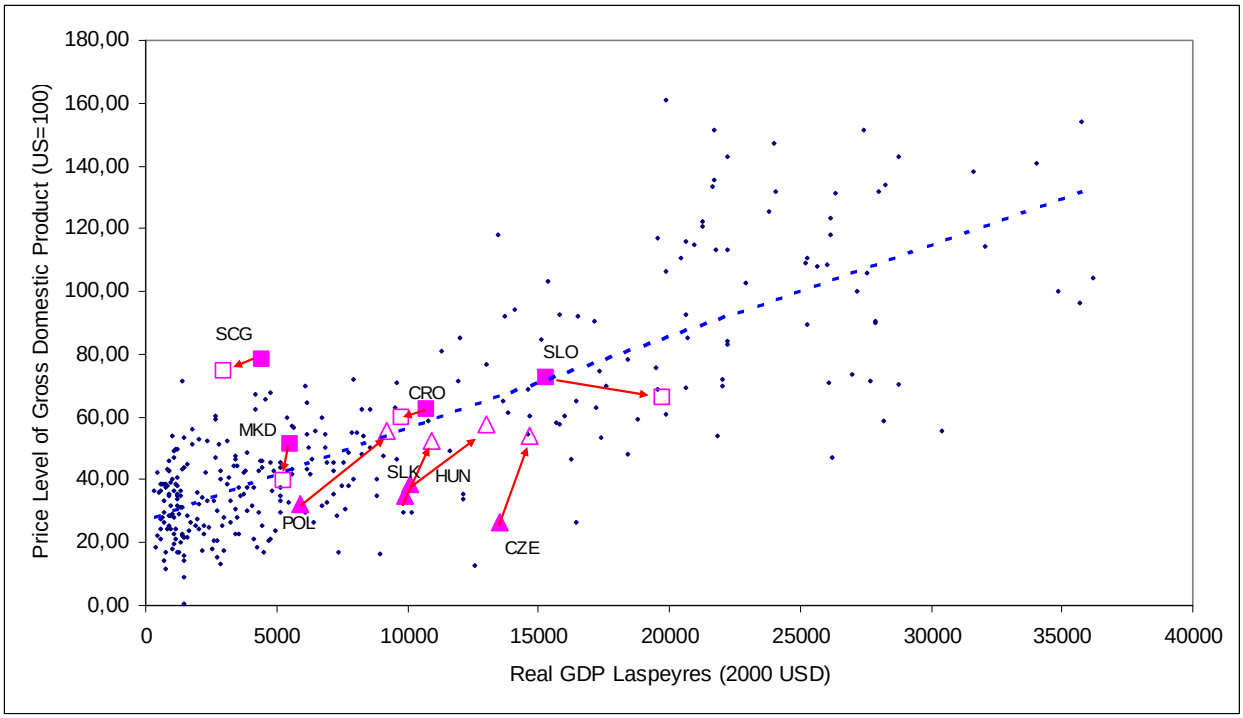
Table 7: Unit Root Tests: Two Breaks

	1996-2006						1990-2006					
	Model "A"			Model "C"			Model "A"			Model "C"		
	β	Break 1	Break 2	β	Break 1	Break 2	β	Break 1	Break 2	β	Break 1	Break 2
Serbia	-0.148	1997.10	2005.11	-0.335	2005.05	2000.12	-0.062	1998.03	2000.11	-0.440	1995.11	2001.04
	(-3.191)	(-0.593)	(0.042)	(-5.019)	(-0.464)	(0.123)	(-2.196)	(2.142)	(5.970)	(-6.483)	(6.338)	(3.316)
Croatia	-0.131	2002.12	2003.10	-0.337	1998.12	2001.07	-0.144	2001.09	2004.06	-0.201	1998.03	2001.07
	(-2.984)	(1.193)	(0.841)	(-5.173)	(4.385)	(-3.355)	(-3.596)	(-1.620)	(1.607)	(-4.529)	(1.276)	(-3.317)
Slovenia	-0.049	1997.04	2003.11	-0.616	1998.10	2002.03	-0.048	1995.04	1997.04	-0.324	1995.08	1998.06
	(-1.494)	(-2.072)	(1.782)	(-6.683)	(5.680)	(0.602)	(-2.327)	(-1.871)	(-1.665)	(-5.913)	(6.015)	(-3.853)
Macdonia	-0.069	1997.03	1997.06	-0.396	1997.05	2000.04	-0.014	1996.10	1997.09	-0.134	1995.05	1997.09
	(-2.124)	(2.521)	(14.148)	(-5.517)	(4.154)	(-5.337)	(-1.319)	(-2.562)	(-2.630)	(-3.092)	(5.035)	(0.123)
Poland							-0.092	2002.05	2003.08	-0.209	2000.12	2003.10
							(-2.952)	(1.961)	(2.770)	(-4.559)	(-1.567)	(--0.296)
Hungary							-0.080	2001.04	2005.08	-0.273	1997.06	2001.12
							(-2.505)	(-3.072)	(0.983)	(-4.132)	(-2.222)	(-1.888)
Czech							-0.214	2003.06	2003.11	-0.321	2001.08	2003.08
							(-3.760)	(1.811)	(1.403)	(-4.809)	(-2.727)	(2.844)
Slovakia							-0.131	1998.11	1999.01	-0.267	1998.07	2000.04
							(-3.515)	(2.550)	(2.707)	(-5.016)	(2.947)	(-1.529)
Panel LM	-12.440***						-13.926***					

Note: ***, **, and * represent rejection of the null hypothesis at the 1%, 5%,and 10% level respectively.
The panel *LM* statistics are ~N(0,1)

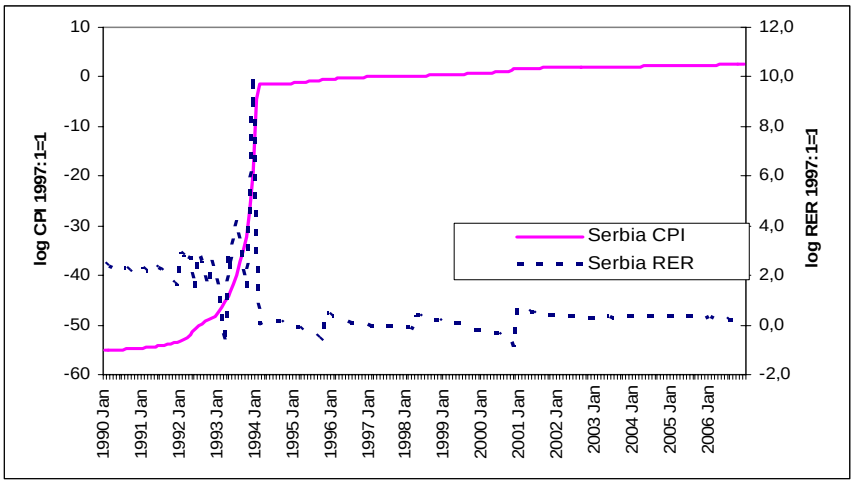
FIGURES

Figure 1: PPP vs GDP per capita (2000 USD) in 1990 and 2003



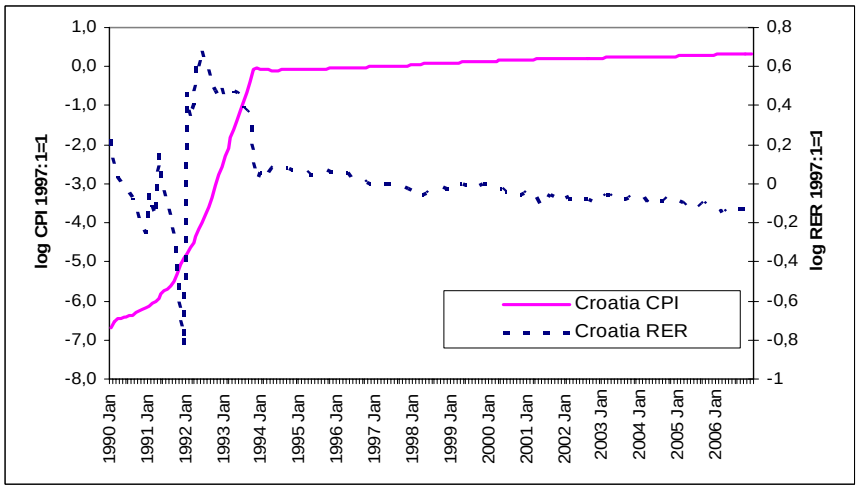
Note: Filled squares represent former Yugoslav countries in 1990 and empty squares in 2003. Filled triangles represent other Central European countries in 1990 and empty triangles in 2003.
Source: Heston, Summers and Betina (2006)

Figure 2: CPI and RER in Serbia 1990:1-2006:12



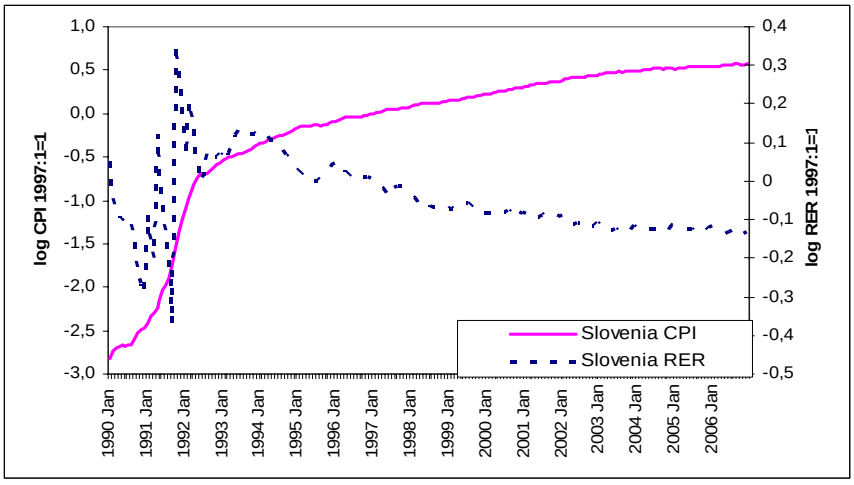
Source: NBS (2007)

Figure 3: CPI and RER in Croatia 1990:1-2006:12



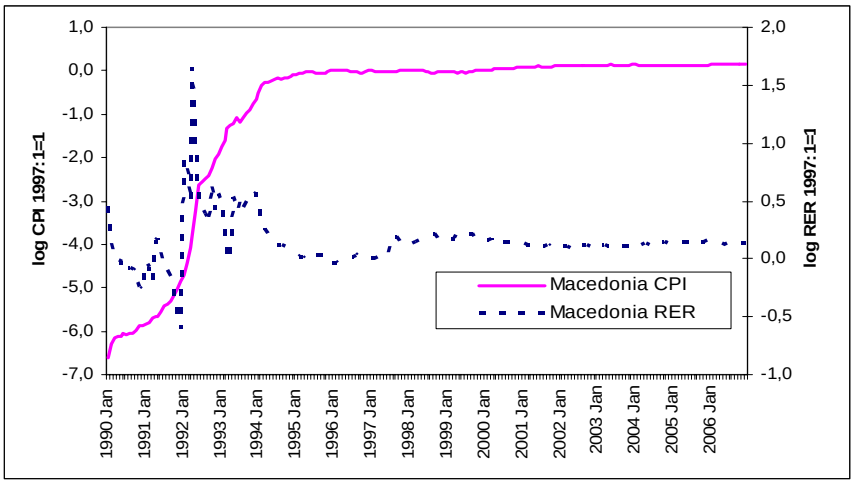
Source: CNB (2008); Anusic et. al. (1995); Tecajevi i Tecajne liste (1993)

Figure 4: CPI and RER in Slovenia 1990:1-2006:12



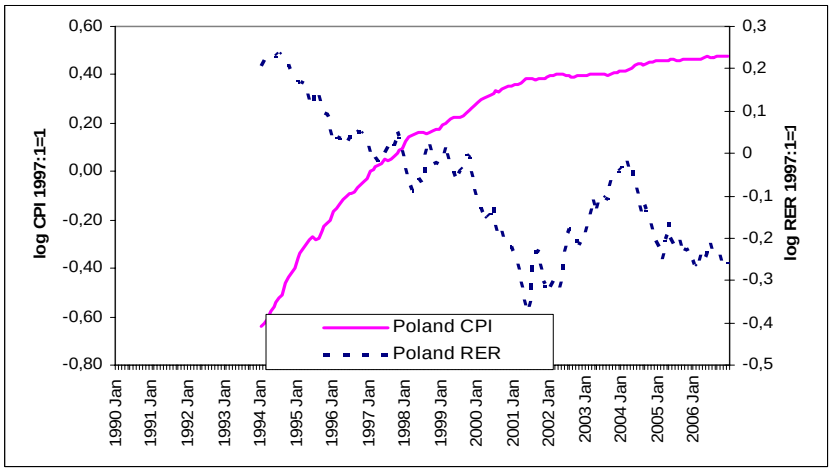
Source: BSI (2007), WIIW (2007)

Figure 5: CPI and RER in Macedonia 1990:1-2006:12



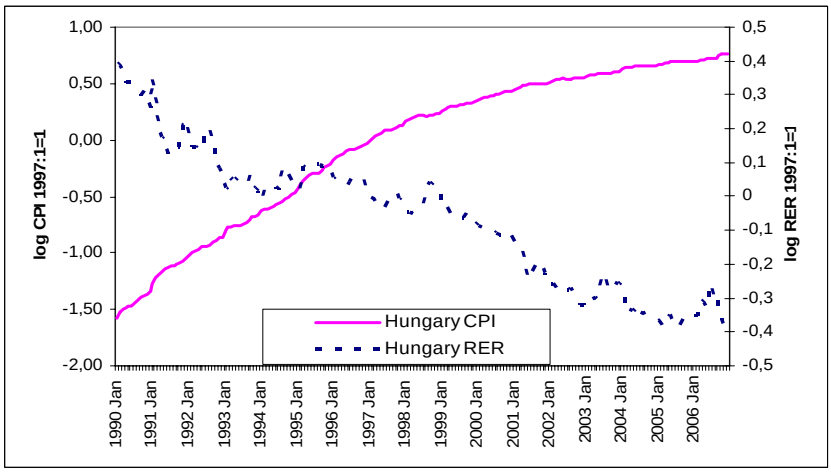
Source: NBRM (2007)

Figure 6: CPI and RER in Poland 1990:1-2006:12



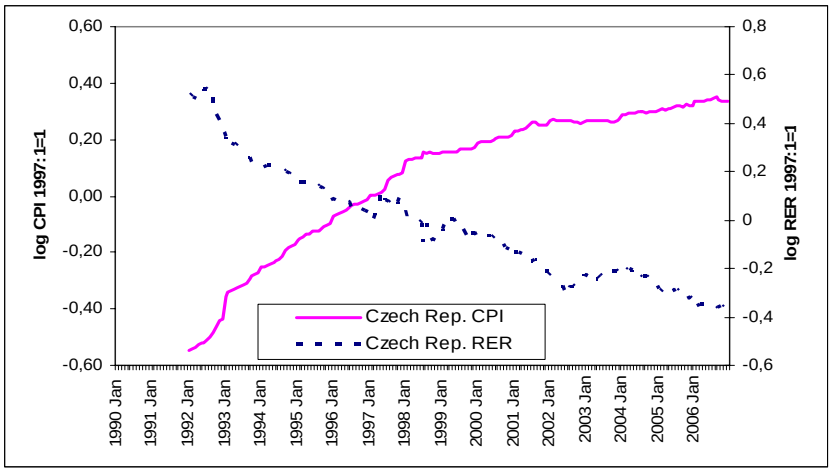
Source: WIIW (2007)

Figure 7: CPI and RER in Hungary 1990:1-2006:12



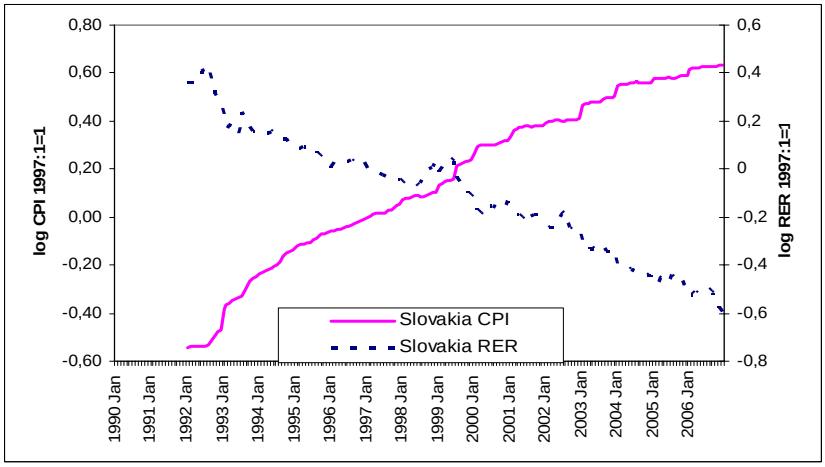
Source: WIIW (2007)

Figure 8: CPI and RER in Czech Rep. 1990:1-2006:12



Source: WIIW (2007)

Figure 9: CPI and RER in Slovakia 1990:1-2006:12



Source: WIIW (2007)