Real Interest Rate Parity for Central and Eastern European Countries: A New Unit Root Test with Two Structural Breaks

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Abstract

This study applies Narayan and Popp's (2010) unit-root test with two endogenous breaks, which has been proven to be more powerful than the other unit root tests with two breaks (Narayan and Popp, 2013) to assess the non-stationary properties of the real interest rate parity (RIRP) for thirteen Central and Eastern European (CEE) countries. We examine the validity of RIRP from the unit root with two breaks of view and provide robust evidence which clearly indicates that RIRP holds true for six countries. Our findings point out their real interest rate convergence is mean reversion towards RIRP equilibrium values with two structural breaks. Our results have important policy implications for these CEE countries under study.

Keywords: *unit root test with two endogenous breaks, real Interest Rate Parity*

JEL Classification: C22, F36

1. Introduction

In an open economy, real interest rate parity (RIRP) provides an indication of whether countries are economically and financially integrated or autonomous. The RIRP indicates that the real interest rates of different countries should be identical, provided that markets are frictionless and economic agents' expectations are rational. When RIRP holds, it implies that assets with identical risk, liquidity and maturity have the same expected return across different countries.

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The RIRP states that, if agents make their forecasts using rational expectations and arbitrage forces are free to act in the goods and assets markets, then real interest rates between countries will equalize (Peel and Venetis, 2005). Meanwhile, the extent of product market integration might provide useful information for countries seeking to join a monetary union. In this study, we analyze whether RIRP holds in Central Eastern European (CEE) countries due to their increasing ambitions to become members of the Economic and Monetary Union (EMU) or European Union (EU, depending on the country). Transition did start in 1989/ 1990 in the Central European countries (CEC) belonging to the former Soviet block and, the process of economic transition started with a liberalization of the foreign exchange markets and a provision of currency convertibility. These drastic steps resulted in initial deep under valuations of the national currency. At the same time, price liberalization was accompanied by very high inflation rates and interest rate. The features of transition economies in CEE countries provide an interesting study of RIRP hypothesis test.

First, there were centrally planned and fast liberalization to prices and markets, and some suffered from high inflation.

Second, and most of all, the initial conditions for CEE countries transition varied extensively and they may be an important indicator in explaining the magnitude of deviations from RIRP.

Third, The CEE countries are the extent to which economies are integrated is of particular importance to those countries either aiming to join a monetary union, or who 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.

The central aim of this study contributes significantly to this field of research because, first of all, we examine evidence for RIRP for CEE countries, using the unit root test with two structure breaks and the test statistics suggested by Narayan and Popp (NP, 2010).

Secondly, to the best of our knowledge, this study is the first of its kind to utilize the unit root test with two structure breaks for long-run RIRP in CEE countries. The empirical results indicate that the RIPP hold true for six of CEE countries studied and our results have important policy implications for these transition countries under study.

The remainder of this study is organized as follows. Section 2 presents the literature reviews. Section 3 describes methodology of the unit root test with two endogenous breaks proposed by Narayan and Popp (2010). Section 4 presents the data used in our study and discusses the empirical findings. Finally, Section 5 reviews the conclusions we draw.

2. Literature Review

Interest rate parity (IRP) is the law of one price in the asset market for securities. In theory, the foreign exchange market should be in equilibrium when deposits of all currencies offer the same rate of return. Covered interest parity (CIP) states that capital flows should equalize returns on assets of equal maturity and default risk across countries, once currency risk has been eliminated by covering the transaction through the use of forward contracts. Since the transaction is then nearly riskless (only subject to default risk), CIP is usually considered to be an arbitrage condition, and significant deviations from CIP are interpreted as reflecting barriers to cross-border capital flows. As pointed out by Obstfeld (1995), the CIP test is therefore one of the most straightforward ways to gauge the extent of capital mobility between countries. Uncovered interest parity (UIP) departs from CIP by not covering the exchange rate exposure of a cross-border investment with a forward currency contract, thus leaving the investor at risk of future spot exchange rates that differs from expectations. If currency markets operate efficiently and UIP holds, then interest differentials should predict the movement of the spot exchange rate over time (Menzie and Guy, 2004). The UIP therefore jointly tests capital mobility and the efficiency of exchange rate markets. According to the UIP, the ratio of changes in exchange rate *E*, within a time period *t*, is a function of domestic interest rate i^d, and foreign interest rate i^f. UIP can be expressed as $E_{t+1}/E_t = (1+i_t^d)/(1+i_t^f)$. If the real rates of interest are equalized across the world through capital mobility and then nominal interest rate difference must reflect differences in expected inflation rates of countries under conditions of similar country risk. The ability of exchange rate markets to anticipate interest differentials is supported by several empirical studies that indicated the long run tendency for these differentials to offset exchange rate changes. In the existing literature, a main hypothesis that has been studied extensively by many researchers is RIRP across countries. However, at least in a theoretical sense, RIRP holds only if UIP and relative purchasing power parity (RPPP) hold, the Fisher relationship holds in each country as well. Of these relationships, Chung and Crowder (2004) argue that UIP is the most commonly violated on account of non-stationary risk premium in the foreign exchange markets. The extent to which RIRP holds therefore serves as an indicator of the degree of product and/or financial market integration.

While empirical evidence on the stationarity of the real interest rate convergence is abundant in developed countries (Mishkin, 1984; Cumby and Mishkin, 1987; Fujii and Chinn, 2001), the literature dealing specifically with the CEE countries and other European transition countries is spare. An overview of the overall convergence processes in EU acceding and accession countries is given for example by Piazolo (2000). Fountas and Wu (1999) find evidence in favor of strong RIRP in the EU member countries using unit root tests that allow for structural breaks in the series. Merlevede, Plasmans and Aarle (2003) analyze various aspects of integration of EU acceding countries with the Euro area in a model in which interest rate parity is part of the nominal exchange rate equation. The development of country-specific risk premia in the three acceding countries Czech Republic, Hungary and Poland has been analyzed by Orlowski (2003) who distinguishes between inflation rate premium and exchange rate premium and interprets a simultaneous decline in both premia as indicator for monetary convergence. Dahlquist and Gray (2000) find that the speed of adjustment of nominal interest rates in the European monetary system is stronger during periods of high interest rates and high volatilities. Evidence on the extent of real convergence for the EU accession countries is mixed. For example, Kozluk (2005) finds that the accession countries are better prepared for the single currency membership than some of the more established members were at the introduction of the Euro. However, Babetskii, Boone and Maurel (2004) find evidence in favor of nominal rather than real convergence. Arghyrou, Gregoriou and Kontonikas (2009) have analyzed the CEE countries and find evidence in support of the RIRP hypothesis in some of these countries investigated. Holmes and Wang (2008) investigate the RIRP based on real interest rate differentials either switch between stationary and non-stationary regimes in a Markov regime-switching framework for EU accession countries. Cuestas and Harrison (2010) analyze the convergence of RIRP for some CEE countries and find that the results support the RIRP, especially when the nonlinearities in real interest rate differential considered. Sonora and Tica (2010) suggest that when structural breaks are took in account, RIRP condition relatively much weaker in some CEE countries.

As for methodology, most studies of RIRP have mostly utilized conventional unit root tests such as the Augmented Dickey Fuller (ADF) (Dickey and Fuller, 1981) and Phillips and Perron (PP, 1988) – but fail to reject the unit root hypothesis. The linear unit root test methodology assumes that in spite of the deviation situation, the process of real interest rate moving to the equilibrium is linear and the velocity of adjustment is a constant. However, in the data generating process (DGP), if the nonlinear factors were neglected, we cannot receive the expected results via RIRP. The linear model critically underestimates the velocity of adjustment of long-term equilibrium, and usually we accept the null hypothesis because of the low power of traditional unit root test. The omission of some structural breaks is a possible cause of the traditional unit root tests failing to reject the null hypothesis for stationary. Perron (1989) argued that if there is a structural break, the power to reject a unit root decreases when the stationary alternative is true and the structural break is ignored. Meanwhile, structural changes present in the DGP, but have been neglected, sway the analysis toward accepting the null hypothesis of a unit root. As we know that interest rates might be affected by internal and external shocks generated by structural changes may be subject to considerable short-run variation. It is important to know whether or not the real interest rate has any tendency to settle down to a long-run equilibrium level, because the RIRP hypothesis requires that real interest rate revolves around a constant or a time trend. If the real interest rate convergence is found stationary by using the unit root test with structural break(s), as a result the effects of shocks such as real and monetary shocks that cause deviations around a mean value or deterministic trend to be only temporary. Cuestas and Harrison (2010) provide evidence showing the existence of structure changes in the RIRP might imply broken deterministic time trends and the result supports the RIRP.

As discussed, traditional unit root tests lose power if structural breaks are ignored in unit root testing. The general method to account for breaks is to approximate those using dummy variables. Perron's (1989) exogenous unit root test, which allows for one structural break, has been the most widely used. Zivot and Andrews (ZA, 1992) modified and extended the Perron test to a case of an endogenous structural break. Subsequently, because of its endogenous treatment of the structural break, the ZA test became popular. The ZA test was further extended to allow for two endogenous structural breaks by Lumsdaine and Papell (LP, 1997) and by Lee and Strazicich (LS, 2003). LS argues that ZA and LP models do not allow for a break under the null and Perron (1997) does not model the break as an innovational outlier (IO), which may result in an over rejection of the unit root null. It is observed that in applied research, where a sufficiently long time series data is used, the LP test have become more popular. Perron (1997) does not model the break as an innovational outlier (IO), which may result in an over rejection of the unit root null. To handle this problem, Lee and Strazicich (2001; 2003) use a minimum Lagrange multiplier (LM) unit root test. Popp (2008) points out that the root of over rejection is that the parameters associated with structural breaks have different interpretations under the null and alternative hypotheses of testing models. Following Schmidt and Phillips (1992), Narayan and Popp (2010) consider two innovational outlier (IO) types specifications, that is, two breaks in the level and two breaks in the level and slope of a trending data series with unknown break times. Narayan and Popp (2010) test allows the generation of a new ADF-type unit root test and generates critical values by assuming unknown break dates with correct size, stable power and identifying the structural breaks accurately.

3. The Theory of Real Interest Rate Parity & Narayan and Popp (2010)'s Unit-root Test with Two Structural Breaks

The RIRP theory contends that the real interest rate between two countries should be equal (Taylor and Sarno, 1998; Mark and Moh, 2005). According to Ferreira and León-Ledesma (2007), RIRP defines that real interest rate differential is constant. Real interest rate differentials can be calculated using either en-ante or ex-post real returns, as well as alternative definitions for nominal interest and inflation rates. Following the majority of existing studies we use ex-post real returns so as to bypass the empirically tricky subject of approximating empirically inflation expectations. In this section, we test the process of the real interest rate differential series r_t using the unit-root with two structural breaks model developed by Narayan and Popp (2010, hereafter NP).

Following Narayan and Popp (2010), The DGP of a time series r_t is described as:

$$r_t = d_t + \mu_t \tag{1}$$

$$u_t = \rho u_{t-1} + \varepsilon_t \tag{2}$$

$$\varepsilon_t = A(L)^{-1} B(L) e_t \tag{3}$$

with d_t being the deterministic component, u_t being the stochastic component and $e_t \sim i.i.d.(0, \sigma_e^2)$. It is assumed that the roots of the lag polynomials A (L) and B (L), which are of order p and q, respectively, lie outside the unit circle. The NP unit root test consider two specifications both for trending data, one allows for two breaks in level (denoted M1 hereafter) and other allows for two breaks in level as well as slope (denoted M2 hereafter). The IO-type models for M1 and M2 are given as follows, respectively:

$$d_t^{M1} = a + btA(L)^{-1}B(L)e_t(L)(q_1 DU_{1,t} + q_2 DU_{2,t}) \tag{4}$$

and

$$d_t^{M2} = a + btA(L)^{-1}B(L)e_t(L)(q_1 DU_{1,t} + q_2 DU_{2,t} + g_1 DT_{1,t} + g_2 DT_{2,t}) \tag{5}$$

with $DU'_{i,t} = I(t > T'_{B,i})$ and $DT'_{i,t} = I(t > T'_{B,i})(t - T'_{B,i})$, i = 1, 2. Here, $T^{'}_{B,i}$, i = 1, 2, denotes the structural break dates. The parameters, q_i and g_i, indicate the magnitude of the level and slope breaks, respectively. The inclusion of $A(L)^{-1} B(L) e_t$ in Equations (4) and (5) enables the breaks to occur slowly over time. The unit root test models for M1 and M2 are presented respectively as follows.

$$r_t = \rho r_{t-1} + \alpha_1^* + \beta_1^* t + \delta_1 DU'_{1,t-1} + \delta_2 DU'_{2,t-1} + \theta_1 D(T'_B)_{1,t} + \theta_2 D(T'_B)_{2,t} + \sum_{j=1}^{k} \beta_j \Delta r_{t-j} + e_t \quad (6)$$

and

$$\begin{aligned} r_t &= \rho r_{t-1} + \alpha_1^* + \beta_1^* t + \delta_1 DU'_{1,t-1} + \delta_2 DU'_{2,t-1} \\ &+ \theta_1 D(T'_B)_{1,t} + \theta_2 D(T'_B)_{2,t} + \gamma_1 DT'_{2,t-1} + \gamma_2 DT'_{2.t-1} + \sum_{j=1}^{k} \beta_j \Delta r_{t-j} + e_t \end{aligned} \quad (7)$$

NP test the unit root null hypothesis of $\rho = 1$ against the alternative hypothesis of $\rho < 1$. Specially, NP makes use of a sequential grid search procedure comparable to Kapetanios (2005) according to the maximum absolute *t*-value of the break dummy coefficient θ_1 under the restrictions $\theta_2 = \delta_2 = 0$ for M1 and $\theta_2 = \delta_2 = \gamma_2 = 0$ for M2. That is

$$\hat{T}_{B,1} = \arg\max_{T_{B,1}} \left| t_{\hat{\theta}_1}\left(T_{B,1}\right) \right| \quad (8)$$

Under the restriction of the first break, $\hat{T}_{B,1}$, NP estimate the second $\hat{T}_{B,2}$ analogously to the first break by:

$$\hat{T}_{B,2} = \arg\max_{T_{B,1}} \left| t_{\hat{\theta}_1}\left(\hat{T}_{B,1}, T_{B,2}\right) \right| \quad (9)$$

The new ADF-type test is invariant approximately to level and slope breaks in finite samples by means of Monte Carlo simulations.

4. Data and Empirical Results

We use monthly data that covers from 1996 to 2011[1] to apply the Narayan and Popp (2010) unit root test with two structural breaks in testing the validity of RIRP. During this period, CEE countries have started their liberalization programs and transited to market economies. The data of our empirical study consists of the 12 CEE countries: including Belarus, Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Moldova, Poland, Romania, Russian Federation, Slovakia and Ukraine. In order to compute real interest rates, our measure of actual rates of inflation is derived from the annual increase in the Consumer Price Index (CPI). For Nominal interest rate we use money market rate or deposit rate, specifically, Belarus, Hungary, Moldova, Ukraine (Deposit Rate), Bulgaria,

[1] Since Slovakia joined the euro zone in 2009, we only use data from 1996 to 2008 for Slovakia.

Czech Republic, Estonia, Lithuania, Latvia, Poland, Romania, Russian Federation, US (Money Market Rate). All data is taken from the International Monetary Fund's International Financial Statistics. We have then computed the interest rate differential for 12 CEE countries against the US. A summary of the statistics is given in Table 1. Our Jarque-Bera test results indicate that, but for that of real interest rate differential, for most countries pairs are approximately non-normal except for Hungary and Lithuania. As shown in Figure 1, visual inspection of the real interest rate differential series for these 12 country pairs reveals significant a positive change in the real interest rate differential indicates real adjustment. We can clearly observe structural shifts in the trend of the data. Accordingly, it appears sensible to allow for structural breaks in testing for a unit root (and/or stationary). The estimated time path of the time-varying intercepts is shown in the Figure 1 and indicates that the structural break approximations seem reasonable and support the notion of long swings in RIRP.

Table 1

Summary Statistics

	Mean	Max.	Min.	Std.	Skewness	Kurtosis	J-B
Belarus	–40.213	5.346	–330.892	73.314	–2.447	8.172	395.089***
Bulgaria	–80.712	64.787	–1 827.051	317.332	–4.344	21.330	3 206.254***
Czech Rep.	1.473	19.246	–3.363	2.693	2.280	14.397	1 174.068***
Estonia	–1.605	11.702	–25.305	5.975	–1.893	8.422	340.813***
Hungary	1.187	6.504	–5.551	2.239	0.009	2.909	0.067
Lithuania	–0.304	11.247	–8.561	3.547	–0.148	3.062	0.717
Latvia	–1.949	18.178	–14.607	4.335	–0.125	5.468	47.947***
Moldova	3.559	19.055	–27.307	8.271	–0.883	4.988	55.086***
Poland	4.304	13.625	–3.175	3.787	0.479	2.264	11.394***
Romania	2.483	111.443	–122.511	28.667	–1.531	12.879	833.635***
Russia Fed.	–9.297	87.552	–117.452	24.763	–1.696	10.959	583.279***
Slovakia	–0.929	5.997	–10.302	2.987	–0.874	5.157	49.786***
Ukraine	13.607	66.536	4.229	9.129	2.463	11.516	754.215***

Note: Std denotes standard deviation and J-B denotes the Jarque-Bera Test for Normality.
*** indicates significance at the 1% level.

Source: Author's calculation.

A. Unit Root Tests

For comparison, several univariate unit root tests, ADF, PP and the Kwiatkowski et al. (1992, KPSS), are first employed to examine the null of a unit root in RIRP for these 13 CEE countries that we study. The result in Table 2 clearly shows the ADF and PP tests fail to reject the null of unit root for CEE countries. The KPSS test also shows the same results with accepting the null of non-stationary. There is no question that three univariate unit root tests – ADF, PP and KPSS all fail to reject the null of non-stationary RIRP for these countries. The result implies that

RIRP not hold CEE countries relative during the sample period. However, the low power of ADF, PP and KPSS tests come from the convergence of real interest rates and the ignorance of structural changes. Therefore, these tests tend to accept the hypothesis of a unit root when the stationary alternative is true.

Table 2

Univariate Unit Root Tests (with constant)

Country	Levels			First Differences		
	ADF	PP	KPSS	ADF	PP	KPSS
Belarus	–2.351(6)	–2.235(9)	0.594[10]**	–4.373(5)***	–6.571(2)***	0.056[9]
Bulgaria	–1.893(4)	–1.781(4)	0.378[10]*	–5.567(4)***	–10.043(3)***	0.027[3]
Czech Republic	–2.177(2)	–2.217(3)	1.159[10] ***	–13.307(1)***	–4.177(3)***	0.182[3]
Estonia	–2.531(1)	–1.927(5)	0.394[10] *	–8.756(0)***	–8.261(7)***	0.347[2]
Hungary	–2.518(1)	–2.148(6)	0.408[10]*	–11.771(0)***	–11.888(5)***	0.105[6]
Lithuania	–2.078(0)	–2.077(0)	0.636[10] **	–14.350(0)***	–14.457(5)***	0.167[6]
Latvia	–2.014(1)	–2.621(5)	0.638[10] **	–17.589(0)***	–18.538(4)***	0.062[8]
Moldova	–2.336(2)	–1.880(8)	0.534[10] **	–9.563(0)***	–10.079(6)***	0.034[8]
Poland	–1.316(1)	–1.554(1)	0.989[10] ***	–17.037(0)***	–16.914(2)***	0.159[5]
Romania	–2.487(0)	–2.449(5)	0.439[9]*	–12.236(0)***	–12.219(3)***	0.028[3]
Russian Federation	–2.082(0)	–2.432(7)	0.869[10] ***	–14.324(0)***	–14.303(6)***	0.050[6]
Slovakia	–2.142(0)	–2.402(3)	0.602[10]**	10.536(0)***	–10.535(1)***	0.057[0]
Ukraine	–1.952(0)	–1.922(8)	1.078[10] ***	–15.944(0)***	–16.109(7)***	0.054[7]

Note: ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.
The number in parenthesis indicates the lag order selected based on the recursive *t*-statistic, as suggested by Perron (1989).
The number in the brackets indicates the truncation for the Bartlett Kernel, as suggested by the Newey-West test (1987).

Source: Author's calculation.

B. Results from the Stationary Test with Two Structural Breaks

As stated earlier, there is a growing consensus that conventional unit root tests such as the ADF and PP tests fail to incorporate the structural breaks in the model, and hence have low power in detecting the mean reversion of real interest rate. Perron (1989) argued that if there is a structural break, the power to reject a unit root decreases when the stationary alternative is true and the structural break is ignored. However, the unit root test taking just a structural break into account can also sway the analysis toward accepting the null hypothesis of a unit root if the other structural changes present in the DGP have been neglected. We proceed to test the real interest rate convergence by using Perron's (1997) unit root test with a structural break. The results in Table 3 show as expected that the Perron's test fails to reject the null hypothesis of unit root for most CEE countries except for Belarus, Czech Republic, Romania and Russian Federation In Contrast, we are proposed to use the NP's (2010) unit root test with two endogenous breaks[2] to test the real interest rate convergence. Table 4 reports the results of unit root test with two endogenous breaks[3] on the real interest rate differential. As we can see from Table 4, the null hypothesis of unit root in the real interest rate differential is rejected for six CEE countries studied here, and they are Bulgaria, Estonia, Lithuania, Romania, Russian Federation and Ukraine. We find that most of the CEE countries have two breaks.[4] One notable characteristic is that most of the individual time series were affected the breaks, with the exception of Czech Republic only in $T_{B,2}$. Looking at the estimated break points we realize that most of these dates are associated with some major events and more than half of these dates are located in 1999. In 1999, the euro was the single currency issued by the European Union's Member States, which together make up the euro area was a major step in European integration. Visual inspection of our real interest rate differential series, we can clearly observe structural shifts in the trend of the data. Accordingly, it appears sensible to allow for structural breaks in testing for a unit root. Apparently, the NP test provided evidence favoring the long-run validity of the RIRP for the six CEE transition countries being studied.

T a b l e 3

Test Statistics of Perron (1997) Unit Root Test with a Structural Break

Country	*t*-statistic	Break Point
Belarus	–5.245**	2 000.7
Bulgaria	–4.400	1 998.6
Czech Republic	–4.973*	1 999.10
Estonia	–4.395	1 999.4
Hungary	–3.837	2 001.5
Lithuania	–4.577	1 998.6
Latvia	–3.643	2 004.1
Moldova	–4.068	1 998.9
Poland	–3.099	2 002.6
Romania	–5.976***	1 998.8
Russian Federation	–8.986***	1 998.9
Slovakia	–3.268	2 000.6
Ukraine	–4.862	1 999.11

Note: ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Source: Author's calculation.

[2] We only consider a specification with a constant but without a time trend because time trend in real interest rate differential is not consistent with the long-run RIRP. Therefore, we only use Equation (6) without the time trend and Narayan and Popp (2010) call this M0 in their study. Narayan and Popp (2013) have shown that their test has both better size and higher power than those of LP and LS, and identify the structural breaks accurately.

[3] The estimation procedures of Narayan and Popp's (2010) unit root test with two endogenous breaks are estimated by GAUSS program, and they are available from the authors upon request.

[4] The determination of structural breaks used by Narayan and Popp (2010)'s Unit-root Test with Two Structural Breaks are decided endogenous with the data. We can also find that the time points with structure break seem identical within Figure 1.

Table 4

Test Statistics of Unit Root Tests with Structural Breaks (M0)

$$r_t = \rho r_{t-1} + \alpha_1^* + \beta_1^* t + \delta_1 DU'_{1,t-1} + \delta_2 DU'_{2,t-1} + \theta_1 D(T'_B)_{1,t} + \theta_2 D(T'_B)_{2,t} + \sum_{j=1}^{k} \beta_j \Delta r_{t-j} + e_t$$

	Belarus	**Bulgaria**	**Czech Republic**	**Estonia**	**Hungary**	**Lithuania**	**Latvia**	**Moldova**	**Poland**	**Romania**	**Russian Federation**	**Slovakia**	**Ukraine**
k	1	2	4	5	1	0	1	2	3	2	3	0	4
$T_{B,1}$	1999.08***	1999.02***	2003.12	1999.03***	1999.02***	1999.09***	2007.05**	1999.05***	2000.01***	1999.02***	1993.03*	1996.06	1999.06***
$T_{B,2}$	1999.12***	2001.12***	2007.12*	1999.12***	2008.05***	2007.12**	2007.07	2000.03***	2001.11***	1999.04***	1999.08***	2000.06	2000.01***
ρ	–0.011	**–0.146****	–0.136	**–0.078****	–0.080	**–0.147****	–0.119	–0.071	–0.081	**–0.154***	**–0.168****	–0.082	**–0.174****
	(–2.067)	**(–4.684)**	(–2.740)	**(–4.110)**	(–3.168)	**(–4.191)**	(–2.987)	(–3.088)	(–3.447)	**(–3.961)**	**(–4.422)**	(–2.685)	**(–4.339)**
α_0^*	–2.311**	–67.450**	0.401	0.157	0.105	0.393*	–0.108	0.418	0.692***	–1.037	–1.572	–0.082**	3.576***
	(–2.874)	(–2.876)	(1.996)	(0.646)	(1.537)	(1.911)	(–0.546)	(1.158)	(3.399)	(–0.443)	(0.988)	(–2.685)	(3.629)
δ_1	5.099	66.800**	–0.440	–0.824	0.084	–0.385	–2.992	–0.905	0.414	19.980	–16.680**	–0.084	0.754
	(1.734)	(2.248)	(–1.680)	(–1.661)	(0.579)	(1.598)	(–1.346)	(–0.942)	(1.701)	(1.463)	(–2.353)	(–0.674)	(0.864)
δ_2	–2.900	0.188	0.045	0.579	–0.058	–0.494	2.670	0.769	–0.957***	–18.480	16.780**	–0.817**	–2.739***
	(–1.003)	(0.009)	(0.182)	(1.396)	(–0.401)	(–1.699)	(1.194)	(0.911)	(–3.575)	(–1.380)	(2.681)	(–2.322)**	(–3.003)
θ_1	32.210***	68.790***	–1.798	5.477***	2.499***	4.375***	–4.567**	–8.618***	–3.226***	37.620***	–19.970*	0.919**	–6.466***
	(7.780)	(3.637)	(–1.529)	(4.380)	(3.924)	(3.628)	(–2.079)	(–4.551)	(–3.603)	(2.448)	(–2.058)	(2.638)	(–3.136)
θ_2	–17.480***	–6.219***	–2.545*	6.555***	–2.021***	–3.757**	5.443	6.209***	–4.051***	–76.470***	67.720***	–6.540***	–6.788***
	(–3.886)	(–4.058)	(–2.153)	(5.523)	(3.176)	(–2.916)	(1.753)	(3.276)	(–4.475)	(–4.242)	(7.043)	(–8.715)	(–3.174)
β_1	0.865***	0.318***	0.176**	0.475***	0.197**		–0.205**	0.274***	–0.235***	0.124	0.092	5.985***	–0.101
	(22.610)	(4.416)	(2.249)	(7.310)	(2.813)		(–2.792)	(4.015)	(–3.458)	(1.737)	(1.487)	(7.733)	(–1.459)
β_2		0.175**	–0.364***	–0.067				0.237***	0.137*	0.169*	0.057		–0.152**
		(2.339)	(–4.616)	(–0.969)				(3.491)	(1.938)	(2.098)	(0.957		(–2.159)
β_3			0.004	0.119					0.153**		–0.233***		–0.069
			(0.055)	(1.693)					(2.249)		(4.057)		(–1.135)
β_4			–0.166**	–0.119									0.217***
			(–2.243)	(–1.749)									(3.573)
β_5				–0.197***									
				(–3.068)									

Notes: ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively. The number in parenthesis indicates the *t*-statistic.

Source: Author’s calculation.

As we know that these CEE transition countries started their liberalization programs in the late-1980s and early 1990s. In some of these countries, this period was characterized by dramatic improvements in budget deficits, debts and inflation. As these countries became increasingly open to trade (and inflation and growth rates converge to that of developed countries), we expect to find more favorable evidence of the parity condition using data in recent years. A survey carried out by the Organization of Economic Cooperation and Development (OECD) points out that even early in the transition process international firms have been impressed at how well these countries have adjusted after the transition and their commitment to a newly adopted market system (OECD, 1994). In fact, many of these countries adopted trade policies that mimic those of the European Union (EU), with a view to alignment in readiness for membership. As the reform process (price liberalization and trade opening) becomes intensified, we may expect a reduction in persistent shocks to international parity. The validity of RIRP is important to policy makers in six CEE countries who base their determination on interest rate adjustments. The result means that the unbounded gains from arbitrage in traded portfolios are impossible among these six countries.

The unit root tests with two structural breaks employed in this study provide some evidence favoring the long-run validity of RIRP for the six CEE countries studied. The major policy implication emerged from this study is that RIRP can be used to determine the equilibrium real interest rate convergence for these six CEE countries. Our findings are consistent with Mark (1985) who suggests that we can use RIRP to test whether national real interest rates were bound to converge, the scope for international portfolio diversification would be significantly reduced; and national monetary policy as a tool of effective macro-management would be restricted to the degree it affects the international real interest rate. 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. 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 those CEE countries who consider sacrificing their own national currency in favor of a common currency. The implication of RIRP's long-run validity indicates that assets of these CEE countries with identical risk, liquidity and maturity characteristics offer the same expected return across different countries. The extent to which RIRP holds therefore serves as an indicator of the degree of product and 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 the other things are equal, international portfolio diversification in the six CEE countries will be more attractive to investors when there are differences in real rates of interest across countries. Meanwhile, the extent of product markets integration in CEE countries might provide useful information for countries seeking to join the EU monetary union. The validity of RIRP is important to policy makers in CEE countries who base their determination on interest rate adjustments.

Conclusion

In this empirical study, we apply Narayan and Popp (2010) unit root test with two endogenous breaks to assess the non-stationary properties of the real interest rate for 13 CEEC countries. This study examined the validity of RIRP and the findings from provide robust empirical evidence supporting the validity of the long-run RIRP, suggesting these six countries that their real interest rate adjustment is mean reversion towards RIRP equilibrium values with two structural breaks. It implies that transaction costs may be affecting the portfolio decisions of the international investors. This might offer an alternative explanation for the difficulty researchers have encountered in rejecting the unit root hypothesis for real interest rate convergence.

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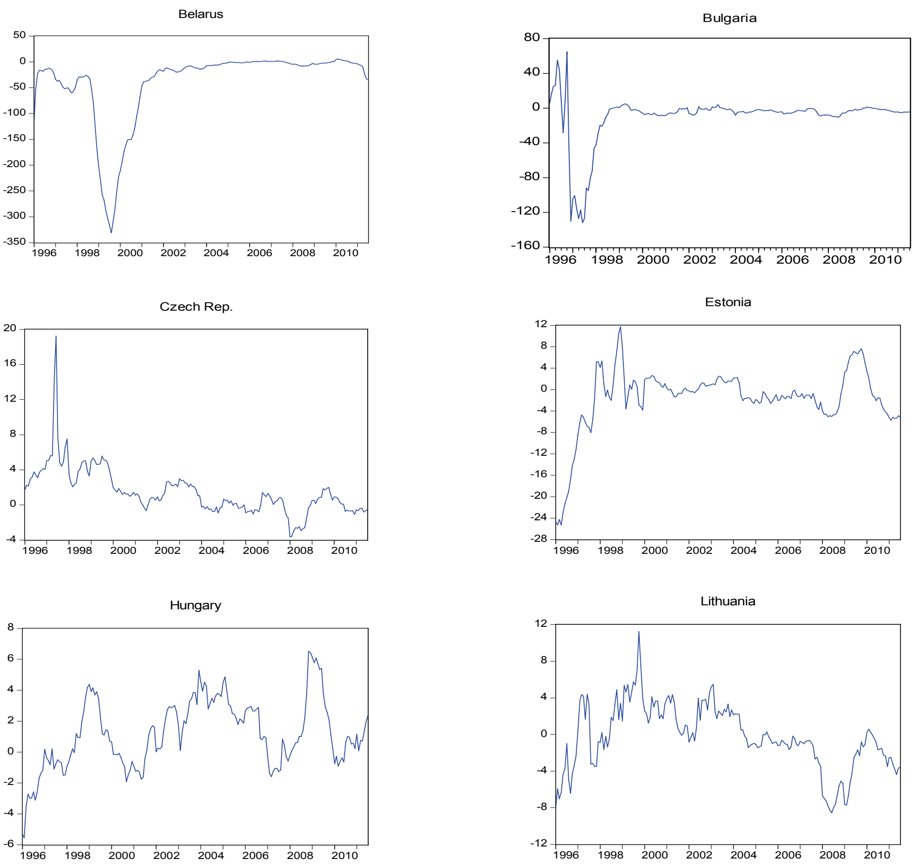
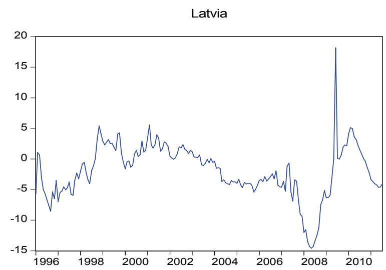
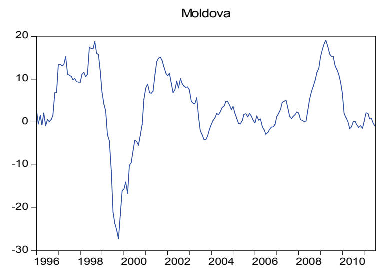
Appendix

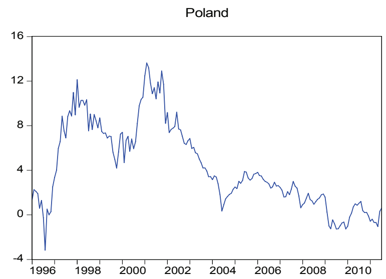
Figure 1

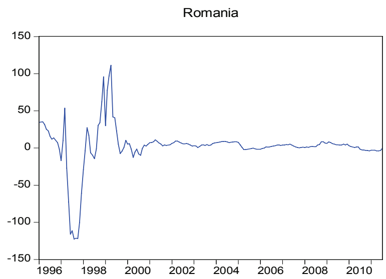
The Tendency of Real interest Rate Differentials for CEE Countries

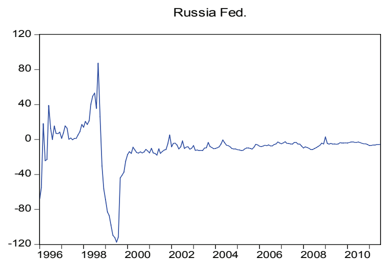


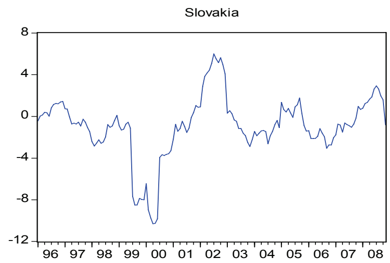


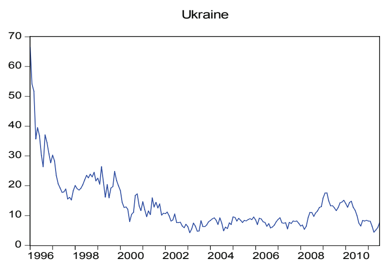












Source: Author's calculation.