Preliminary version

THE VALIDITY OF PURCHASING POWER PARITY THEORY IN TRANSITION

Darja Boršič
University of Maribor, Slovenia

INTRODUCTION

The theory of purchasing power parity became particularly interesting after the introduction of flexible exchange rate regimes in the 1970s. Since then there is a number of theoretical as well as empirical studies dealing with the phenomena of purchasing power parity.

Empirical contributions consider mainly the developed countries observed in the long run. Among these studies one can find May (1999), Meier (1997), Parikh and Wakerly (2000), Anker (1999), Enders (1995), Cheung and Lai (2000), Culver and Papell (1999) and others. Developing countries are dealt with in Boyd (1999) and Holmes (2001). Eastern European countries are the topic of rare empirical studies in this field, such as Christev and Noorbakhsh (2000) and Choudry (1999).

This paper analyses the validity of purchasing power parity in Slovenia, Czech Republic and Hungary in comparison with selected members of European Union: Austria, Germany, France and Italy, which are also main EU trading partners of the Central European countries in question. The observed period ranges from January 1992 (1993 for Czech Republic) to December 2000. That is from the beginning of transition till the end of the individual European currencies and the introduction of Euro.

The purchasing power parity theory suggests that exchange rate system should provide a mechanism, which would enable a basket of goods being purchased in both analysed countries to cost the same amount of money when recalculated in one currency.

Regarding the low national price level[1] of all countries in question compared to the members of European Union after the decade of reforms, one can conclude that the purchasing power parity does not hold.

The empirical studies show different results regarding the validity of purchasing power parity[2]. However, empirical studies of purchasing power parity usually find evidence in favour of purchasing power parity in the long run and/or when there are huge price differentials among the two countries (McNown and Wallace, 1989). However, Choudry et al. 1993 and Abuaf and Jorion 1990 argue that neither the long

[1] The results of ICP for the year of 1999 present the price level in Slovenia as of 64 % of the price level average in OECD. The same data for the Czech Republic state 39 % and 42 % in Hungary. For the purpose of comparison let us look at the price levels in Europe. The average of 15 European countries reaches the 99 % of OECD price level and the EMU members 96 %, while Austria 102 %, Germany 105 %, France 104 % and Italy 86 %.
[2] Review articles in this filed are: Officer 1976, Froot and Rogoff 1995, Rogoff 1996 and Sarno and Taylor 2002.

run nor the high inflation is not the sufficient condition for the validity of purchasing power parity. The analyses proving the validity of this theory in the periods of high inflation include Frenkel (1978), Taylor and McMahon (1988), McNown and Wallace (1989) and Liu (1992).

Consequently, there is a chance that the hypothesis of this paper could be rejected due to the periods of relatively high inflation in the observed Central European countries in the beginning of the transition period.

Since the observed Central European countries are all suppose to became full members of EU in the near future, the purchasing power parity and the price level should gradually converge to the European average. Thus, this study can contribute to the recognition and understanding of the present differences in the purchasing power parity and price levels among the Central European countries and their main EU trading partners.

THEORY OF PURCHASING POWER PARITY

The absolute purchasing power parity

According to the theory of purchasing power parity the exchange rate among two countries should be equal to the price level of the observed economies. For each basket of goods the exchange rate is suppose to provide the mechanism enabling to buy the same basket of goods abroad for the same price as at home. Thus, the absolute version of the theory applies that the exchange rates and the national price levels constitute an equilibrium relation ship, which can be presented as follows.

$$e_t = \alpha_0 + \alpha_1 p_t + \xi_t \qquad (1),$$

where e_t is the logarithm of nominal exchange rate measured in the units of domestic currency needed for a unit of foreign currency, p_t is the logarithm of price ratio and ξ_t is the residual.

The relative purchasing power parity

The relative version of the theory applies that relative change in exchange rate equals the relative change in price level in the two observed economies. This version of purchasing power parity actually suggests that exchange rate fluctuations eliminate the price differences among the two countries. If E_t presents the nominal exchange rate, P_t indicates price index and * a foreign country, the relative version of the purchasing power parity can be expressed as below:

$$\frac{E_t}{E_{t-1}} = \frac{P_t}{P_{t-1}} \frac{P^*_{t-1}}{P^*_t} \qquad (2)$$

Price indices show the costs of a basket of goods in the observed time period compared to a base point in time. Increased price indices are a sign of inflation, indicating that relative costs of the same basket of goods increased. Consumer price index and producer price index are the most common price indices, the later presenting tradables prices, while the former reflecting also the prices of non tradable goods. However, the methodology of the price recording varies from a country to a country, resulting in specific baskets of goods in national price indices and disabling a proper comparison of prices among the economies. Here the relative version of the theory has an advantage since it deals with the changes in price indices and exchange rates and not with their absolute figures.

TESTING FOR THE PURCHASING POWER PARITY IN TRANSITION

The general model of testing for purchasing power parity (Cheung and Lai 1993) is the following:

$$e_t = \alpha_0 + \alpha_1 P_t - \alpha_2 P_t^* + \xi_t \qquad (3),$$

where e_t stands for nominal exchange rates, presented as the price of foreign currency in the units of domestic currency, P are domestic prices and P* are foreign prices. All the variables are in the logarithmic form. In the most restrictive form, there are the following restrictions: $\alpha_0 = 0$, $\alpha_1 = \alpha_2 = 1$. The symmetry restriction applies that α_1 and α_2 are equal, while the limitation of α_1 and α_2 being equal to one is called the proportionality restriction (Froot in Rogoff 1995).

Testing the real exchange rates

The empirical analysis starts off with the most restrictive version of the model ($\alpha_1 = \alpha_2 = 1$), that is testing the real exchange rates. In the context of the relative PPP the movements in exchange rates are expected to compensate for price level shifts. Thus, real exchange rates should be constant over a long run and their time series should be stationary.

The real exchange rates are calculated from the nominal exchange rates using the consumer price index (CPI), which includes the whole range of price, the tradables as well as the non tradables:

$$re_t = e_t + p_t^* - p_t \qquad (4),$$

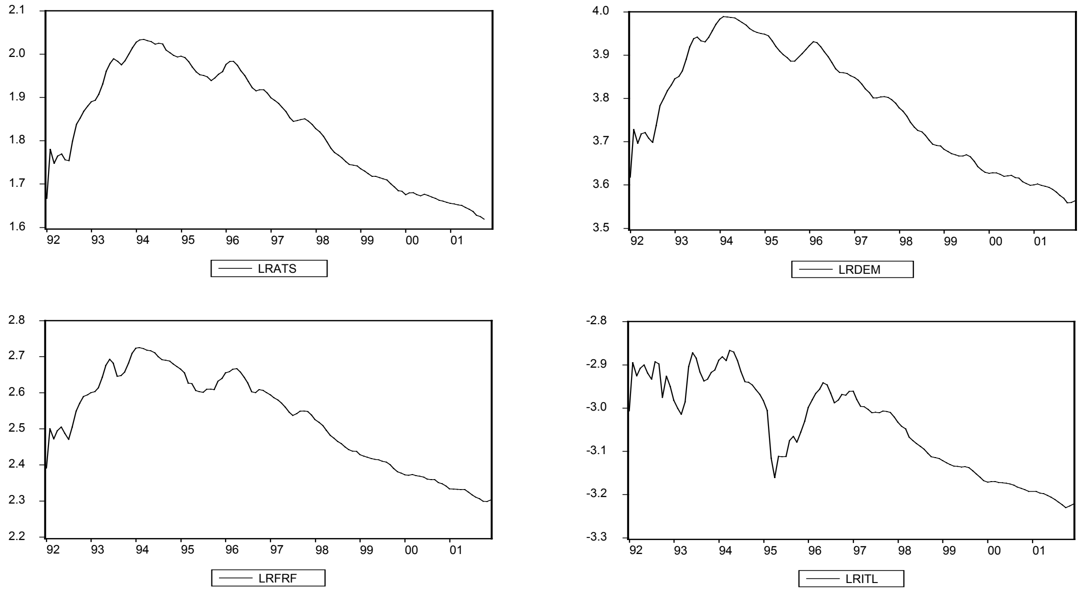
where re_t stands for the real exchange rate, e_t is the price of a foreign currency in units of domestic currency , p are consumer price indices and * indicates a foreign country. In this way, the real exchange rates are calculated for Slovene tolar, Hungarian forint and the Czech koruna regarding Austria, Germany, France and Italy.

The stationarity of real exchange rates is first being checked graphically and then confirmed by Augmented Dickey Fuller test. Time series are stationary if their mean and variance are constant over time, while the value of the covariance depends only on the time lag and not on the actual time point where the covariance is being calculated.

Enders (1995) argues that the shocks to which a stationary time series is exposed to are temporary and their influence gradually diminish. Consequently, the time series converges to its long run mean. The covariance of a stationary time series converges to its mean and fluctuates around its constant long run mean, the variance of the series does not depend on a time lag and its correlogram disappears while the time lag increase. On the contrary, the mean and the variance of a nonstationary time series depend on the time lag, there is no long run mean to which the series would converge, the variance depends on the time lag and its value increases while the time lag increases, its correlogram does not diminish quickly but slowly decreases.

The graphical analysis is presented in the following figures. The graph of a stationary time series is not suppose to reflect any kind of a time trend. Figure 1 presents the graphs of real exchange rates of Slovene tolar, where one can clearly see the time trend and conclude that these time series are not stationary.

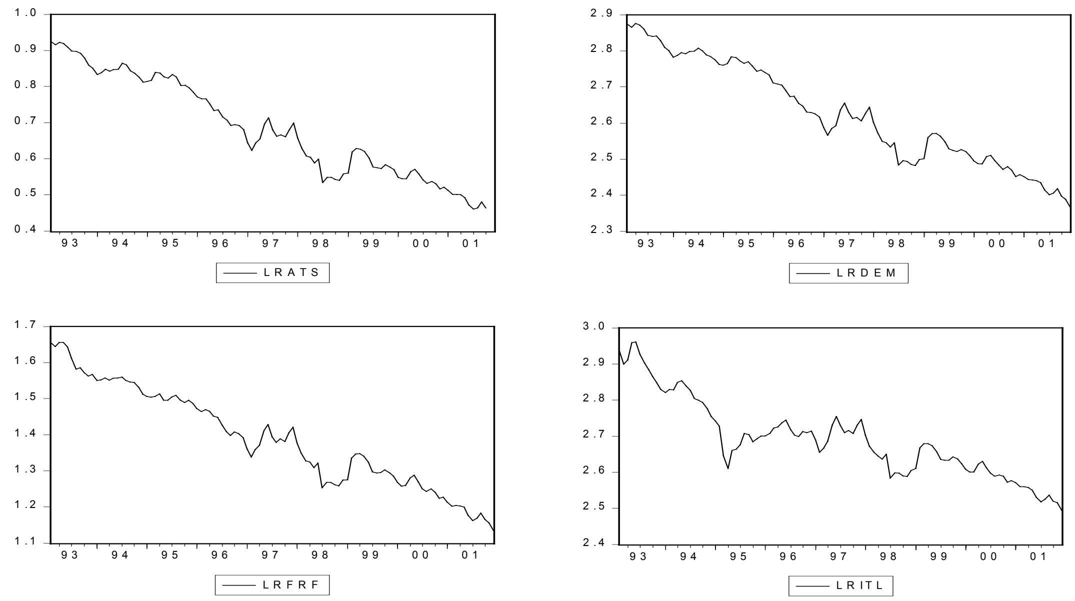
Figure 1: Real exchange rates of Slovene tolar



Source of data: Bank of Slovenia

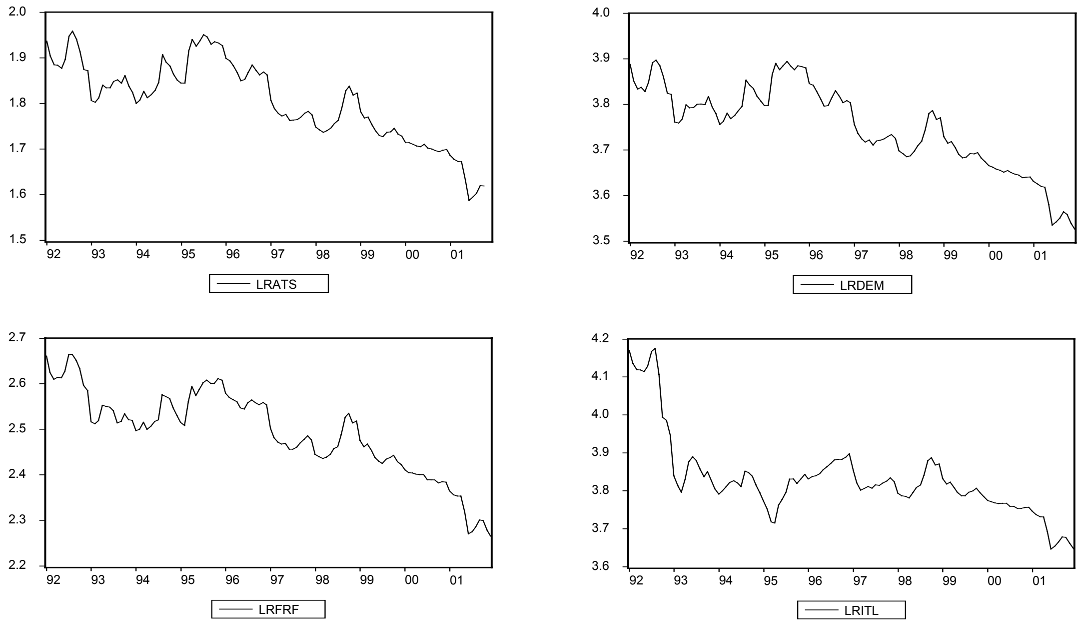
The same result can be concluded from the figures 2 and 3, presenting the real exchange rates of Hungarian forint and the Czech koruna. In both cases there is a clear time trend. Thus, the main hypothesis of this paper can be accepted, that is, the purchasing power parity in Slovenia, Hungary and the Czech Republic does not hold in the observed time period.

Figure 2: Real exchange rates of Czech koruna



Source of data: Czech national bank

Figure 3: Real exchange rates of Hungarian forint



Source of data: Hungarian national bank

The stationarity of a time series can be graphically determined also by the correlogram of the autocorrelation function, which is defined as (Gujarati 1995):

$$\rho_k = \gamma_k / \gamma_0 \qquad (6),$$

where γ_k presents the covariance if k-th time lag, while γ_0 indicates the variance of the time series. The value of ρ_k ranges from -1 to 1. The correlogram of the autocorrelation function is a graph, which reflects the values of ρ_k according to the time lag. In the case of a stationary time series, the autocorrelation function will rapidly converge to 0. While in the case of a non stationary time series the autocorrelation function only gradually converges to 0.

Tables 1 to 3 showing the values of autocorrelation functions of the real exchange rates for different time lags, present similar results as the graphs above. In almost every case there is only a gradual convergence to 0. For Slovene tolar (table 1) the real exchange rate of Italian lira exhibits the lowest value of the autocorrelation function after the twelve time lags and it is only near to 0,5, all other real exchange rates of tolar stops at about 0,68. Thus, also from this graphical methodology the hypothesis can be accepted and the purchasing power parity in Slovenia in the observed period compared to its main EU trading partners does not hold.

As for the real exchange rates of the Czech koruna, after the twelve time lags the value of the autocorrelation function ranges from 0,682 to 0,424 for Austrian schilling and Italian lira respectively. The real exchange rate of koruna in comparison to lira reaches far the lowest value, since the autocorrelation function of all other real exchange rates of koruna are above 0,6.

The autocorrelation functions of the real exchange rates of Hungarian forint have the lowest value of all ranging from 0,51 in comparison to German mark to even 0,136 for Italian lira. Thus, this is the first evidence in favour of purchasing power parity between Hungarian forint and Italian lira.

Table 1: Correlograms for the real exchange rates of Slovene tolar

Correlogram LRATS
Sample: 1992:01 2001:10
Included observations: 118

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>.|******* |</td><td>.|****** |</td><td>1</td><td>0.974</td><td>0.974</td><td>114.86</td><td>0.000</td></tr>
<tr><td>.|******* |</td><td>.|* |</td><td>2</td><td>0.956</td><td>0.146</td><td>226.53</td><td>0.000</td></tr>
<tr><td>.|******* |</td><td>*|. |</td><td>3</td><td>0.933</td><td>-0.098</td><td>333.72</td><td>0.000</td></tr>
<tr><td>.|******* |</td><td>.|. |</td><td>4</td><td>0.910</td><td>-0.043</td><td>436.49</td><td>0.000</td></tr>
<tr><td>.|******* |</td><td>.|. |</td><td>5</td><td>0.886</td><td>-0.012</td><td>534.84</td><td>0.000</td></tr>
<tr><td>.|******* |</td><td>.|. |</td><td>6</td><td>0.860</td><td>-0.047</td><td>628.44</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>*|. |</td><td>7</td><td>0.831</td><td>-0.094</td><td>716.62</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>.|. |</td><td>8</td><td>0.802</td><td>-0.041</td><td>799.41</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>.|. |</td><td>9</td><td>0.773</td><td>0.010</td><td>877.09</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>.|. |</td><td>10</td><td>0.743</td><td>-0.035</td><td>949.49</td><td>0.000</td></tr>
<tr><td>.|***** |</td><td>.|. |</td><td>11</td><td>0.713</td><td>-0.036</td><td>1016.7</td><td>0.000</td></tr>
<tr><td>.|***** |</td><td>.|. |</td><td>12</td><td>0.682</td><td>-0.016</td><td>1078.8</td><td>0.000</td></tr>
</table>

Correlogram LRDEM
Sample: 1992:01 2001:12
Included observations: 120

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>.|******** |</td><td>.|******** |</td><td>1</td><td>0.976</td><td>0.976</td><td>117.24</td><td>0.000</td></tr>
<tr><td>.|******* |</td><td>.|* |</td><td>2</td><td>0.958</td><td>0.108</td><td>231.13</td><td>0.000</td></tr>
<tr><td>.|******* |</td><td>*|. |</td><td>3</td><td>0.934</td><td>-0.124</td><td>340.29</td><td>0.000</td></tr>
<tr><td>.|******* |</td><td>.|. |</td><td>4</td><td>0.911</td><td>-0.026</td><td>444.93</td><td>0.000</td></tr>
<tr><td>.|******* |</td><td>.|. |</td><td>5</td><td>0.886</td><td>-0.011</td><td>544.97</td><td>0.000</td></tr>
<tr><td>.|******* |</td><td>.|. |</td><td>6</td><td>0.861</td><td>-0.036</td><td>640.27</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>*|. |</td><td>7</td><td>0.833</td><td>-0.087</td><td>730.20</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>.|. |</td><td>8</td><td>0.804</td><td>-0.044</td><td>814.70</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>.|. |</td><td>9</td><td>0.776</td><td>0.018</td><td>894.12</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>.|. |</td><td>10</td><td>0.747</td><td>-0.030</td><td>968.33</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>.|. |</td><td>11</td><td>0.718</td><td>-0.024</td><td>1037.5</td><td>0.000</td></tr>
<tr><td>.|***** |</td><td>.|. |</td><td>12</td><td>0.688</td><td>-0.030</td><td>1101.6</td><td>0.000</td></tr>
</table>

Correlogram LRFRF
Sample: 1992:01 2001:12
Included observations: 120

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>.|******* |</td><td>.|******* |</td><td>1</td><td>0.975</td><td>0.975</td><td>117.02</td><td>0.000</td></tr>
<tr><td>.|******* |</td><td>.|. |</td><td>2</td><td>0.954</td><td>0.063</td><td>230.01</td><td>0.000</td></tr>
<tr><td>.|******* |</td><td>*|. |</td><td>3</td><td>0.928</td><td>-0.104</td><td>337.87</td><td>0.000</td></tr>
<tr><td>.|******* |</td><td>.|. |</td><td>4</td><td>0.904</td><td>-0.001</td><td>440.98</td><td>0.000</td></tr>
<tr><td>.|******* |</td><td>.|. |</td><td>5</td><td>0.881</td><td>0.031</td><td>539.74</td><td>0.000</td></tr>
<tr><td>.|******* |</td><td>.|. |</td><td>6</td><td>0.857</td><td>-0.021</td><td>634.12</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>*|. |</td><td>7</td><td>0.830</td><td>-0.095</td><td>723.40</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>*|. |</td><td>8</td><td>0.801</td><td>-0.060</td><td>807.32</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>.|. |</td><td>9</td><td>0.772</td><td>-0.004</td><td>886.00</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>.|. |</td><td>10</td><td>0.743</td><td>-0.022</td><td>959.48</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>.|. |</td><td>11</td><td>0.715</td><td>-0.002</td><td>1028.1</td><td>0.000</td></tr>
<tr><td>.|***** |</td><td>.|. |</td><td>12</td><td>0.687</td><td>-0.011</td><td>1092.1</td><td>0.000</td></tr>
</table>

Correlogram LRITL
Sample: 1992:01 2001:12
Included observations: 120

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>.|*******|</td><td>.|******* |</td><td>1</td><td>0.964</td><td>0.964</td><td>114.35</td><td>0.000</td></tr>
<tr><td>.|*******|</td><td>*|. |</td><td>2</td><td>0.918</td><td>-0.164</td><td>218.89</td><td>0.000</td></tr>
<tr><td>.|*******|</td><td>.|. |</td><td>3</td><td>0.875</td><td>0.044</td><td>314.71</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>*|. |</td><td>4</td><td>0.828</td><td>-0.095</td><td>401.31</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>.|. |</td><td>5</td><td>0.786</td><td>0.061</td><td>479.98</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>.|. |</td><td>6</td><td>0.751</td><td>0.051</td><td>552.40</td><td>0.000</td></tr>
<tr><td>.|***** |</td><td>*|. |</td><td>7</td><td>0.711</td><td>-0.111</td><td>617.84</td><td>0.000</td></tr>
<tr><td>.|***** |</td><td>.|. |</td><td>8</td><td>0.667</td><td>-0.053</td><td>675.91</td><td>0.000</td></tr>
<tr><td>.|***** |</td><td>.|. |</td><td>9</td><td>0.629</td><td>0.062</td><td>728.02</td><td>0.000</td></tr>
<tr><td>.|**** |</td><td>*|. |</td><td>10</td><td>0.587</td><td>-0.091</td><td>773.86</td><td>0.000</td></tr>
<tr><td>.|**** |</td><td>.|. |</td><td>11</td><td>0.547</td><td>0.043</td><td>814.12</td><td>0.000</td></tr>
<tr><td>.|**** |</td><td>.|. |</td><td>12</td><td>0.515</td><td>0.021</td><td>850.04</td><td>0.000</td></tr>
</table>

Source of data: Bank of Slovenia

Table 2: Correlograms for the real exchange rates of Czech koruna

Correlogram of LRATS
Sample: 1993:02 2001:12
Included observations: 105

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |******* |	. |******* |	1	0.966	0.966	100.78	0.000
. |******* |	. |. |	2	0.932	-0.018	195.46	0.000
. |******* |	.*|. |	3	0.894	-0.065	283.56	0.000
. |******* |	. |. |	4	0.858	-0.002	365.47	0.000
. |****** |	. |. |	5	0.825	0.033	441.98	0.000
. |****** |	. |. |	6	0.796	0.032	513.87	0.000
. |****** |	.*|. |	7	0.763	-0.069	580.67	0.000
. |****** |	. |. |	8	0.732	-0.002	642.75	0.000
. |***** |	. |. |	9	0.702	0.009	700.44	0.000
. |***** |	. |. |	10	0.677	0.054	754.60	0.000
. |***** |	. |. |	11	0.656	0.047	805.99	0.000
. |***** |	. |. |	12	0.637	0.006	854.96	0.000

Correlogram of LRDEM
Sample: 1993:02 2001:12
Included observations: 107

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |******* |	. |******* |	1	0.964	0.964	102.20	0.000
. |******* |	. |. |	2	0.928	-0.005	197.96	0.000
. |******* |	. |. |	3	0.892	-0.035	287.19	0.000
. |******* |	. |. |	4	0.859	0.031	370.77	0.000
. |****** |	. |. |	5	0.826	-0.018	448.81	0.000
. |****** |	. |. |	6	0.794	-0.005	521.66	0.000
. |****** |	. |. |	7	0.761	-0.041	589.12	0.000
. |****** |	. |. |	8	0.730	0.023	651.87	0.000
. |***** |	. |. |	9	0.701	0.010	710.34	0.000
. |***** |	. |. |	10	0.675	0.021	765.12	0.000
. |***** |	. |. |	11	0.652	0.033	816.79	0.000
. |***** |	. |. |	12	0.633	0.035	865.94	0.000

Correlogram of LRFRF
Sample: 1993:02 2001:12
Included observations: 107

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|******* |	. |******* |	1	0.959	0.959	101.09	0.000
.|******* |	. |. |	2	0.918	-0.008	194.71	0.000
. |******* |	. |. |	3	0.877	-0.029	280.98	0.000
. |****** |	. |. |	4	0.839	0.020	360.77	0.000
. |****** |	. |. |	5	0.803	-0.010	434.41	0.000
. |****** |	. |. |	6	0.768	0.008	502.51	0.000
. |****** |	. |. |	7	0.734	-0.010	565.35	0.000
. |***** |	. |. |	8	0.703	0.015	623.54	0.000
. |***** |	. |. |	9	0.674	0.017	677.64	0.000
. |***** |	. |. |	10	0.649	0.024	728.26	0.000
. |***** |	. |. |	11	0.626	0.013	775.80	0.000
. |***** |	. |. |	12	0.606	0.036	820.91	0.000

Correlogram of LRITL
Sample: 1993:02 2001:12
Included observations: 107

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |******* |	. |******* |	1	0.941	0.941	97.447	0.000
. |******* |	. |. |	2	0.883	-0.021	184.09	0.000
. |****** |	. |. |	3	0.827	-0.015	260.82	0.000
. |****** |	.*|. |	4	0.766	-0.078	327.21	0.000
. |***** |	. |. |	5	0.705	-0.025	384.11	0.000
. |***** |	. |. |	6	0.653	0.030	433.31	0.000
. |***** |	. |. |	7	0.598	-0.045	475.05	0.000
. |**** |	. |. |	8	0.550	0.018	510.63	0.000
. |**** |	. |. |	9	0.508	0.023	541.30	0.000
. |**** |	. |. |	10	0.472	0.031	568.08	0.000
. |*** |	. |. |	11	0.445	0.053	592.16	0.000
. |*** |	. |. |	12	0.424	0.023	614.20	0.000

Source of data: Czech national bank

Table 3: Correlograms for the real exchange rates of Hungarian forint

Correlogram of LRATS
Sample: 1992:01 2001:12
Included observations: 118

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>.|******* |</td><td>.|*******|</td><td>1</td><td>0.947</td><td>0.947</td><td>108.65</td><td>0.000</td></tr>
<tr><td>.|******* |</td><td>*|. |</td><td>2</td><td>0.886</td><td>-0.117</td><td>204.42</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>.|. |</td><td>3</td><td>0.822</td><td>-0.048</td><td>287.57</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>.|. |</td><td>4</td><td>0.759</td><td>-0.020</td><td>359.11</td><td>0.000</td></tr>
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<tr><td>.|***** |</td><td>.|* |</td><td>6</td><td>0.657</td><td>0.096</td><td>475.15</td><td>0.000</td></tr>
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<tr><td>.|**** |</td><td>.|. |</td><td>11</td><td>0.520</td><td>0.012</td><td>686.13</td><td>0.000</td></tr>
<tr><td>.|**** |</td><td>*|. |</td><td>12</td><td>0.493</td><td>-0.059</td><td>718.57</td><td>0.000</td></tr>
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Correlogram of LRDEM
Sample: 1992:01 2001:12
Included observations: 120

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
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<tr><td>.|***** |</td><td>.|. |</td><td>6</td><td>0.694</td><td>-0.016</td><td>505.06</td><td>0.000</td></tr>
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<tr><td>.|**** |</td><td>.|. |</td><td>10</td><td>0.561</td><td>0.024</td><td>695.79</td><td>0.000</td></tr>
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Correlogram of LRFRF
Sample: 1992:01 2001:12
Included observations: 120

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
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<tr><td>.|**** |</td><td>.|* |</td><td>8</td><td>0.577</td><td>0.068</td><td>584.74</td><td>0.000</td></tr>
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<tr><td>.|**** |</td><td>.|. |</td><td>10</td><td>0.510</td><td>0.020</td><td>658.10</td><td>0.000</td></tr>
<tr><td>.|**** |</td><td>.|. |</td><td>11</td><td>0.480</td><td>-0.008</td><td>689.08</td><td>0.000</td></tr>
<tr><td>.|*** |</td><td>.|. |</td><td>12</td><td>0.448</td><td>-0.034</td><td>716.23</td><td>0.000</td></tr>
</table>

Correlogram of LRITL
Sample: 1992:01 2001:12
Included observations: 120

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>.|******* |</td><td>.|*******|</td><td>1</td><td>0.920</td><td>0.920</td><td>104.16</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>*|. |</td><td>2</td><td>0.828</td><td>-0.118</td><td>189.31</td><td>0.000</td></tr>
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<tr><td>.|***** |</td><td>*|. |</td><td>4</td><td>0.649</td><td>-0.072</td><td>310.93</td><td>0.000</td></tr>
<tr><td>.|**** |</td><td>.|. |</td><td>5</td><td>0.558</td><td>-0.045</td><td>350.63</td><td>0.000</td></tr>
<tr><td>.|**** |</td><td>.|. |</td><td>6</td><td>0.469</td><td>-0.057</td><td>378.85</td><td>0.000</td></tr>
<tr><td>.|*** |</td><td>*|. |</td><td>7</td><td>0.375</td><td>-0.085</td><td>397.10</td><td>0.000</td></tr>
<tr><td>.|** |</td><td>.|. |</td><td>8</td><td>0.294</td><td>0.014</td><td>408.38</td><td>0.000</td></tr>
<tr><td>.|** |</td><td>.|* |</td><td>9</td><td>0.239</td><td>0.107</td><td>415.93</td><td>0.000</td></tr>
<tr><td>.|** |</td><td>.|* |</td><td>10</td><td>0.212</td><td>0.120</td><td>421.92</td><td>0.000</td></tr>
<tr><td>.|* |</td><td>*|. |</td><td>11</td><td>0.176</td><td>-0.114</td><td>426.09</td><td>0.000</td></tr>
<tr><td>.|* |</td><td>.|. |</td><td>12</td><td>0.139</td><td>-0.041</td><td>428.70</td><td>0.000</td></tr>
</table>

Source of data: Hungarian national bank

After the preliminary graphical tests the time series of the observed real exchange rates are empirically tested for the presence of a unit root by the Dickey-Fuller test.

Dickey and Fuller (1979) take into account three different regressions for testing the presence of a unit root:

$$\Delta Y_t = \delta\, Y_{t-1} + u_t \qquad (7),$$

$$\Delta Y_t = \beta_1 + \delta\, Y_{t-1} + u_t \qquad (8),$$

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta\, Y_{t-1} + u_t \qquad (9),$$

where t indicates a time trend. In each of the above regressions the zero hypothesis is that there is unit root in the time series (H_0: $\delta = 0$). The difference in equation 9 in comparison with equations 7 and 8 is the inclusion of a constant and a time trend. If the residuals are autocorrelated, the equation 9 can be rewritten as:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta\, Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-1} + \varepsilon_t \qquad (10),$$

where $\Delta Y_{t-1} = Y_{t-1} - Y_{t-2}$ and time lags are used in the first differences. The hypothesis is still the same as above. The Dickey-Fuller test according to the equation 10 is called augmented Dickey-Fuller test and will be used also in this analysis.

The results of these tests are presented in tables 4 to 6. The constant was included in the tests of the level and first difference series. In order not to unnecessarily loose too many observations in relatively short time series the included lag was never longer than six months and was determined by AIC.

Tables 4 to 6 require some additional explanation. The first ADF statistic of each of the real exchange rates presents the ADF statistic of the level series, while the second one represents the results of the test for first difference series. The subscript next to the ADF statistics indicates the time lag used in the test, which was as mentioned above for each of the time series selected by the Akaike information criterion.

Table 4: Results of ADF tests of real exchange rates of Slovene tolar

SITATS			SITDEM		
ADF statistic	Critical Value		ADF statistic	Critical Value	
$-0{,}6400_6$	1%	-3,4900	$-0{,}81620_6$	1%	-3,4890
	5%	-2,8874		5%	-2,8870
	10%	-2,5804		10%	-2,5802
$-2{,}9538_6$	1%	-3,4906	$-3{,}257902_6$	1%	-3,4895
	5%	-2,8877		5%	-2,8872
	10%	-2,5805		10%	-2,5803
SITFRF			**SITITL**		
ADF statistic	Critical Value		ADF statistic	Critical Value	
$-0{,}6003_6$	1%	-2,4890	$-0{,}8123_4$	1%	-3,4880
	5%	-2,8870		5%	-2,8865
	10%	-2,5802		10%	-2,5799
$-2{,}8850_6$	1%	-3,4895	$-5{,}3557_4$	1%	-3,4885
	5%	-2,8872		5%	-2,8868
	10%	-2,5803		10%	-2,5801

Source of data: Bank of Slovenia

The results in table 4 show that the four time series of the real exchange rates of tolar are integrated of order 1, which means one cannot reject the hypothesis of the presence of the unit root. Thus, also the ADF test confirms the graphical results of non stationarity in the observed time series.

According to table 5 the real exchange rates of Czech koruna are non stationary since all of the ADF test statistics in level data are above the critical values indicating that the series are integrated of order 1 and the purchasing power parity in the Czech Republic does not hold.

While table 6 shows similar situation for Hungarian forint in the case of real exchange rates of forint to German mark, Austrian schilling and French frank, there is some evidence in favour of purchasing power parity in the case of Italian lira. Namely, the real exchange rate of the forint to Italian lira has proven to be stationary. The ADF statistic of the level series is -4,2603, which is well below the lowest critical value of the test (-3,4890), resulting in accepting the H_0 of the ADF test.

Table 5: Results of ADF tests of the real exchange rates of the Czech koruna

CZKATS			CZKDEM		
ADF statistic	Critical Value		ADF statistic	Critical Value	
$-0,7843_1$	1%	-3,4946	$-0,4984_1$	1%	-3,4934
	5%	-2,8895		5%	-2,8889
	10%	-2,5815		10%	-2,5812
$-4,2397_6$	1%	-3,4986	$-4,1920_6$	1%	-3,4972
	5%	-2,8912		5%	-2,8906
	10%	-2,5824		10%	-2,5821
CZKFRF			CZKITL		
ADF statistic	Critical Value		ADF statistic	Critical Value	
$-0,3030_6$	1%	-3,4965	-1,5060	1%	-3,4965
	5%	-2,8903		5%	-2,8903
	10%	-2,5819		10%	-2,5819
$-4,0726_6$	1%	-3,4972	-3,9556	1%	-3,4972
	5%	-2,8906		5%	-2,8906
	10%	-2,5821		10%	-2,5821

Source of data: Czech national bank

Table 6: Results of ADF tests of the real exchange rates of Hungarian forint

HUFATS			HUFDEM		
ADF statistic	Critical Value		ADF statistic	Critical Value	
$-0,4161_6$	1%	-3,4900	$0,2551_6$	1%	-3,4890
	5%	2,8874		5%	-2,8870
	10%	2,5804		10%	-2,5802
$-6,3955_5$	1%	-3,4900	$-5,9214_5$	1%	-3,4890
	5%	-2,8874		5%	-2,8870
	10%	-2,5804		10%	-2,5802
HUFFRF			HUFITL		
ADF statistic	Critical Value		ADF statistic	Critical Value	
$-0,5868_1$	1%	-3,4865	$-4,2603_6$	1%	-3,4890
	5%	-2,8859		5%	-2,8870
	10%	-2,5796		10%	-2,5802
$-7,1321_1$	1%	-3,4870	$-6,8286_1$	1%	3,4870
	5%	-2,8861		5%	-2,8861
	10%	-2,5797		10%	-2,5797

Source of data: Hungarian national bank

The Engle-Granger test of cointegration

Relaxing the proportionality condition in equation (1) allows us to test if nominal exchange rates and relative prices are cointegrated. PPP holds if the presence of long-run equilibrium relation is confirmed. Taylor (1988), Kim (1990), Mark (1990) and Pufnik (2002) are some of the examples of this approach.

In the case of searching for cointegration among two variables Engle-Granger test is an appropriate one (Maddala and Kim 1998). It can be undertaken in two steps. First the order of integration must be checked for the observed variables. The series included in the test must be of the same order of integration.

Table 7: Results of ADF tests of nominal exchange rates and relative prices

SLOVENIA			
Nominal exchange rates			
	level	1st difference	2nd difference
LATS	/	I(1)	
LDEM	/	I(1)	
LFRF	/	I(1)	
LITL	/	I(1)	
Relative prices			
LCPISIA	/	I(1)	
LCPISIG	/	I(1)	
LCPISIF	/	I(1)	
LCPISII	/	I(1)	
CZECH REPUBLIC			
Nominal exchange rates			
	level	1st difference	2nd difference
LATS	/	I(1)	I(2)
LDEM	/	I(1)	I(2)
LFRF	/	I(1)	I(2)
LITL	/	I(1)	I(2)
Relative prices			
LCPICZA	/	/	I(2)
LCPICZG	/	/	I(2)
LCPICZF	/	/	I(2)
LCPICZI	/	/	I(2)
HUNGARY			
Nominal exchange rates			
	level	1st difference	2nd difference
LATS	/	I(1)	I(2)
LDEM	/	I(1)	I(2)
LFRF	/	/	I(2)
LITL	/	I(1)	I(2)
Relative prices			
LCPIHUA	I(0)	I(1)	I(2)
LCPIHUG	I(0)	I(1)	I(2)
LCPIHUF	I(0)	I(1)	I(2)
LCPIHUI	I(0)	I(1)	I(2)

Source of data: National banks of corresponding countries

After using ADF test to determine the order of integration of nominal exchange rates and relative prices (table 7), we can check of the residuals in the equation 11. Because of testing the stationarity of residuals in the equation:

$$e_t = \alpha_0 + \alpha_1 (Pt / P_t^*) + \xi_t \qquad (11),$$

this test is also called residual based cointegration test. The variables in the equation 11 are equal as in the equation 3. In this case it can be seen that symmetry conditions still holds, while the proportionality restriction was abandoned and α_1 can be different than 1.

The results of this test are presented in the tables 8 to 10[3]. In explaining the results in these tables, attention must be paid on table 10, which states the orders of integration of the observed variables.

Table 8: The results of Engle-Granger test for Slovenia

RESIDSITATS			RESIDSITDEM		
ADF statistic	Critical Value		ADF statistic	Critical Value	
$-1,9711_6$	1%	-3,4900	$-2,3231_6$	1%	-3,4890
$-1,9711_6$	5%	-2,8874	$-2,3231_6$	5%	-2,8870
$-1,9711_6$	10%	-2,5804	$-2,3231_6$	10%	-2,5802
$-3,3988_6$	1%	-3,4906	$-3,7395_6$	1%	-3,4895
$-3,3988_6$	5%	-2,8877	$-3,7395_6$	5%	-2,8872
$-3,3988_6$	10%	-2,5805	$-3,7395_6$	10%	-2,5803
RESIDSITFRF			RESIDSITITL		
ADF statistic	Critical Value		ADF statistic	Critical Value	
$-2,7777_6$	1%	-3,4890	$-2,7775_4$	1%	-3,4880
$-2,7777_6$	5%	-2,8870	$-2,7775_4$	5%	-2,8865
$-2,7777_6$	10%	-2,5802	$-2,7775_4$	10%	-2,5799
$-3,2183_6$	1%	-3,4895	$-5,8960_3$	1%	-3,4880
$-3,2183_6$	5%	-2,8872	$-5,8960_3$	5%	-2,8865
$-3,2183_6$	10%	-2,5803	$-5,8960_3$	10%	-2,5799

Source of data: Bank of Slovenia

Due to relaxed assumptions of the empirical test of purchasing power parity, there is evidence in favour of this theory in the case of Slovene tolar in comparison to French frank and Italian lira. The table 8 shows that nominal exchange rates and relative prices in these two cases constitute a long run equilibrium relation ship since the residuals of the equation 11 have proven to be stationary. However, there is still no evidence in favour of purchasing power parity for tolar regarding the Austrian schilling and German mark.

In the case of Czech koruna, Engle-Granger test also provide some evidence in favour of purchasing power parity for Italian lira. Namely, the residuals of the equation 11 have proven to be integrated of order 0 since 10% critical value is above the value of the ADF test statistics.

The Engle-Granger test has confirmed the previous results of the validity of purchasing power parity among Hungarian forint and Italian lira (the ADF test statistic of level data is well below the lowest critical value) but has not provided any additional evidence in favour of purchasing power parity theory of forint towards other observed European currencies. However, the stationarity of relative prices in Hungary (table 7) has to be taken into account when interpreting the results of Engle-Granger test.

Table 9: The results of Engle-Granger test for the Czech Republic

[3] The characteristics of tables 8 to 10 are the same as above described characteristics of tables 4 to 6.

RESIDCZKATS			RESIDCZKDEM		
ADF statistic	Critical Value		ADF statistic	Critical Value	
$-2,5359_1$	1%	-3,4946	$-2,0704_1$	1%	-3,4934
	5%	-2,8895		5%	-2,8889
	10%	-2,5815		10%	-2,5812
$-6,3195_1$	1%	-3,4952	$-6,1891_1$	1%	-3,4940
	5%	-2,8897		5%	-2,8892
	10%	-2,5816		10%	-2,5813
RESIDCZKFRF			RESIDCZKITL		
ADF statistic	Critical Value		ADF statistic	Critical Value	
$-2,0413_1$	1%	-3,4934	$-2,5947_3$	1%	-3,4946
	5%	-2,8889		5%	-2,8895
	10%	-2,5812		10%	-2,5815
$-6,3430_1$	1%	-3,4940	$-5,7650_2$	1%	-3,4946
	5%	-2,8892		5%	-2,8895
	10%	-2,5813		10%	-2,5815

Source of the data: Czech national bank

Table 10: The results of Engle-Granger test for Hungary

RESIDHUFATS			RESIDHUFDEM		
ADF statistic	Critical Value		ADF statistic	Critical Value	
$-2,1428_1$	1%	-3,4875	$-1,6872_1$	1%	-3,4865
	5%	-2,8863		5%	-2,8859
	10%	-2,5798		10%	-2,5796
$-5,8592_5$	1%	-3,4900	$-6,8941_1$	1%	-3,4870
	5%	-2,8874		5%	-2,8861
	10%	-2,5804		10%	-2,5797
RESIDHUFFRF			RESIDHUFITL		
ADF statistic	Critical Value		ADF statistic	Critical Value	
$-1,6697_1$	1%	-3,4865	$-3,6201_6$	1%	-3,4890
	5%	-2,8859		5%	-2,8870
	10%	-2,5796		10%	-2,5802
$-7,0589_1$	1%	-3,4870	$-6,8041_1$	1%	-3,4870
	5%	-2,8861		5%	-2,8861
	10%	-2,5797		10%	-2,5797

Source of data: Hungarian national bank

CONCLUSION

The analysis of this paper starts with graphical presentation of real exchange rates of Slovene tolar, Czech koruna and Hungarian forint in comparison with Austrian schilling, German mark, French frank and Italian lira in the 1990s. According to the figures of real exchange rates and the values of their autocorrelation function, there is little evidence in favour of purchasing power parity theory. All of the real exchange rates have proven to be non stationary with the exception of Hungarian forint in comparison to Italian lira. The ADF test has confirmed the conclusions derived from the graphical analysis.

Relaxing the assumption of proportionality and testing for long run equilibrium relation ship among nominal exchange rates and relative prices, Engle-Granger test of cointegration was conducted. The results show that all three of the observed currencies exhibit a long run equilibrium relation with Italian lira and additionally also Slovene tolar with respect to French frank. However, the stationarity of relative prices in Hungary (table 7) has to be taken into account when interpreting the results of Engle-Granger test.

In searching for further evidence of purchasing power parity in transition, the assumption of symmetry could be neglected and Johansen cointegration test carried out, testing for cointegration between nominal exchange rates and individual rather than relative prices. Nevertheless, the further analysis is out of the scope of this paper.

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