Does Real Interest Rate Parity hold in Central and Eastern European Countries?

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Abstract

This paper analyses the empirical fulfilment of the Real Interest Rate Parity (RIRP) theory for a pool of Central and Eastern European Countries. To do so, we apply the recently developed Ng and Perron (2001) unit root tests, that are corrected versions of existing unit root tests and the Kapetanios et al. (2003) unit root test which generalises the alternative hypothesis to the globally stationary smooth transition autoregression model. Our results point to the existence of evidence in favour of the empirical fulfilment of the RIRP, in particular, when taking into account the possibility of nonlinearities in the real interest rate differential.

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1 Introduction

In recent decades, markets have become increasingly integrated as globalisation has gathered momentum. One way of testing the degree of integration is by investigating whether real interest rate parity (RIRP) holds. In brief, RIRP implies that assets with identical risk, liquidity and maturity characteristics offer the same expected return across different countries. However, at least in a theoretical sense as demonstrated in Section 2 below, RIRP holds only if uncovered interest parity (UIP) and relative purchasing power parity (RPPP) hold. The extent to which RIRP holds therefore serve as an indicator of the degree of product and/or financial market integration. This might be important for several reasons and ever since Grubel (1968) it has been well known that diversifying a portfolio along international lines might improve the portfolio's risk-return characteristics. If all other things are equal, international portfolio diversification will be most attractive to investors when there are differences in real rates of interest across countries. Similarly, the extent of product market integration might provide useful information for countries seeking to join a monetary union.

As well as being an indicator of market integration, RIRP is central to our understanding of open economy macroeconomics. If it holds, individual countries will be unable to alter their real interest rate which will be set internationally. This will severely limit their ability to pursue an independent monetary policy thus placing severe restrictions on their power to influence the real economy through this channel.

Intuitively we might expect that in efficient markets, arbitrage would ensure that assets with identical risk, liquidity and maturity characteristics would offer the same expected return. Despite this, the evidence of RIRP is mixed. For example, Mishkin (1984); Cumby and Obstfeld (1984); Cumby and Mishkin (1987); and Fujii and Chinn (2000) found, at best, very limited support for RIRP in the short run. On the other hand, using a data span of 300 years, Lothian (2002) finds supportive evidence for the RIRP hypothesis among developed countries. Because data sets sometimes cover only relatively short spans of time, some studies have used panel data to test for RIRP. For example, Wu and Chen (1998), and Holmes (2002) find evidence of RIRP for developed countries using this approach. Similarly Ferreira and Léon-Ledesma (2007), and Camarero, et al. (2007) find evidence of RIRP in a sample of industrialised and emerging economies applying nonlinear unit root tests, in the former, and for OECD countries applying panel unit root tests with structural changes, in the latter. Baharumshah et al. (2005) find evidence of RIRP for East Asian countries with respect to Japan.

The debate about RIRP remains unsettled and we aim to contribute to the literature by investigating RIRP among those Central and East European countries[1][2]. These countries are of interest because the extent to which economies are integrated is of particular importance to those countries either aiming to join a monetary union, or who

[1] Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Macedonia, Poland, Romania, Slovakia and Slovenia

[2] Slovenia adopted the common currency on January, 1st, 2008 but is included in this study because of its recent entry into the Euro so that we can provide an initial assessment of the appropriateness of Slovenia's decision to joint the common currency.

have recently joined a monetary union. The more highly integrated economies are, the more likely they are to have synchronised business cycles and the closer their real rates of interest are likely to approximate to each other. Unlike Denmark and the United Kingdom, the ten new Members from Central and Eastern Europe have no special status with respect to adopting the euro. They have joined EMU with the status of "countries with a derogation" and are supposed to adopt the euro as soon as they satisfy the convergence criteria as set out in the Maastricht Treaty. To the best of our knowledge only Arghyrou et al. (2008) have analysed the empirical fulfilment of the RIRP condition for a group of CEECs, among others, by means of applying unit root tests with structural changes, finding some evidence in support of the RIRP hypothesis in some of these countries investigated.

As mentioned above, we expect that assuming absence of capital controls and the presence of exchange rate bands within the European Exchange Rate System (EMS), interest rates across countries within the EMS may be cointegrated, in particular in light of the convergence of inflation rates which has been observed since its inception (Devine, 1997). The contribution of our paper is that it provides an important perspective on the extent to which those member states that are the target of our investigation, are integrated with the rest of Europe. This is important because under its current mandate, the European Central Bank is required to set nominal interest rates at the European Monetary Union (EMU) average. It is also required to maintain inflation at an EMU average of no more than 2 per cent, and the main instrument for achieving this is adjustment in its key rates of interest. However, for adjustments in interest rates to be transmitted symmetrically to all member countries, real interest rate differentials must be mean reverting and display similar persistence patterns. If this is not the case, an EMU wide monetary policy based on the average inflation rate for all member states is likely to generate asymmetric effects in output gaps and asset prices in different countries.

In terms of whether the single monetary policy is the optimal choice for particular countries, it is therefore crucial to assess the extent of deviations from RIRP. The more highly integrated countries are, the more likely that the single monetary policy will be appropriate and candidates adopting a common currency will therefore experience fewer asymmetries in their responses to monetary policy shocks. Such considerations are crucial for countries considering sacrificing their own national currency in favour of a common currency and we aim to provide a timely contribution to the literature.

In this paper we aim at contributing to the empirical literature about the validity of the RIRP in the CEECs applying the recently developed Kapetanios et al. (2003) (KSS) nonlinear unit root test, that takes into account the possibility of a smooth transition autoregression (STAR) in the data generation process (DGP). According to these authors, traditional (linear) unit root tests may fail to reject the null hypothesis the the (DGP) is indeed nonlinear and globally stationary. In this context, as KSS (p.369) claim

"*Owing to transaction costs and other frictions, it is quite plausible that the more these* *variables deviate dfrom their equilibrium values, the larger will be the investment/arbritage adjustment flows that drive them back again*".

To the best of our knowledge only KSS and Baharumshah et al. (2007), have applied these unit root tests to the RIRP hypothesis. In general, their results show stronger support for RIRP than tests with linear unit root tests. Nonetheless, we compare the results of applying the KSS test to the CEECs with the Ng and Perron (2001) unit root test. As expected, our results show stronger support for the RIRP hypothesis when taking into account the possibility of asymmetric speed of mean reversion.

The remainder of the article is organised as follows. In the next section, we summarise the RIRP theory, in section 3 we summarise the econometric methodology and in sections 4 and 5 we present our results and conclusions, respectively.

2 The real interest rate parity theory

The RIRP theory contends that the real interest rate between two countries should be equal, i.e.,

$$r_t = r_t^* \tag{1}$$

Where:

$$r_t = i_t - E_t(\Delta p_{t+1}), \tag{2}$$

$$r_t^* = i_t^* - E_t(\Delta p_{t+1}^*), \tag{3}$$

i_t is the nominal interest rate and Δp_{t+1} is the inflation rate between period t and $t+1$, E_t stands for the expected value in period t, and the symbol * refers to the variables of the foreign country. Equation (1) implies that UIP and RPPP between the home and foreign country hold. This relationship is straightforward to prove since the UIP theory implies that:

$$E_t(\Delta e_{t+1}) = i_t - i_t^* \tag{4}$$

whereas RPPP implies

$$\Delta e_t = \Delta p_t - \Delta p_t^*. \tag{5}$$

where Δe_t is the change in the nominal exchange rate between period $t-1$ and t. The latter equation can be rewritten for period $t+1$ and, after taking expected values, it can be written as:

$$E_t(\Delta e_{t+1}) = E_t(\Delta p_{t+1}) - E_t(\Delta p_{t+1}^*). \tag{6}$$

Hence, substituting (4) into (6) we obtain $i_t - i_t^* = E_t(\Delta p_{t+1}) - E_t(\Delta p_{t+1}^*)$, and rearranging gives:

$$i_t - E_t(\Delta p_{t+1}) = i_t^* - E_t(\Delta p_{t+1}^*) \tag{7}$$

which is equivalent to equation (1), i.e. the RIRP condition[3].

[3] See Taylor and Sarno (2004), and Mark and Moh (2005) for more discussion on the relationship between the real exchange rate and the interest rate differential.

3 Econometric Methodology

As noted above, the RIRP above defined implies that the real interest rate differential ($rid_t = r_t - r_t^*$) is constant. Hence, according to Ferreira and Léon-Ledesma (2007), RIRP implies that the rid is a stationary process, since the existence of adjustment costs and imperfect information prevents the rid from being constant at every point. This implies that we can represent rid in Vector Autoregressive (VAR) form as follows:

$$rid_t = \alpha_0 + \alpha_1 rid_{t-1} + \vartheta_t \tag{8}$$

which can be reparameterised as

$$\Delta rid_t = \beta_0 + \beta_1 rid_t + \Sigma_{i=2}^{p} \varphi_i \Delta rid_{t-i+1} + \vartheta_t \tag{9}$$

Now for RIRP to hold empirically, we need to test $H_0 : \beta_1 = 0$ vs. $H_1 : \beta_1 < 0$, which we do by testing for unit roots in the rid. Note that we allow $\beta_0 \neq 0$, since different countries may have different risk premia (Ferreira and Léon-Ledesma, 2007).

In order to test for RIRP in the CEECs we apply two sets of unit root tests. The first tests are Ng and Perron (2001) unit root tests. These authors propose several upgrades to existing unit root tests in order to correct their power and size. In particular, traditional unit root tests may suffer from power problems when the autoregressive parameter is close to 1, and when the errors of a moving average are near to -1. In such cases, the standard information criteria tend to select a relatively low lag length. Given this problem, Ng and Perron (2001) propose the use of a Modified Information Criterion corrected by sample size. They also propose detrending the data by means of Generalised Least Squares (GLS) to overcome the power problem associated with the traditional unit root tests. Thus, the upgraded unit root tests are the Phillips (1987) and Phillips and Perron (1988), MZ_α and MZ_t; the Bhargava (1986) unit root tests, MSB; and the modified version of the Elliot et al. (1996) Point Optimal Test, MP_t.

In order to take into account the possibility of asymmetric speed of mean reversion, we apply the KSS unit root test. According to KSS, traditional (linear) unit root tests may suffer from power problems when the actual DGP is a nonlinear stationary process. In this case the traditional unit root tests might incorrectly conclude that the series are nonstationary. Hence, KSS consider a univariate smooth transition autoregressive model of order 1, STAR(1),

$$x_t = \beta x_{t-1} + \gamma x_{t-1}\Theta(\theta; x_{t-d}) + \varepsilon_t, t = 1, ..., T \tag{10}$$

where $\epsilon_t \sim (0, \sigma^2)$ and $\Theta(\theta; y_{t-d})$ is the transition function. KSS adopt a exponential function in order to define the transition between regimes such that:

$$\Theta(\theta; x_{t-d}) = 1 - e^{-\theta x_{t-d}^2} \tag{11}$$

where $\theta, d \geq 1$. The transition function defined in (11) is bounded between 0 and 1 , i.e. $\Theta(0) = 0$ and $\lim_{y \to \infty} \Theta(y) = 1$.

Plugging (11) into (10) we obtain:

$$x_t = \beta x_{t-1} + \gamma x_{t-1} \left(1 - e^{-\theta x_{t-d}^2}\right) + \epsilon_t. \tag{12}$$

For practical purposes, it is common to reparameterise equation (12) as follows:

$$\Delta x_t = \alpha x_{t-1} + \gamma y_{t-1} \left(1 - e^{-\theta x_{t-d}^2}\right) + \epsilon_t \tag{13}$$

KSS impose $\alpha = 0$ which implies that $x_t \sim I(1)$ in the central regime. In addition and following the recent contributions, we set $d = 1$ (see Bahmani-Oskooee et al. (2007), Bhamani-Oskooe and Gelan, 2007, among others).

Testing for unit roots in this context implies testing $H_0 : \theta = 0$ vs. $H_1 : \theta > 0$. Intuitively, this means testing for unit roots in the outer regime. Note that the process is globally stationary under the alternative hypothesis, provided that $-2 < \gamma < 0$ holds.

However, testing for a unit root in the outer regime is not possible in practice since γ cannot be identified under H_0. In order to compute the test, KSS propose a first-order Taylor series approximation so as to obtain:

$$\Delta x_t = \delta x_{t-1}^3 + error \tag{14}$$

Now, the exercise of hypotheses testing becomes testing $H_0 : \delta = 0$ vs. $H_1 : \delta < 0$, by means of a t-statistic test. Of course, equation (14) may include lags of the dependent variable to control for autocorrelation in the residuals. In this case, the lag length can be obtained by standard procedures such as information criteria. KSS shows that the test can be applied to the raw, demeaned or demeaned and detrended data.

4 Results

4.1 The data

The data for our empirical analysis consists of real interest rate differentials for a pool of Central and Eastern European countries, (Bulgaria, Croatia, Czech Rep., Estonia, Hungary, Latvia, Lithuania, Macedonia, Poland, Romania, Slovenia and Slovak Rep). In order to compute real interest rates, we consider two approaches to the formation of inflation expectations: *ex ante* and *ex post*. The former implies that we obtain expected values for future inflation, whereas the latter assumes that agents are rational and have perfect forecasting skills so that their inflation expectations are equal to the realised inflation. In the first case we have made two assumptions: the first of these assumptions is that agents use previous inflation to form their expectations of future inflation[4], that is, $E_t(\Delta p_{t+1}) = \Delta p_t$, and the second is that agents use a form of smoothed inflation

[4]Juselius (1995) also uses this definition of future expected prices to test for the Purchasing Power Parity (PPP) and UIP hypothesis empirically.

forecasting to extrapolate expectations of future inflation. To derive values for the expected rate of inflation, we apply the Hodrick and Prescott (1997) filter over time, that is, $E_t(\Delta p_{t+1}) = \Delta p^T_{t+1}$. Our measure of actual rates of inflation is derived from the annual increase in the CPI. For nominal interest rates we have used 3-month interest rates. These variables were obtained from the *International Financial Statistics* of the *International Monetary Fund*. We have then computed the interest rate differential against the EU, for the latter the inflation rate is based on the annual increase of the Harmonised Consumer Price Index (HCPI) obtained from the OECD *Main Economic Indicators* data base. For purposes of comparison we have also tested the RIRP against the US. The data is monthly and spans the period 1994:1-2007:12 for *ex ante* RIRP and 1994:1-2006:12 for *ex post* RIRP. The nominal interest rates are as follows; Bulgaria and the EU (Interbank rate), Croatia, Latvia, Lithuania, Romania and Slovenia (Money Market rate), Czech Rep., Hungary, Poland and the US (Treasury Bill rate), Estonia, Macedonia and Slovak Rep. (Deposit rate).

4.2 Empirical evidence

As a preliminary analysis, we have plotted the autocorrelation functions in order to provide a first check on the speed of decay. The graphs are displayed in Figures 1 - 2[5]. From these figures it is possible to notice in general a high degree of persistence.

[5] In order to save space we have only plotted the autocorrelation functions for the case $E_t(\Delta p_{t+1}) = \Delta p_t$. However for the other two definitions of RIRP the graphs are available upon request.

In Tables 1, 2 and 3 we display the results of the Ng and Perron (2001) and KSS unit root tests for the two definitions of *ex ante* and *ex post* RIRP. Table 1, shows that *ex ante* RIRP, (when $E_t(\Delta p_{t+1}) = \Delta p_t$), holds for Bulgaria, Estonia, Hungary, Lithuania, Macedonia, Poland (only against the EU), Romania and Slovak Rep. For the second definition of *ex ante* RIRP, Table 2 shows that the condition holds for Croatia in addition to the former countries, but on both definitions it fails to hold for Poland and for Estonia against the euro. Finally, when applying the tests to *ex post* data, the results suggest that the RIRP theory holds empirically for all countries in our investigation except Estonia and Latvia. Table 4, provides a summary of our results. These provide strong evidence that RIRP increases once smooth transition has been incorporated into our analysis. This has important implications since it implies that failure to find evidence in favour of the empirical fulfilment of the RIRP condition may be caused by the existence of an asymmetric speed of adjustment towards equilibrium neglected in previous empirical work. We have also plotted 1 minus the transition function in figure 3, that is $e^{-\theta y_{t-1}^2}$, for the *ex post* RIRP vs. the EU for the stationary cases since this provides us with a measure of the speed of adjustment, or the single unit root conditional to y_{t-1} where the variable y is the real interest rate differential (KSS, 2003). Note that for $y_{t-1} = 0$, the variable behaves as a unit root; whereas it is a mean reverting process as y_{t-1} becomes larger than 0 in absolute terms. Figure 3 indicates that Bulgaria, Lithuania and the Slovak Rep., are the countries with faster mean reversion. It is also apparent that for

Croatia and Macedonia, most of the observations lie on the right hand side of 0 and here again, real interest rates are mean reverting.

Finally, in order to gain some insight into potential reasons for our failure to find empirical support for RIRP for Estonia and Latvia, we look at the existence of common trends between national and foreign real interest rates. To identify common trends, we apply Bierens (2000) nonlinear and nonparametric cotrending analysis. Bierens' technique allows as to test for the existence of common nonlinear deterministic trends if the variables are stationary or for cointegrating relations if the data are I(1). We run this analysis for the real interest rate differentials (*ex post*) for Estonia and Latvia vs, the EU and the US. The results of the unit root test for the real interest rates confirm that the variables are unit root processes in all cases. Bierens' approach therefore becomes a test for cointegrating vectors. As suggested by the RIRP theory, we should find a cointegrating vector such that (1,-1). In all cases, we find that there is one cointegrating vector and therefore one common stochastic trend. However, we reject the hypothesis that the (1,-1) vector is cointegrated. Indeed for Estonia the relationship between national and foreign real interest rate is inverse implying meaning that both parameters in the cointegrating vector have the same sign[6]. That means that, if we allow for a weak version of the RIRP condition where the parameters of the cointegrating vector can be different, but holding the opposite sign assumption, then we find that the weak version of the RIRP theory holds in the case of Latvia.

[6]Results available upon request.

Overall we can say that there is a high degree of market integration between the CEECs and the EU, as shown by the summary of our results. This is especially true when analysing RIRP using *ex post* inflation. That means that under the hypothesis of rational expectations and perfect forecasting, both the markest of goods and money appear to be quite integrated with the EU. In general, our results are similar to those obtained by Ferreira and León-Ledesma (2007) and by KSS and Baharumshah et al. (2007), that is, the evidence in favour of the RIRP hypothesis increases when nonlinearities are accounted for.

5 Conclusions

This paper tests RIRP for a group of CEE countries with the US and the EU. To test for the presence of a unit root we use the Ng-Perron test and the KSS test. The KSS test takes account of any parameter instability over time and gives a better understanding of the processes observed. We test two definitions of RIRP ex ante and ex post. Our results show that using our first measure of ex ante inflation RIRP holds for Bulgaria, Estonia, Hungary, Lithuania, Macedonia, Poland (against the EU), Romania and the Slovak Rep. In this ex ante model of expected inflation is a martingale process with mean reverting properties. It is therefore a stationary process and we further use the Ng-Perron and the KSS tests to confirm whether it is stationary for different countries. Since the KSS test takes account of parameter instability over time, that is, the possibility of asymmetric speeds of adjustment towards equilibrium it is likely to provide more convincing results and on this basis we conclude that ex ante RIRP holds for these countries. This is an important result since it suggests that one reason several earlier investigations failed to find support for RIRP, is their neglect of asymmetric speeds of adjustment towards equilibrium.

For our second definition of ex ante RIRP where we assume that agents use a form of smooth inflation forecasting, our results show that the condition holds for Croatia in addition to those countries for which our first definition of RIRP holds, that is, Bulgaria, Hungary, Lithuania, Macedonia, Romania and the Slovak Rep. However, we find no evidence that the relationship holds for either Poland or Estonia against the EU.

In general, we find stronger evidence of the RIRP hypothesis taking into account the possibility of asymmetries in the speed of mean reversion, which implies that transaction costs may be affecting the portfolio decisions of the international investors.

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Table 1: Ng and Perron (2001) and KSS unit root tests results, *ex ante* $E_t(\Delta p_{t+1}) = \Delta p_t$

Country	**Numeraire**	MZ_α^{GLS}	MZ_t^{GLS}	MSB^{GLS}	MP_T^{GLS}	$\hat{t}_{NL}$	$\hat{t}_{NLD}$
Bulgaria	EU	-20.4620**	-3.1985**	0.1563**	1.1976**	-3.4651**	-3.4362**
	US	-20.395**	-3.1933**	0.1565**	1.2014**	-3.4645**	-3.4358**
Croatia	EU	0.5066	6.5143	12.8571	9272.44	-0.7033	-0.5924
	US	0.5032	6.2924	12.5027	8761.36	-0.6377	-0.5306
Czech Rep.	EU	-1.0855	-0.7071	0.6514	21.3439	-1.3931	-1.7345
	US	-2.5636	-1.1259	0.4391	9.52829	-1.4868	-1.6225
Estonia	EU	0.1044	0.1206	1.1554	74.3121	-3.4295**	-3.1236**
	US	-0.0218	-0.0244	1.1176	67.7835	-2.9619**	-2.6729*
Hungary	EU	-7.5454*	-1.8381*	0.2436*	3.6346*	-3.9651**	-3.7254**
	US	-3.1151	-1.0118	0.3248	7.5542	-2.9044**	-3.2762**
Latvia	EU	0.8033	0.4327	0.5386	24.4191	-0.4828	-1.0708
	US	1.4910	1.0058	0.6746	38.7035	-1.0063	-1.4973
Lithuania	EU	0.4209	1.8675	4.4366	1086.79	-7.6169**	-7.5784**
	US	0.3888	1.6728	4.3022	1014.08	-7.5180**	-7.4940**
Macedonia	EU	0.3810	1.0495	2.7543	418.932	-9.8486**	-9.8172**
	US	0.4512	1.7237	3.8197	813.501	-9.8733**	-9.8459**
Poland	EU	-1.0425	-0.6862	0.6582	21.9028	-2.8121**	-2.5683
	US	-3.9354	-1.4021	0.3562	6.2261	-1.7570	-2.1764
Romania	EU	-16.7688**	-2.8955**	0.1726**	1.4611**	-2.9359**	-2.7753*
	US	-16.7283**	-2.8920**	0.1728**	1.4648**	-2.9129**	-2.7173*
Slovak Rep.	EU	-1.3661	-0.7439	0.5445	15.8508	-3.4410**	-3.3856**
	US	-3.0214	-1.2081	0.3998	8.0698	-2.9872**	-3.0073**
Slovenia	EU	-0.3964	-0.2805	0.7076	28.7341	-1.0767	-1.2478
	US	0.1494	0.1256	0.8411	43.0997	-1.3934	-1.6339

Note: The order of lag to compute the tests has been chosen using the modified AIC (MAIC) suggested by Ng and Perron (2001). The Ng-Perron tests include an intercept, whereas the KSS test has been applied to the raw data, $\hat{t}_{NL}$ say, and to the demeaned data, $\hat{t}_{NLD}$ say. The symbols * and ** mean rejection of the null hypothesis of unit root at the 10% and 5% respectively. The critical values for the Ng-Perron tests have been taken from Ng and Perron (2001), whereas those for the KSS have been obtained by Monte Carlo simulations with 50,000 replications:

Fractile	MZ_α^{GLS}	MZ_t^{GLS}	MSB^{GLS}	MP_T^{GLS}	$\hat{t}_{NL}$	$\hat{t}_{NLD}$
5%	-8.100	-1.980	0.233	3.170	-2.196	-2.906
10%	-5.700	-1.620	0.275	4.450	-1.908	-2.636

Table 2: Ng and Perron (2001) and KSS unit root tests results, *ex ante* $E_t(\Delta p_{t+1}) = \Delta p^T_{t+1}$

Country	**Numeraire**	MZ_{α}^{GLS}	MZ_t^{GLS}	MSB^{GLS}	MP_T^{GLS}	$\hat{t}_{NL}$	$\hat{t}_{NLD}$
Bulgaria	EU	-5.3403	-1.6309*	0.3054	4.5966	-3.0604**	-3.3696**
	US	-5.2500	-1.6170	0.3080	4.6754	-3.0624**	-3.3690**
Croatia	EU	-0.0736	-0.0671	0.9114	46.8139	-4.2187**	-4.1507**
	US	-0.0686	-0.0621	0.9065	46.4391	-4.1903**	-4.1265**
Czech Rep.	EU	-1.1821	-0.7134	0.6034	18.8121	-1.5171	-1.6762
	US	-2.5745	-1.0587	0.4112	9.1857	-1.5649	-1.6976
Estonia	EU	-0.0573	-0.0504	0.8801	44.2961	-1.3022	-1.1078
	US	-0.3410	-0.2383	0.6987	28.5666	-2.4542**	-2.0818
Hungary	EU	-6.9460*	-1.8217*	0.2622*	3.6797*	-1.7253	-1.7791
	US	-7.7720*	-1.9244*	0.2476*	3.3310*	-1.4777	-1.7743
Latvia	EU	-3.3505	-1.1191	0.3340	7.2229	-1.1517	-1.6400
	US	-2.8958	-1.0663	0.3682	8.1379	-1.4843	-1.6548
Lithuania	EU	-4.3738	-1.4784	0.3380	5.6022	-1.8828	-2.4418
	US	-13.690**	-2.6163**	0.1911**	1.7898**	-2.1610*	-2.0535
Macedonia	EU	0.4800	2.3225	4.8379	1310.24	-10.5711**	-0.0463
	US	0.4665	2.3713	5.0828	1440.61	-10.5083**	-10.5644**
Poland	EU	-0.5142	-0.4246	0.8257	35.4871	-1.4963	-1.6896
	US	-0.7878	-0.5243	0.6655	23.8045	-1.0626	-1.9152
Romania	EU	-1.5862	-0.8041	0.5069	13.8777	-6.4652**	-6.4658**
	US	-1.5874	-0.7953	0.5010	13.7121	-6.4640**	-6.4631**
Slovak Rep.	EU	-3.0162	-1.1688	0.3875	8.0130	-3.1250**	-2.5107
	US	-6.4856*	-1.7272*	0.2663*	4.0320*	-2.7769**	-2.7439*
Slovenia	EU	-0.8066	-0.5246	0.6504	22.9385	-0.8494	-0.9621
	US	-0.4223	-0.3711	0.8787	40.2562	-1.4268	-1.5438

Note: See Table 1.

Table 3: Ng and Perron (2001) and KSS unit root tests results, ex post

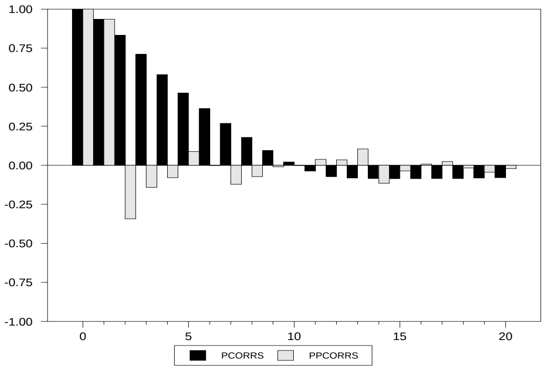
Country	**Numeraire**	MZ_{α}^{GLS}	MZ_{t}^{GLS}	MSB^{GLS}	MP_{T}^{GLS}	$\hat{t}_{NL}$	$\hat{t}_{NLD}$
Bulgaria	EU	-22.3056**	-3.3382**	0.14966**	1.10315**	-2.2640**	-2.2228
	US	-22.3020**	-3.3380**	0.14968**	1.10287**	-2.2618**	-2.2207
Croatia	EU	0.1204	0.1148	0.9540	53.0818	-10.1823**	-9.9195**
	US	-0.3311	-0.2332	0.7043	28.9788	-10.2980**	-10.0127**
Czech Rep.	EU	-2.2793	-1.0577	0.4640	10.6796	-2.0195*	-1.8861
	US	-4.0548	-1.4177	0.3496	6.0499	-2.0683*	-2.8518*
Estonia	EU	-0.0275	-0.0306	1.1135	67.2416	-1.3022	-1.5768
	US	-0.2824	-0.2565	0.9081	44.1267	-1.70392	-1.9316
Hungary	EU	-6.1024*	-1.7392*	0.2850	4.0402*	-1.6416	-2.8542*
	US	-12.851**	-2.5295**	0.1968**	1.9278**	-1.6390	-2.9861**
Latvia	EU	1.8778	1.7634	0.9391	73.2052	0.6899	-0.2198
	US	1.5272	1.5621	1.0228	80.4495	-0.0142	-0.3940
Lithuania	EU	0.4008	0.4919	1.2273	89.1612	-4.0514**	-4.0596**
	US	-0.2351	-0.1684	0.7163	30.4198	-4.0268**	-4.0061**
Macedonia	EU	0.5545	6.1671	11.1217	7021.99	-8.9894**	-9.0728**
	US	0.5558	5.1768	9.3142	4928.66	-8.9704**	-9.0552**
Poland	EU	-6.6106*	-1.8166*	0.2748*	3.7110*	-2.4820**	-3.6617**
	US	-3.6107	-1.3270	0.3675	6.7894	-1.5022	-3.1136**
Romania	EU	-13.6705**	-2.6043**	0.1905**	1.8317**	-3.5510**	-3.1637**
	US	-13.6094**	-2.5975**	0.1908**	1.8438**	-3.5643**	-3.1314**
Slovak Rep.	EU	-0.8987	-0.5467	0.6082	20.4601	-2.3396**	-2.2767
	US	-5.2608	-1.5949	0.3031	4.7327	-2.3521**	-2.4487
Slovenia	EU	-0.2759	-0.1961	0.7108	29.7744	-4.8560**	-4.8800**
	US	0.0997	0.0859	0.8609	44.3079	-4.6216**	-4.7157**

Note: See Table 1.

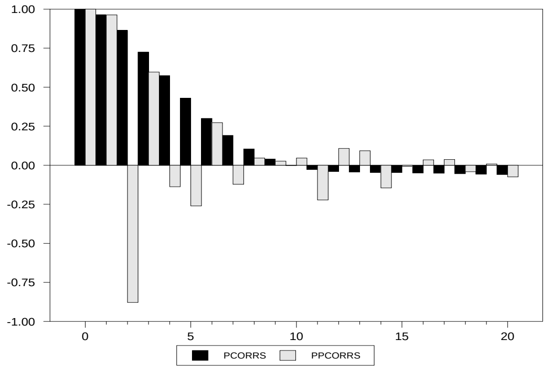
Table 4: Summary of the results

Country	**Numeraire**	NgP(Δp_t)	KSS(Δp_t)	NgP(Δp^T_{t+1})	KSS(Δp^T_{t+1})	NgP(Δp_{t+1})	KSS(Δp_{t+1})
Bulgaria	EU	**I(0)**	**I(0)**	I(1)	**I(0)**	**I(0)**	**I(0)**
	US	**I(0)**	**I(0)**	I(1)	**I(0)**	**I(0)**	**I(0)**
Croatia	EU	I(1)	I(1)	I(1)	**I(0)**	I(1)	**I(0)**
	US	I(1)	I(1)	I(1)	**I(0)**	I(1)	**I(0)**
Czech Rep.	EU	I(1)	I(1)	I(1)	I(1)	I(1)	**I(0)**
	US	I(1)	I(1)	I(1)	I(1)	I(1)	**I(0)**
Estonia	EU	I(1)	**I(0)**	I(1)	I(1)	I(1)	I(1)
	US	I(1)	**I(0)**	I(1)	**I(0)**	I(1)	I(1)
Hungary	EU	**I(0)**	**I(0)**	**I(0)**	I(1)	**I(0)**	**I(0)**
	US	I(1)	**I(0)**	**I(0)**	I(1)	**I(0)**	**I(0)**
Latvia	EU	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
	US	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Lithuania	EU	I(1)	**I(0)**	I(1)	I(1)	I(1)	**I(0)**
	US	I(1)	**I(0)**	**I(0)**	**I(0)**	I(1)	**I(0)**
Macedonia	EU	I(1)	**I(0)**	I(1)	**I(0)**	I(1)	**I(0)**
	US	I(1)	**I(0)**	I(1)	**I(0)**	I(1)	**I(0)**
Poland	EU	I(1)	**I(0)**	I(1)	I(1)	**I(0)**	**I(0)**
	US	I(1)	I(1)	I(1)	I(1)	I(1)	**I(0)**
Romania	EU	**I(0)**	**I(0)**	I(1)	**I(0)**	**I(0)**	**I(0)**
	US	**I(0)**	**I(0)**	I(1)	**I(0)**	**I(0)**	**I(0)**
Slovak Rep.	EU	I(1)	**I(0)**	I(1)	**I(0)**	I(1)	**I(0)**
	US	I(1)	**I(0)**	**I(0)**	**I(0)**	I(1)	**I(0)**
Slovenia	EU	I(1)	I(1)	I(1)	I(1)	I(1)	**I(0)**
	US	I(1)	I(1)	I(1)	I(1)	I(1)	**I(0)**

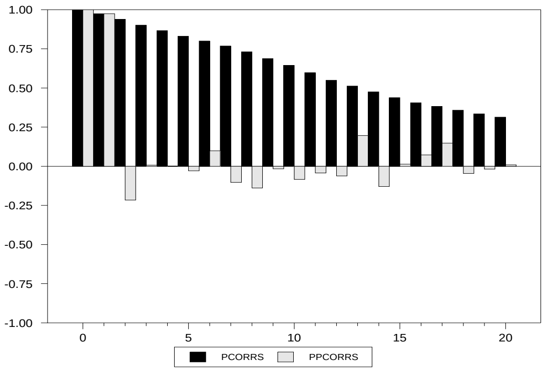
Figure 1: Autocorrelation functions, Real Interest Rate Differential ($E_t(\Delta p_{t+1}) = \Delta p_t$) vs. the EU



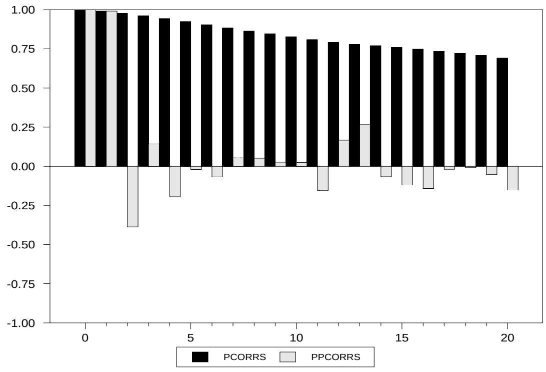
(a) Bulgaria



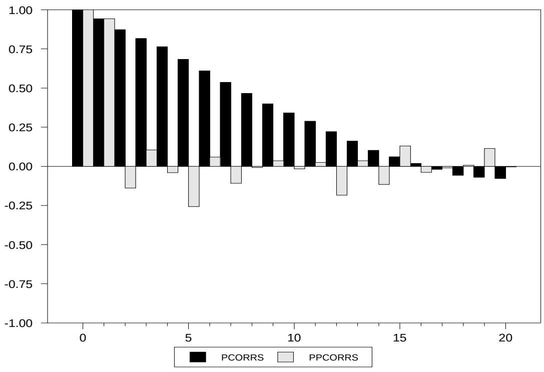
(b) Croatia



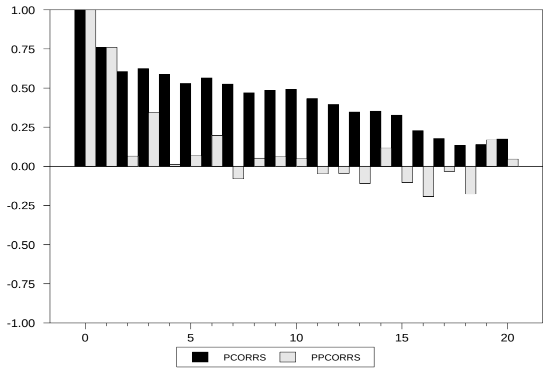
(c) Czech Republic



(d) Estonia

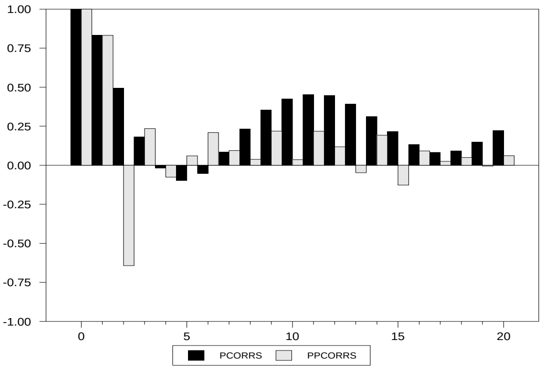


(e) Hungary

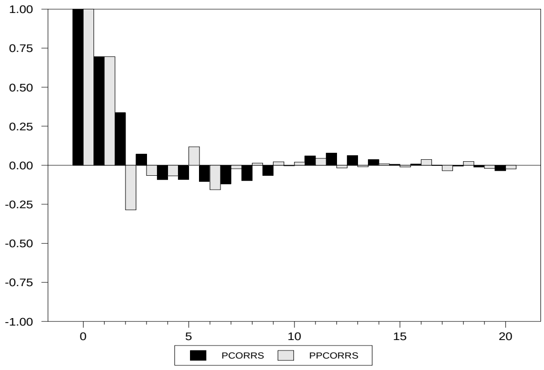


(f) Latvia

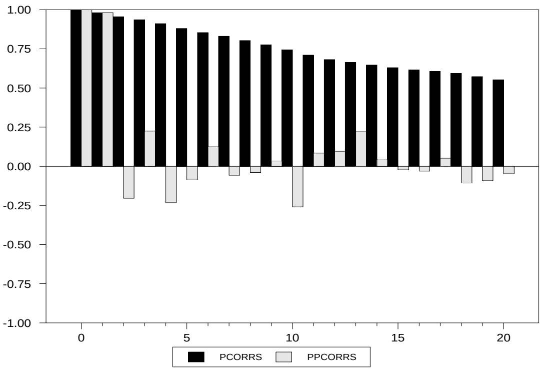
Figure 2: Autocorrelation functions, Real Interest Rate Differential ($E_t(\Delta p_{t+1}) = \Delta p_t$) vs. the EU (continued)



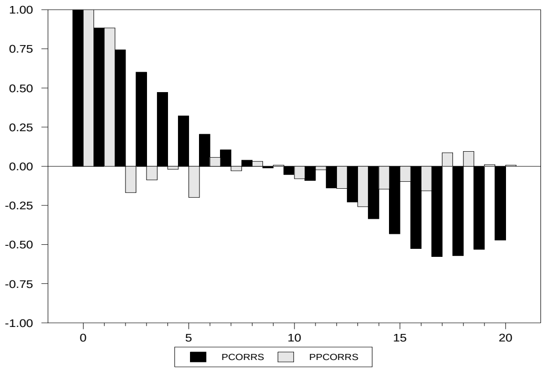
(a) Lithuania



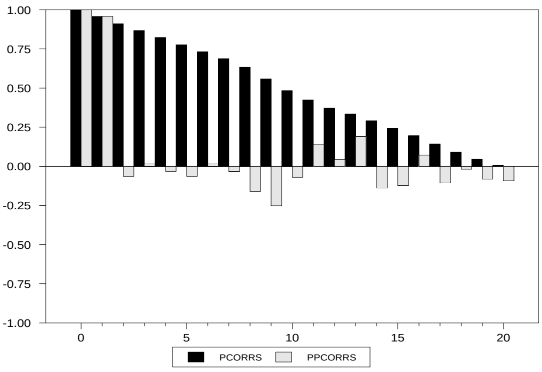
(b) Macedonia



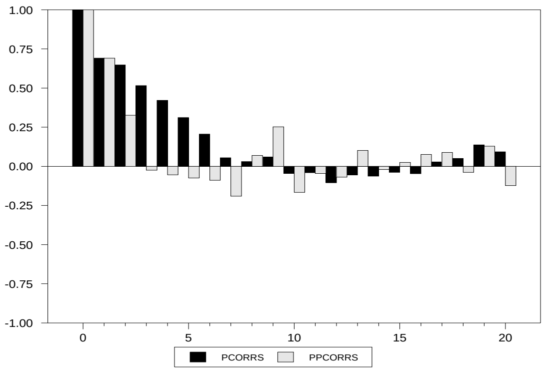
(c) Poland



(d) Romania

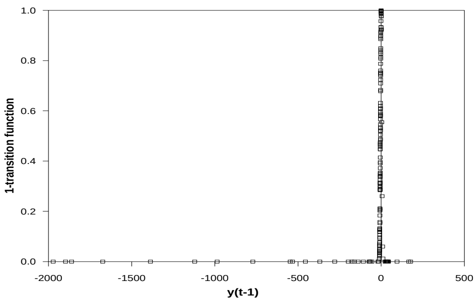


(e) Slovak Republic

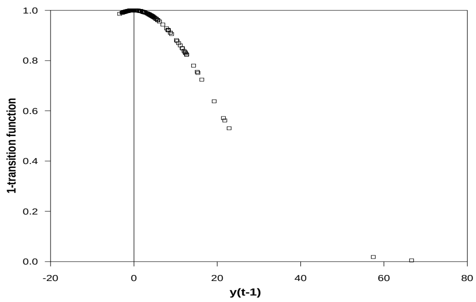


(f) Slovenia

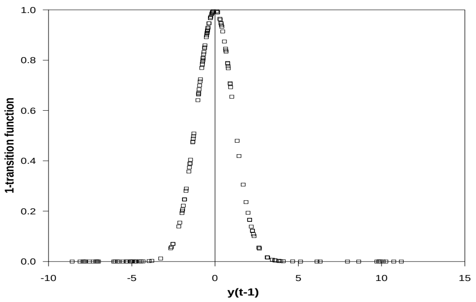
Figure 3: Estimated $e^{-\theta y_{t-1}^2}$, *ex post* RIRP vs. EU



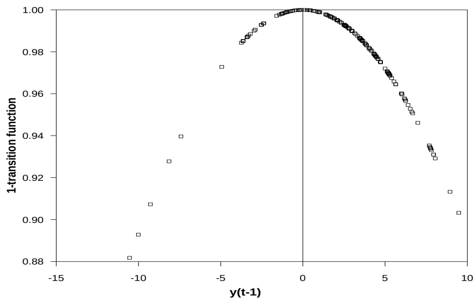
(a) Bulgaria



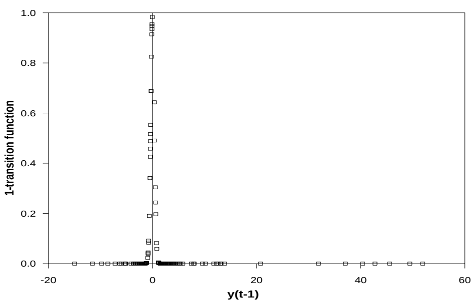
(b) Croatia



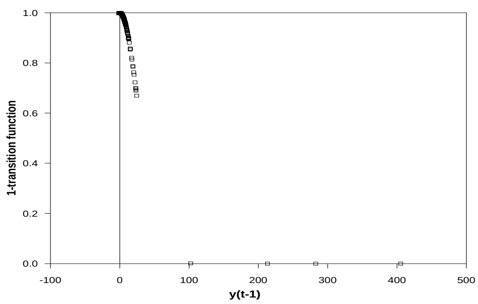
(c) Czech Republic



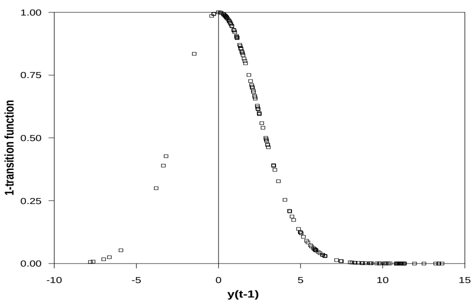
(d) Hungary



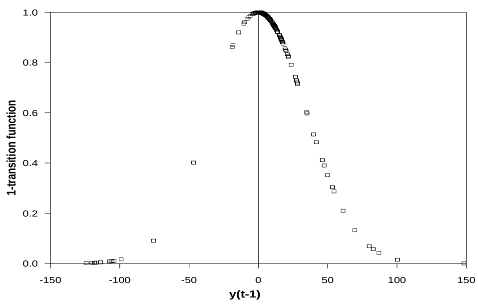
(e) Lithuania



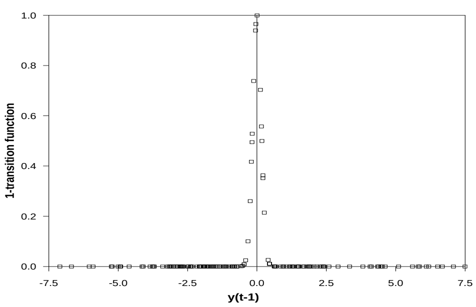
(f) Macedonia



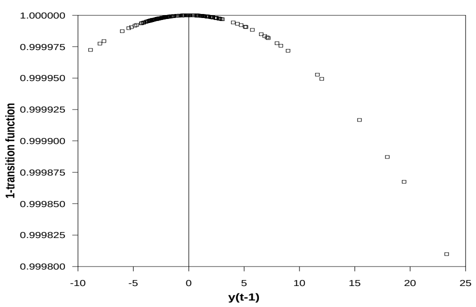
(g) Poland



(h) Romania



(i) Slovak Republic



(j) Slovenia