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ON THE EVOLUTION OF COMPETITIVENESS IN CENTRAL AND EASTERN EUROPE: IS IT BROKEN?

JUAN CARLOS CUESTAS

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On the evolution of competitiveness in Central and Eastern Europe: is it broken?

Juan Carlos Cuestas*

Abstract

In this paper we aim to analyse the evolution of the real exchange rate (RER) as a measure of competitiveness for a group of Central and Eastern European countries. To do so, we apply unit root tests with breaks and estimate equations with structural breaks. The results show that even though RERs have become flatter, which means less competitiveness is lost against main trading partners, they have become less mean reverting, meaning that shocks now tend to have longer effects. Policy conclusions are derived from this analysis.

JEL Codes: C22, F15

Keywords: real exchange rates, Central and Eastern Europe, structural breaks, European integration

The views expressed are those of the author and do not necessarily represent the official views of Eesti Pank or the Eurosystem.

* Author's email: cuestas@uji.es.

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Non-technical summary

The purchasing power parity (PPP) theory and analysis of the dynamics of the real exchange rate (RER) have probably been among the most frequently chosen topics in academic writing on economics since the first works were written by the monks of Salamanca. The PPP theory, in its absolute version, states that prices in different countries should be equal when measured in a common currency. It is hence believed that PPP could be a proxy for economic integration, since the absence of barriers to trade would facilitate the empirical fulfilment of that trade. If the RER is defined as the ratio of the prices of two countries denominated in a common currency, absolute PPP implies that the RER should be equal to one. Empirically, it is known that if the PPP theory holds, it does so only in the long run. In consequence, applying tests for the order of integration of RER has been a very popular way of analysing the application of the PPP theory in practice.

Empirical analysis of the PPP hypothesis and analysis of the dynamics of the RER are relevant for analysis of how the competitiveness of countries evolves. This is because departures from PPP imply that the relative competitiveness of the countries has diverged. Competitiveness is a key factor for enhancing economic growth, especially for members of the Economic and Monetary Union (EMU), who cannot devalue their currencies.

In this paper we focus on analysing the evolution of the RER in a group of Central and Eastern European countries (CEECs), namely Bulgaria, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia. We not only test the empirical validity of the PPP theory, but we go a step further and analyse how the RER has behaved as a proxy of competitiveness over the past 25 years. We particularly want to see how crises have affected this key variable.

Analysis of the evolution of competitiveness has gathered momentum in policy. As an example of that we can point to several competitiveness reports published by the central banks of some of these countries.

From the empirical point of view, the fulfilment of the PPP theory would imply that the RER is a mean-reverting process, which it clearly is not in the CEECs. In this paper we focus on analysing how the RER evolves, as it has been established that PPP does not hold in these countries. Recent contributions have then gone in the direction of analysing the determinants of the RER and their impact on economic growth and the current account. However, this more recent literature stops its analysis in 2014 in the best case. Here, we want to know how the dynamics of the RER in our target CEECs have been affected by crises and economic events, with particular attention to potential breaks in 2008.

So the research question of this paper is twofold: first we want to analyse formally how the apparent deterministic trend has changed over time, and second, once those changes have been incorporated in the model, we can examine how the speed of reversion towards the equilibrium of the RER has changed over time. The closer it is to stationarity, the quicker the mean reversion is, and this means that shocks have only a temporary effect on competitiveness. However, if the RER has become more persistent, or has higher hysteresis, then shocks tend to have permanent effects on competitiveness and policy making may need to be reconsidered.

Overall, we find that the Great Recession made the loss of relative competitiveness smaller, as the RER became flatter and the variable became less stationary, which may imply that deeper surveillance of the evolution of the RERs of these countries is needed.

Contents

1. Introduction

The purchasing power parity (PPP) theory and analysis of the dynamics of the real exchange rate (RER) have probably been among the most frequently chosen topics in academic writing on economics since the first works were written by the monks of Salamanca (Officer, 1982). The PPP theory, in its absolute version, states that prices in different countries should be equal when measured in a common currency. It is hence believed that PPP could be a proxy for economic integration, since the absence of barriers to trade would facilitate the empirical fulfilment of that trade (Wei and Parsely, 1995). If the RER is defined as the ratio of the prices of two countries denominated in a common currency, absolute PPP implies that the RER should be equal to one. Empirically, it is known that if the PPP theory holds, it does so only in the long run (see Sarno and Taylor, 2002, amongst many others). In consequence, applying tests for the order of integration of RER has been a very popular way of analysing the application of the PPP theory in practice.

Empirical analysis of the PPP hypothesis and analysis of the dynamics of the RER are relevant for analysis of how the competitiveness of countries evolves. This is because departures from PPP imply that the relative competitiveness of the countries has diverged. Competitiveness is a key factor for enhancing economic growth, especially for members of the Economic and Monetary Union (EMU), who cannot devalue their currencies.

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Analysis of the evolution of competitiveness has gathered momentum in policy. As an example of that we can point to several competitiveness reports published by the central banks of some of these countries (see for example Lepik and Cuestas, 2019). Looking at the evolution of the RER as shown in Figures 1 and 2[1] reveals two important features. The first is the Balassa-Samuelson effect (Balassa, 1964, and Samuelson, 1964), which occurs when countries with higher economic growth experience real appreciation of their currencies, and which has been formalised by Devereux (2003) and Beckmann et al. (2015), and the second feature is a break, or a change in the trend, in the years around 2008.

From the empirical point of view, the fulfilment of the PPP theory would imply that the RER is a mean-reverting process, which it clearly is not in the CEECs. For example, Sideris (2006) finds that there is some evidence of mean reversion, but the estimated coefficients of the regressions are not those predicted by the PPP hypothesis. Later, Cuestas (2009) finds that deterministic trends are actually necessary for the null of unit root to be rejected. So any deviation from a mean-reverting process around a constant value violates the essence of the PPP theory. This is why in this paper we focus on analysing how the RER evolves, as it has been established that PPP does not hold in these countries. Recent contributions have then gone in the direction of analysing the determinants of the RER and their impact on economic growth (see Cuestas et al., 2019, and the references therein) and the current account (see Gabrisch and Staehr, 2015, amongst others). However, this more recent literature stops its

[1] Data sources and definitions are explained in more detail in the data section.

analysis in 2014 in the best case. Here, we want to know how the dynamics of the RER in our target CEECs have been affected by crises and economic events, with particular attention to potential breaks in 2008.

So the research question of this paper is twofold: first we want to analyse formally how the apparent deterministic trend has changed over time, and second, once those changes have been incorporated in the model, we can examine how the speed of reversion towards the equilibrium of the RER has changed over time. The closer it is to stationarity, the quicker the mean reversion is, and this means that shocks have only a temporary effect on competitiveness. However, if the RER has become more persistent, or has higher hysteresis, then shocks tend to have permanent effects on competitiveness and policy making may need to be reconsidered.

The remainder of the paper is organised as follows. The next section briefly summarises the implications of analysing the dynamics of the RER in our target group of countries and presents a brief literature review. Section 3 presents the data and some stylised facts. Section 4 describes the statistical methods used to study the dynamics of the RER. In Section 5 we present the results and discuss their implications for policy making and the last section concludes.

2. Real exchange rate economics in CEECs in brief

As mentioned in the previous section, RERs can be understood as a measure of competitiveness. The RER, q_t, is defined as:

$$q_t = \frac{s_t p_t}{p_t^*} \tag{1}$$

where s_t is the nominal bilateral exchange rate between the national currency and the foreign currency defined as the price of one unit of national currency in terms of the foreign currency, p_t is the national price level, and p_t^* is the foreign price level. Since the numerator and the denominator are based in the same currency, the RER indicates the evolution of national prices relative to foreign ones. According to the absolute PPP theory, this should make the RER equal to one. A more relaxed version of the PPP theory is the relative PPP theory, which states that what matters is that the inflation rates are the same when measured in the same currency. This implies that the RER is allowed to be different from one, but should maintain a constant value over time. A number of papers have been published since the papers by Sideris (2006) and Cuestas (2009) that aim to provide more evidence in favour of the mean reversion of the RER for CEECs, giving more support for the relative version of PPP theory by relaxing the assumptions in their auxiliary regressions. A notable contribution by Maican and Sweeney (2013) applies a battery of unit root tests that incorporate nonlinearities both in the deterministic components and in the autoregressive parameters of the auxiliary regressions, and they find that structural breaks have indeed been part of the evolution of the real exchange rates of the CEECs. However, their data do not cover the Great Recession period.[2]

Since the Balassa-Samuelson effect is present in the data among other things, as explained in the introduction, testing for the PPP hypothesis becomes irrelevant.

[2] A more detailed and up-to-date review of the literature analysing PPP in the CEECs can be found in Bekő and Kavkler (2019).

Analysis of the statistical properties of the RER in the CEECs becomes much more relevant when the evolution of their competitiveness is studied. First, changes in the deterministic components of the RER may affect the speed of mean reversion, and so a change towards shocks becoming more persistence may be a call to policy action (see for example, Christidou and Panagiotidis, 2010 and Holmes et al., 2012, amongst others).

The group of countries analysed here have been involved in a very intense process of major structural change in recent decades to become market economies and full members of the European Union (EU). Most importantly, changes in their exchange rate system to fulfil the Maastricht criteria may have structurally affected how their competitiveness has evolved. We should note that the degree of EU integration is different for each of these countries. Some of them are already euro area members, as Slovenia has been since 2007, Slovakia since 2009, Estonia since 2010, and Latvia and Lithuania since 2015, while others still need to fulfil the Maastricht criteria and are not even in the Exchange Rate Mechanism II, meaning that shocks to their RER may have had different responses. Bulgaria has an exchange rate peg with the euro, but the remainder maintain a floating exchange rate system.

3. The data

The data for this analysis come from *Eurostat* and we use quarterly observations of the real effective exchange rate (REER) (series *ert_eff_ic_q*) for Bulgaria, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia from 1994Q1 until 2019Q1. We use two definitions of the REER. These are REER, deflator: consumer price index (CPI) – 37 trading partners – industrial countries; and REER, deflator: unit labour costs in the total economy (ULC) – 37 trading partners – industrial countries. We consider that both CPIs and ULCs are good measures of competitiveness. The idea of using effective exchange rates instead of bilateral ones is that they give us a measure of competitiveness against the main trading partners. The variable is computed as an index with 100 in 2010.

The data are displayed in Figures 1 and 2. Figure 1 shows that the CPI-based REERs suffer a change in trend around 2008 in all cases, becoming flatter in general terms and more volatile. Leaving aside the deeper effects of economic slowdowns, this visual analysis corroborates that the REERs have become flatter after the ignition of the crises around 2008. In addition, there is some turmoil around 1997–1998 in the cases of Romania, Slovakia and Slovenia because of the Russian and Asian crises, while Bulgaria suffered a major crisis in 1996–1997.

From Figure 2, it is not very clear whether the REERs based on ULC suffered the same fate after 2008, as the shock for some countries seemed to have had only temporary effects on the trend and volatility of the variable, as seen in Bulgaria and the Baltics. It may be that competitiveness measured as the REER based on ULC is less sensitive to the cycle, and shocks only have transitory effects. This is corroborated in Figures 3 and 4, where we display the percentage changes of both definitions of REER, and Tables 1 and 2, where we present some descriptive statistics on the percentage changes of both REERs.

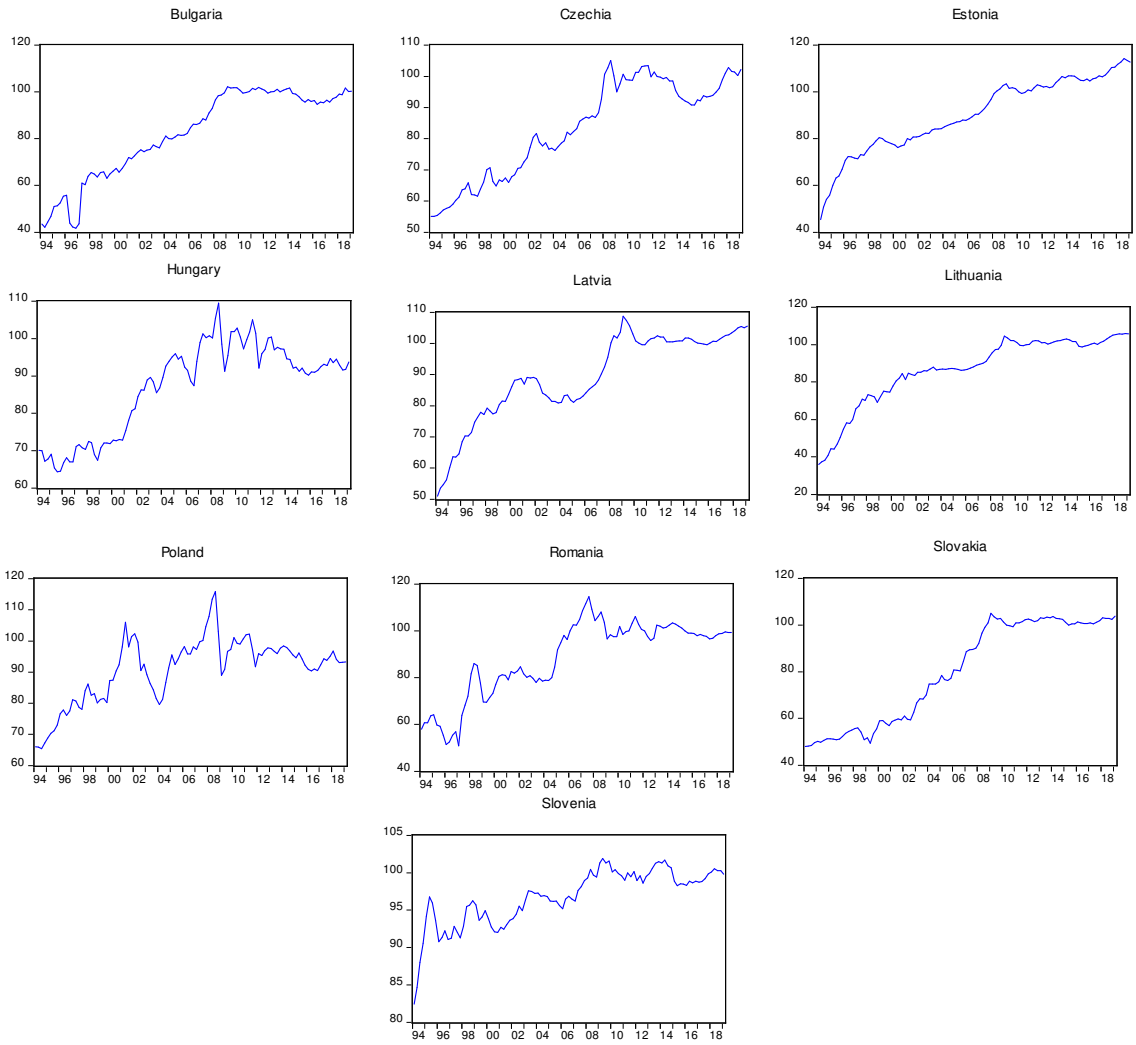


Figure 1: Real effective exchanges rates, CPI based

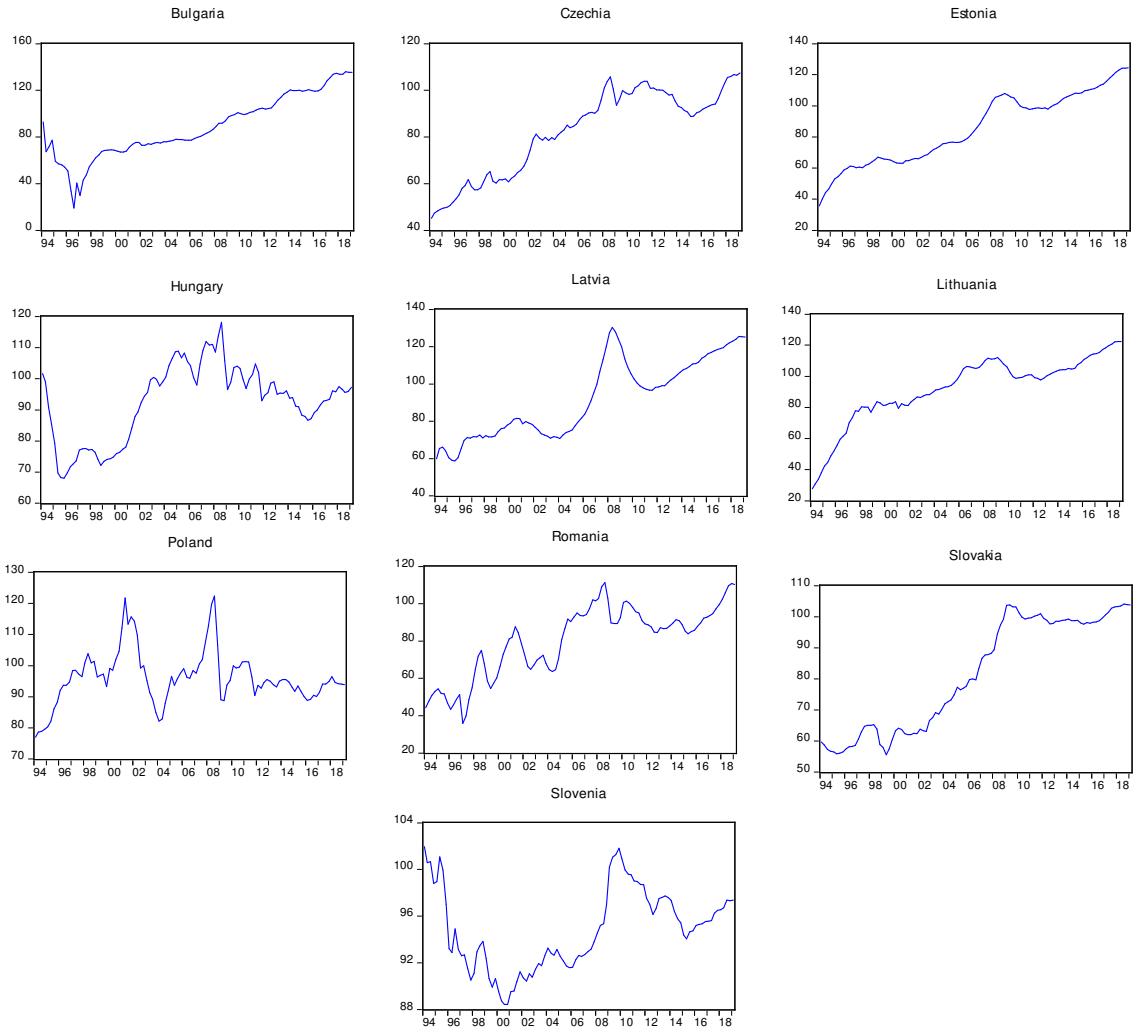


Figure 2: Real effective exchange rates, ULC based

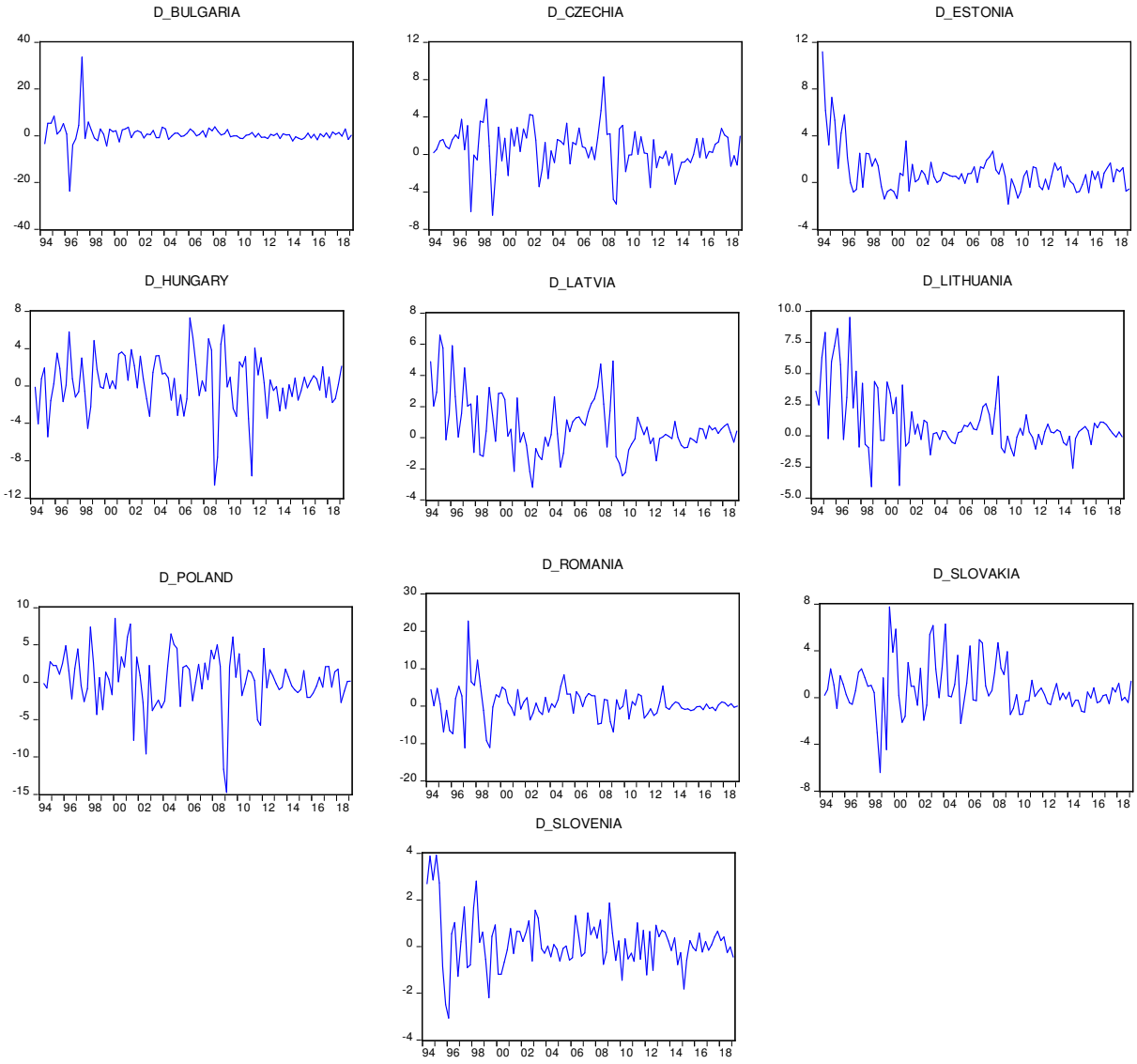


Figure 3: Percentage change of REER, CPI based

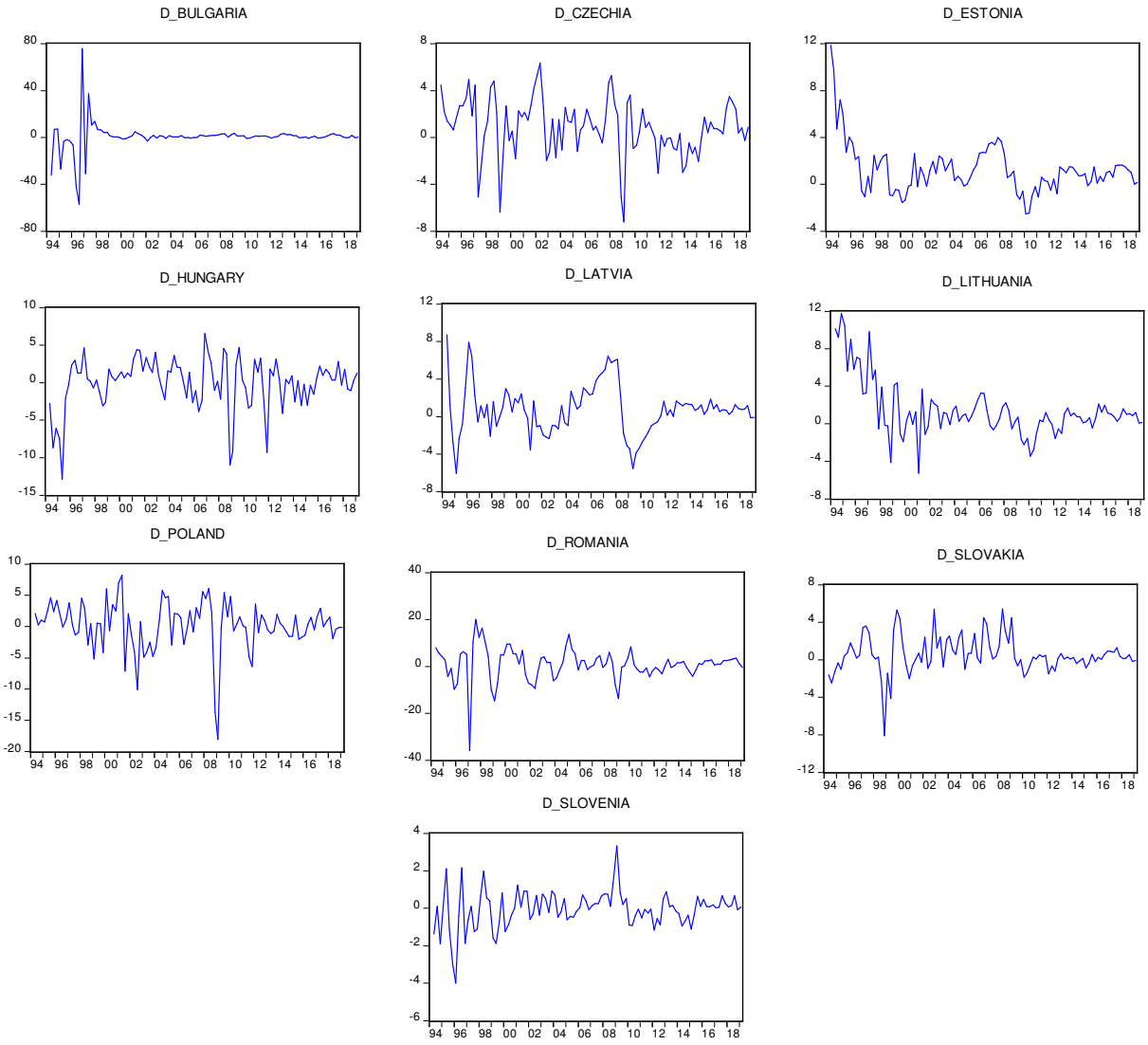


Figure 4: Percentage change of REER, ULC based

Table 1: Descriptive statistics for the REER percentage change, CPI based

	D_BULGARIA	D_CZECHIA	D_ESTONIA	D_HUNGARY	D_LATVIA	D_LITHUANIA	D_POLAND	D_ROMANIA	D_SLOVAKIA	D_SLOVENIA
Mean	0.836394	0.619431	0.909486	0.290531	0.726980	1.079060	0.344695	0.536236	0.771249	0.191662
Median	0.565493	0.748873	0.652132	0.443277	0.345977	0.346310	0.643913	0.243917	0.381064	0.140643
Maximum	33.62758	8.284594	11.19438	7.261877	6.587097	9.502125	8.561823	22.74564	7.755220	3.919948
Minimum	–23.76935	–6.487814	–1.854797	–10.61624	–3.195684	–4.079886	–14.71139	–11.12567	–6.414528	–3.058807
Std. Dev.	4.619922	2.322098	1.871412	2.972184	1.846122	2.401102	3.656426	4.318165	2.169574	1.144087
Skewness	2.145692	–0.321994	2.545036	–0.751516	0.896502	1.333943	–1.013542	1.005407	0.526764	0.609967
Kurtosis	34.28486	4.668661	12.51983	5.106124	4.059718	5.257471	6.123280	9.795005	4.893352	4.941426
Jarque-Bera	4154.826	13.32979	485.5669	27.89526	18.07444	50.89081	57.76645	209.2311	19.56125	21.90572
Probability	0.000000	0.001275	0.000000	0.000001	0.000119	0.000000	0.000000	0.000000	0.000057	0.000018
Sum	83.63937	61.94306	90.94865	29.05315	72.69801	107.9060	34.46955	53.62365	77.12493	19.16618
Sum Sq. Dev.	2113.024	533.8219	346.7160	874.5541	337.4086	570.7636	1323.576	1846.008	465.9979	129.5846
Observations	100	100	100	100	100	100	100	100	100	100

Table 2: Descriptive statistics for the REER percentage change, ULC based

	D_BULGARIA	D_CZECHIA	D_ESTONIA	D_HUNGARY	D_LATVIA	D_LITHUANIA	D_POLAND	D_ROMANIA	D_SLOVAKIA	D_SLOVENIA
Mean	0.378990	0.866092	1.250115	–0.045949	0.737563	1.481588	0.198461	0.914072	0.552992	–0.045960
Median	0.843400	0.912238	0.969013	0.446971	0.780060	0.868358	0.488871	1.166106	0.286491	0.059652
Maximum	75.92404	6.336843	11.88419	6.524589	8.724789	11.77172	8.205739	19.99608	5.451445	3.317239
Minimum	–57.31437	–7.205217	–2.524949	–12.87114	–6.058574	–5.263404	–18.02607	–36.01067	–8.108802	–3.984339
Std. Dev.	12.57645	2.398421	2.138661	3.376142	2.602417	2.998466	3.896704	6.824411	1.947218	0.990814
Skewness	0.677805	–0.625177	2.057364	–1.391593	0.402061	1.354344	–1.530930	–1.444205	–0.266081	–0.399079
Kurtosis	20.92261	4.287479	10.19351	5.731176	4.054739	5.455313	8.105796	10.88573	6.610328	6.140556
Jarque-Bera	1346.073	13.42078	286.1567	63.35602	7.329526	55.68979	147.6839	293.8651	55.49028	43.75061
Probability	0.000000	0.001218	0.000000	0.000000	0.025610	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	37.89901	86.60919	125.0115	–4.594927	73.75626	148.1588	19.84613	91.40716	55.29917	–4.595973
Sum Sq. Dev.	15658.54	569.4898	452.8133	1128.435	670.4850	890.0893	1503.246	4610.686	375.3741	97.18954
Observations	100	100	100	100	100	100	100	100	100	100

4. Methodology

Our analysis uses univariate methods that aim to estimate a measure or proxy of the speed of mean reversion of the REER, taking into account possible changes in both the deterministic trends and the autoregressive parameters. The baseline is to begin with some basic unit root analysis like the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979, and Said and Dickey, 1984), which is based on the following auxiliary regression:

$$\Delta q_t = \rho q_{t-1} + \varepsilon_t \tag{2}$$

with the null of unit root implying that $\rho = 0$, versus the alternative of stationarity, $\rho < 0$. Note that it is usual to include lags of the dependent variable on the right hand side of equation (2). Equation (2) may also include a constant and a time trend. In this paper we apply the ADF test along with a set of tests developed by Ng and Perron (2001) that improve the size and power of the traditional unit root tests.

The previous tests only account for linear trends, as mentioned before, and there are obvious signs of changes in the deterministic components, so we also apply unit root tests incorporating one structural break, following the initial framework developed by Perron (1989), and Perron and Vogelsang (1992a, 1992b). According to these authors the breaks may happen in the constant or in the trend at an unknown date that is selected by the test, and the break can be an innovational outlier in a model with a permanent change, or an additive outlier, which is just a temporary break.

Finally, we test for changes in the autoregressive parameter ρ, which is a proxy of the speed of mean reversion after a shock, by applying the Bai and Perron (1998, 2003a, 2003b) method. This allows us to estimate the following equation with structural breaks:

$$\Delta q_t = \gamma_1 I(t < T_b) + \gamma_2 I(t \geq T_b) + \alpha_1 t I(t < T_b) + \alpha_2 t I(t \geq T_b) + \rho_1 I(t < T_b) q_{t-1} + \rho_2 I(t \geq T_b) q_{t-1} + \varepsilon_t \tag{3}$$

where I(.) is the indicator function, which takes the value one if the condition in parentheses is satisfied or zero otherwise. In equation (3) we have assumed only one structural break, defining two temporal segments for the parameters. However, in our empirical analysis the number of breaks can be up to three in any one case. Using equation (3) we can estimate different coefficients for the constant, the trend and the autoregressive parameter, depending on the given date. The idea is to obtain some estimation of how the deterministic components have changed and, more importantly, of how the speed of mean reversion has been affected by structural changes. The authors of this approach also provide methods for obtaining the number of breaks from a maximum selected by the user. In our application we use the sequential method to obtain the number of breaks, with a maximum of five.

5. Empirical analysis

In this section we present the results of our analysis. In Tables 3 and 4 we present some preliminary results for the unit root tests.

In Table 3 we display the results of the ADF and Ng and Perron (2001) unit root tests for the REER based on CPIs. The auxiliary regression contains a drift and a linear time trend. In this case, the null of unit root is only rejected in Estonia and Slovenia with the ADF test, but not with the Ng and Perron (2001) test, so there is little evidence of mean reversion in the

REER of our target countries. In Table 4 we present the results of the same tests but for the REER computed using ULC. The results from this table do not show very much evidence against the null, since the only countries for which we find the null being rejected are Latvia and Lithuania. In Table 5 we present a summary of the results.

Table 3: Unit root tests results: model with a constant and a trend, REER, CPI based

	ADF	**MZa**	**MZt**	**MSB**	**MPT**
Bulgaria	–0.878835	–3.93176	–1.24096	0.31562	21.2658
Czechia	–1.507027	–4.20014	–1.38752	0.33035	21.0846
Estonia	–6.072990***	–2.29346	–0.95908	0.41818	34.7114
Hungary	–0.841461	–3.76365	–1.27269	0.33815	22.8393
Latvia	–2.882903	–3.56179	–1.24281	0.34893	24.0942
Lithuania	–3.090271	–0.31480	–0.21545	0.68442	95.4940
Poland	–2.441373	–6.48010	–1.70481	0.26308	14.0926
Romania	–1.595986	–4.91187	–1.45411	0.29604	17.9686
Slovakia	–0.510570	–1.63219	–0.75457	0.46230	43.2915
Slovenia	–4.760658***	–3.60087	–1.23215	0.34218	23.5898
Critical values					
1%	–4.052411	–23.8000	–3.42000	0.14300	4.03000
5%	–3.455376	–17.3000	–2.91000	0.16800	5.48000
10%	–3.153438	–14.2000	–2.62000	0.18500	6.67000

Note: Lag length chosen using the Modified Bayesian Information criteria proposed by Ng and Perron (2001) from a maximum of 12 lags. In the first row, the M-tests are the modified tests proposed by Ng and Perron (2001).

Table 4: Unit root tests results: model with a constant and a trend, REER, ULC based

	ADF	**MZa**	**MZt**	**MSB**	**MPT**
Bulgaria	–2.105353	–4.30139	–1.40041	0.32557	20.5832
Czechia	–1.693721	–4.41934	–1.45509	0.32926	20.3578
Estonia	–2.875015	–7.86814	–1.97808	0.25140	11.5965
Hungary	–1.807659	–4.63438	–1.52203	0.32842	19.6614
Latvia	–3.882854**	–24.7508***	–3.51749***	0.14212***	3.68396***
Lithuania	–4.381412***	–1.90523	–0.91981	0.48278	44.0842
Poland	–2.890712	–6.60604	–1.78686	0.27049	13.8129
Romania	–2.092896	–6.13658	–1.75154	0.28543	14.8494
Slovakia	–1.787877	–6.12023	–1.72899	0.28250	14.8768
Slovenia	–2.893597	–4.38224	–1.44423	0.32956	20.4847
Critical values					
1%	–4.052411	–23.8000	–3.42000	0.14300	4.03000
5%	–3.455376	–17.3000	–2.91000	0.16800	5.48000
10%	–3.153438	–14.2000	–2.62000	0.18500	6.67000

Note: Lag length chosen using the Modified Bayesian Information criteria proposed by Ng and Perron (2001) from a maximum of 12 lags. In the first row, the M-tests are the modified tests proposed by Ng and Perron (2001).

Table 5: Summary of the results of the unit root tests

	ADF (CPI)	ADF (ULC)	Ng and Perron (CPI)	Ng and Perron (ULC)
Bulgaria	I(1)	I(1)	I(1)	I(1)
Czechia	I(1)	I(1)	I(1)	I(1)
Estonia	**I(0)**	I(1)	I(1)	I(1)
Hungary	I(1)	I(1)	I(1)	I(1)
Latvia	I(1)	**I(0)**	I(1)	**I(0)**
Lithuania	I(1)	**I(0)**	I(1)	I(1)
Poland	I(1)	I(1)	I(1)	I(1)
Romania	I(1)	I(1)	I(1)	I(1)
Slovakia	I(1)	I(1)	I(1)	I(1)
Slovenia	**I(0)**	I(1)	I(1)	I(1)

In Tables 6 and 7 we present the results of the unit root tests by Perron and Vogelsang (1992a, 1992b), which incorporate breaks in the deterministic components. We also show the date of the potential break. We show the results for both the innovational and the additive outlier specifications. It may be remembered that these tests impose one break. We have selected the break endogenously as the date which minimises the t-statistic of the ADF test, in a model where both the drift and the constant are allowed to change. In Table 6 we display the results for the REER computed using the CPIs. Those two tests find evidence of stationarity around a broken trend in Bulgaria with only one specification and only at the 10% level of significance, in Estonia and Slovenia they find it with both specifications and in Hungary with the innovational outlier model. In all four cases the break happens in 2006–2007, just before the beginning of the crisis. This is a good sign that the evolution of the REER in these countries predicted the beginning of the crisis. The results are very similar when we apply the tests to the ULC-based REER. From Table 7 we find that the unit root hypothesis is rejected in Bulgaria and Hungary. The break date for Hungary seems to be related to the ignition of the global crisis in 2008, but the break in Bulgaria is related to the crisis in that country in 1996. A summary is provided in Table 8. Although there is more evidence against the null, it is not overwhelming.

Table 6: Results of the unit root tests with breaks: model with a constant and a trend, REER, CPI based

	ADF Innov.	ADF Addit.
Bulgaria	–4.961042*	–4.492221
	2007Q4	2007Q2
Czechia	–3.865776	–3.404957
	2007Q3	2007Q1
Estonia	–6.711335***	–6.072999***
	2007Q2	2007Q2
Hungary	–5.225952**	–4.849055
	2006Q3	2009Q1
Latvia	–3.732757	–3.476859
	2007Q1	2006Q4
Lithuania	–4.164842	–4.015201
	1995Q4	1995Q3
Poland	–3.856103	–3.681338
	2008Q3	2008Q2
Romania	–3.868073	–3.904919
	2004Q3	2004Q3
Slovakia	–3.747500	–3.094533
	2006Q3	2006Q2
Slovenia	–5.695258**	–5.606890**
	2007Q1	2007Q1
Critical values		
1%	–5.719131	–5.719131
5%	–5.175710	–5.175710
10%	–4.893950	–4.893950

Note: Lag length chosen using the Modified Bayesian Information criteria proposed by Ng and Perron (2001) from a maximum of 12 lags.

Table 7: Results of the unit root tests with breaks: model with a constant and a trend, REER, ULC based

	ADF Innov.	ADF Addit.
Bulgaria	–6.285102***	–6.260866***
	1996Q3	1996Q3
Czechia	–2.663417	–2.668901
	2001Q2	2001Q2
Estonia	–4.013212	–3.692317
	2006Q1	2005Q4
Hungary	–5.537583**	–4.799381*
	2008Q3	2001Q1
Latvia	–2.282164	–4.599537
	2005Q4	2005Q4
Lithuania	–4.725649	–4.185352
	2009Q2	1994Q3
Poland	–3.601859	–3.660566
	2002Q1	2002Q1
Romania	–3.004320	–3.017660
	1997Q1	1997Q1
Slovakia	–3.639940	–3.407797
	2006Q3	2006Q3
Slovenia	–3.720967	–3.697377
	1995Q2	1995Q2
Critical values		
1%	–5.719131	–5.719131
5%	–5.175710	–5.175710
10%	–4.893950	–4.893950

Note: Lag length chosen using the Modified Bayesian Information criteria proposed by Ng and Perron (2001) from a maximum of 12 lags.

Table 8: Summary of the results of the unit root tests with breaks

	ADF Innov. (CPI)	ADF Innov. (ULC)	ADF Addit. (CPI)	ADF Addit. (ULC)
Bulgaria	**I(0)**	**I(0)**	I(1)	**I(0)**
Czechia	I(1)	I(1)	I(1)	I(1)
Estonia	**I(0)**	I(1)	**I(0)**	I(1)
Hungary	**I(0)**	**I(0)**	I(1)	**I(0)**
Latvia	I(1)	I(1)	**I(0)**	I(1)
Lithuania	I(1)	I(1)	**I(0)**	I(1)
Poland	I(1)	I(1)	I(1)	I(1)
Romania	I(1)	I(1)	I(1)	I(1)
Slovakia	I(1)	I(1)	I(1)	I(1)
Slovenia	**I(0)**	I(1)	**I(0)**	I(1)

We have to remember that the Perron and Vogelsang tests impose one break in the deterministic components but not in the autoregressive parameter. However, we are interested in understanding how the speed of mean reversion may have changed over time and when. For this purpose we estimate equation (3) as proposed by Bai and Perron (1998, 2003a, 2003b). The results are presented in Tables 9 and 10. We first test for the optimal number of breaks, from a minimum of no breaks to a maximum of five. In most cases we find one or two breaks and only in one case do we find three breaks, that case being Slovakia, see Table 9. On the opposite side we do not find any breaks in Lithuania, Table 9, or Romania, Table 10, meaning that the models are linear and the results of Tables 3 and 4 apply. We present the estimated parameters for the constant, the trend and the autoregressive parameter in all sub-periods. In Table 9 we display the results for the CPI-based REER. Interestingly the first break in Bulgaria happens in 1999, which coincides with the recovery from the Russian crisis,[3] while the second one is related to the Great Recession. The estimated parameters show that the trend became flatter after both breaks and the autoregressive parameter became less mean-reverting. So we find that the trend changes towards becoming more competitive, but shocks have longer lasting effects. In Czechia the breaks are in 2008 and 2012, the second possibly related to the sovereign debt crisis. Interestingly, the trend of the variable does not really change in the second sub-period, but the autoregressive parameter becomes more stationary. However, after the second break the trend becomes flatter and the autoregressive parameter shows a slower mean reversion, if any at all. In Estonia, we find again that the break happens in 2007, and although the speed of mean reversion does not seem to change, the trend also becomes flatter. For Hungary we find that the break coincides with the date from Table 6 and the trend becomes negative, which implies an improvement in competitiveness on average, and the REER then returns faster to this trend. The interesting result for Latvia is that the trend becomes flatter after the second break, but the exchange rate seems to be quite explosive, as the autoregressive parameter is positive and significant. This implies that the Latvian authorities should monitor shocks to the RER closely to avoid permanent deviations. In Poland the breaks happen in 2003 and 2008. The main observation is that the RER becomes more mean reverting in the last sub-period and the trend becomes negative, which is good news for policy making. For Romania, we find only one break in 2006, after which the trend becomes almost flat and the speed of mean reversion is slightly reduced. In Slovakia, we find

[3] Because the trimming is set at 15% of observations, 1999Q3 is the earliest date with enough observations to detect a break.

three breaks, which are related to the recovery from the Russian crisis,[4] the process of European integration, and the great recession. The main observations are that the trend becomes more and more positive after the first and second breaks, and the speed of mean reversion reduces after 2002. In Slovenia the break occurs in 2009, when the trend becomes flatter and the exchange rate more mean-reverting.

The results of estimating equation (3) for the REER based on ULCs, shown in Table 10, are slightly different. However, in general we find that the REER becomes flatter in the last sub-period and less stationary.

In Figure 5 we display the graphs of the series along with the estimated breaks found with the different methods of ADF with a break and Bai and Perron. It is obvious that there are some discrepancies in the estimated dates when definitions of the REER are compared. This is because the CPI relates to final products even though there are proxies of prices or cost, and ULC relate to the cost of one input. In addition, the discrepancies between the ADF with breaks and Bai and Perron come from the different underlying models. It may be remembered that the ADF test with Perron and Vogelsang imposes one break in the deterministic component, whereas with Bai and Perron we first test for the number of breaks without imposing a minimum, and we allow not only the deterministic components but also the autoregressive parameter to change. However, we can say that there are some commonalities as it seems there is a break in most cases around 2000–2002 and another break around 2007–2008. In addition, there is a break in Czechia in around 2010–2011 and one in Hungary in 2015.

We can then draw some policy implications from our analysis. One implication is that since the trend has become flatter, and although this may be a consequence of the global financial crisis, prices in these countries are in general increasing at the same speed as those in their competitors. A countervailing implication though is that the RER becoming less stationary means that the effects of shocks last longer. The authorities need to keep an eye out in these cases as the shocks will need to be reverted by means of intervention.

[4] See note 3.

Table 9: Estimation of the broken equations, REER, CPI based

	γ_1 α_1 ρ_1	T_1	γ_2 α_2 ρ_2	T_2	γ_3 α_3 ρ_3	T_3	γ_4 α_4 ρ_4
Bulgaria	29.05920 [0.00] 2.411357 [0.00] –1.139032 [0.00]	1999Q3	46.89099 [0.00] 0.665372 [0.00] –0.933622 [0.00]	2007Q3	20.77455 [0.01] –0.027255 [0.21] –0.187475 [0.02]	-	
Czechia	32.07893 [0.00] 0.373654 [0.00] –0.599948 [0.00]	2008Q1	88.75043 [0.00] 0.349788 [0.01] –1.116512 [0.00]	2012Q2	20.07811 [0.12] –0.010493 [0.84] –0.197945 [0.06]	-	
Estonia	18.46844 [0.00] 0.124813 [0.00] –0.273105 [0.00]	2007Q3	20.82397 [0.00] 0.068856 [0.00] –0.249063 [0.00]	-			
Hungary	10.23116 [0.14] 0.103164 [0.28] –0.164034 [0.17]	2006Q3	61.72348 [0.00] –0.120787 [0.00] –0.544739 [0.00]	-		-	
Latvia	18.38969 [0.04] 0.124741 [0.39] –0.235511 [0.11]	2002Q2	–13.97965 [0.00] 0.235421 [0.00] 0.045701 [0.36]	2009Q2	–13.39055 [0.29] 0.029715 [0.03] 0.108788 [0.38]	-	
Lithuania	NO BREAK MODEL						
Poland	40.66846 [0.00] 0.597356 [0.00] –0.622041 [0.00]	2003Q1	15.08150 [0.18] 0.459979 [0.00] –0.385195 [0.01]	2008Q4	96.81874 [0.00] –0.145640 [0.00] –0.888193 [0.00]	-	
Romania	22.69012 [0.00] 0.261910 [0.00] –0.389468 [0.00]	2006Q1	51.20915 [0.00] –0.050710 [0.09] –0.469975 [0.00]	-			
Slovakia	12.85439 [0.143] –0.093410 [0.27] –0.221921 [0.20]	1999Q3	41.69610 [0.00] 0.298164 [0.03] –0.862156 [0.00]	2002Q4	14.02407 [0.00] 0.688131 [0.00] –0.584825 [0.00]	2008Q2	46.22674 [0.00] 0.021543 [0.17] –0.472381 [0.00]
Slovenia	61.75527 [0.00] 0.082503 [0.00] –0.680339 [0.00]	2009Q1	79.14261 [0.00] –0.018973 [0.04] –0.777728 [0.00]	-			

Note: T_i indicates the date of the breaks. The regression contains 8 lags of the dependent variables, which do not change over time. P-values are given in brackets.

Table 10: Estimation of the broken equations, REER, ULC based

	γ_1 α_1 ρ_1	T_1	γ_2 α_2 ρ_2	T_2	γ_3 α_3 ρ_3
Bulgaria	–6.248554 [0.35] 3.990931 [0.00] –1.083461 [0.00]	1999Q3	3.916743 [0.16] 0.083958 [0.19] –0.086516 [0.22]	-	
Czechia	16.66763 [0.00] 0.337352 [0.00] –0.381386 [0.00]	2011Q2	11.33217 [0.26] 0.025571 [0.52] –0.138550 [0.10]	-	
Estonia	41.72991 [0.00] 0.431989 [0.00] –0.776574 [0.00]	2000Q1	2.317254 [0.01] 0.034762 [0.04] –0.046544 [0.03]	-	
Hungary	9.607195 [0.01] 0.165885 [0.00] –0.160789 [0.01]	2008Q4	139.7977 [0.00] –0.498940 [0.00] –1.060112 [0.00]	2015Q1	15.72921 [0.25] 0.441041 [0.03] –0.607776 [0.04]
Latvia	33.23319 [0.00] 0.356358 [0.00] –0.536871 [0.00]	2001Q3	–6.966019 [0.00] 0.137018 [0.00] 0.024389 [0.24]	2008Q2	3.956191 [0.07] 0.079045 [0.00] –0.092613 [0.00]
Lithuania	12.31269 [0.00] 0.181596 [0.00] –0.207846 [0.00]	2009Q2	6.657600 [0.07] 0.109003 [0.00] –0.143079 [0.00]	-	
Poland	36.15304 [0.00] 0.238017 [0.09] –0.402296	2003Q1	–1.799352 [0.87] 0.401290 [0.01] –0.172083 [0.15]	2008Q4	71.95094 [0.00] –0.090782 [0.10] –0.685075 [0.00]
Romania	NO BREAK MODEL				
Slovakia	25.47313 [0.00] 0.057215 [0.09] –0.433848 [0.00]	2002Q2	25.91908 [0.00] 1.051978 [0.00] –0.966146 [0.00]	2008Q2	30.07347 [0.00] 0.026569 [0.09] –0.323010 [0.00]
Slovenia	80.63834 [0.00] –0.247025 [0.00] –0.824003 [0.00]	2001Q1	48.99834 [0.00] 0.075847 [0.00] –0.568081 [0.00]	2008Q4	38.80943 [0.00] –0.030851 [0.00] –0.374156 [0.00]

Note: T_1 indicates the month of the first time break, T_2 indicates the month of the second time break. The regression contains 8 lags of the dependent variables, which do not change over time. P-values are given in brackets.

Figure 5: Real exchange rates and break dates

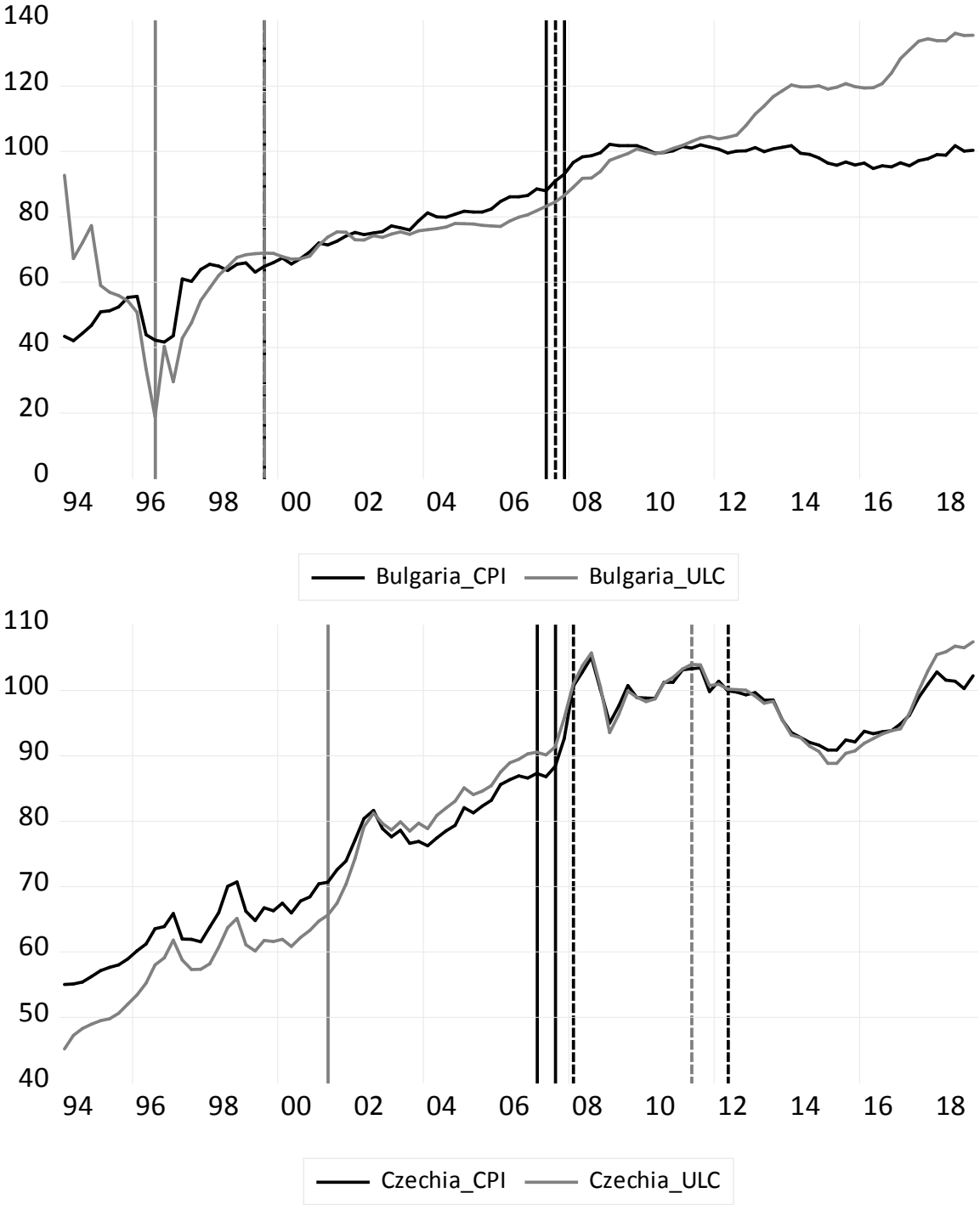
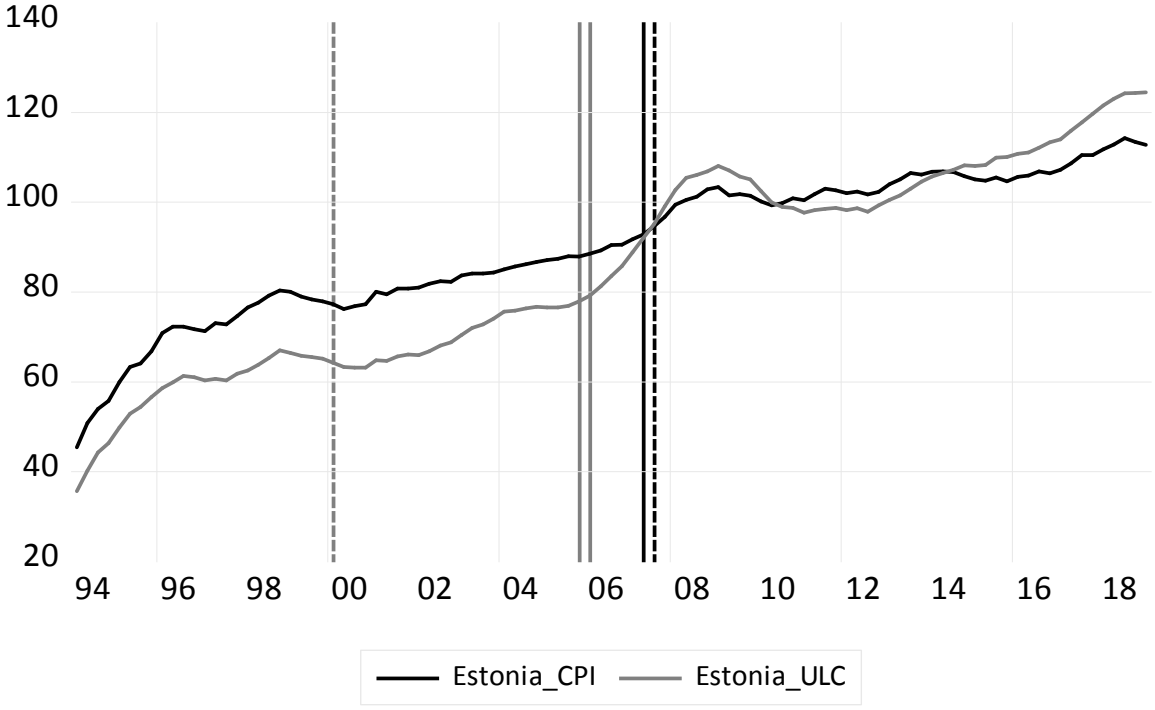


Figure 5: Real exchange rates and break dates

Note: Vertical lines are the breaks obtained with the different models. Solid lines are the breaks with the ADF with breaks test and dashed lines are the Bai and Perron method.



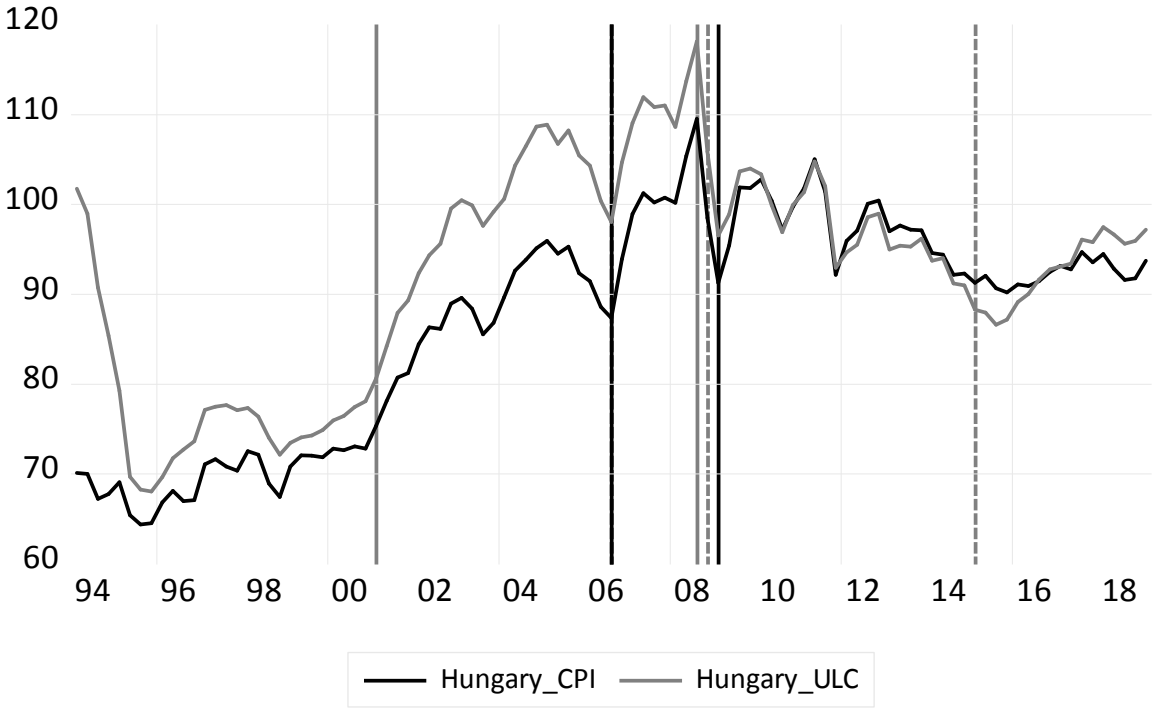
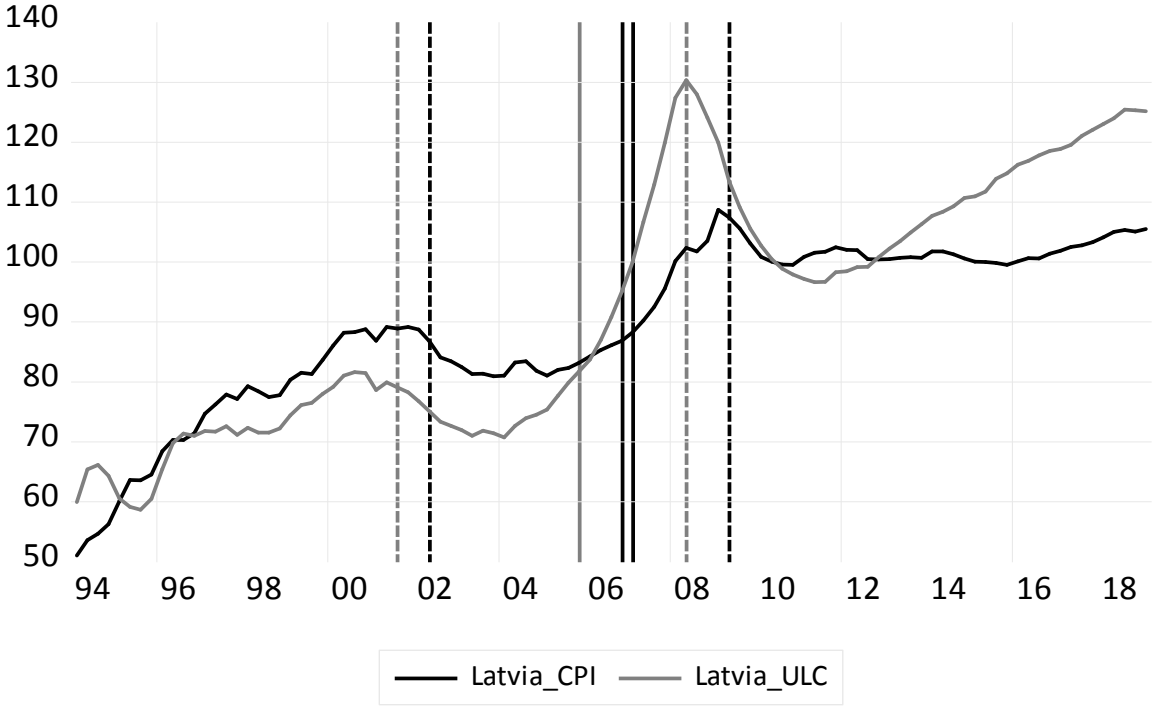


Figure 5: Real exchange rates and break dates (continued)

Note: Vertical lines are the breaks obtained with the different models. Solid lines are the breaks with the ADF with breaks test and dashed lines are the Bai and Perron method.



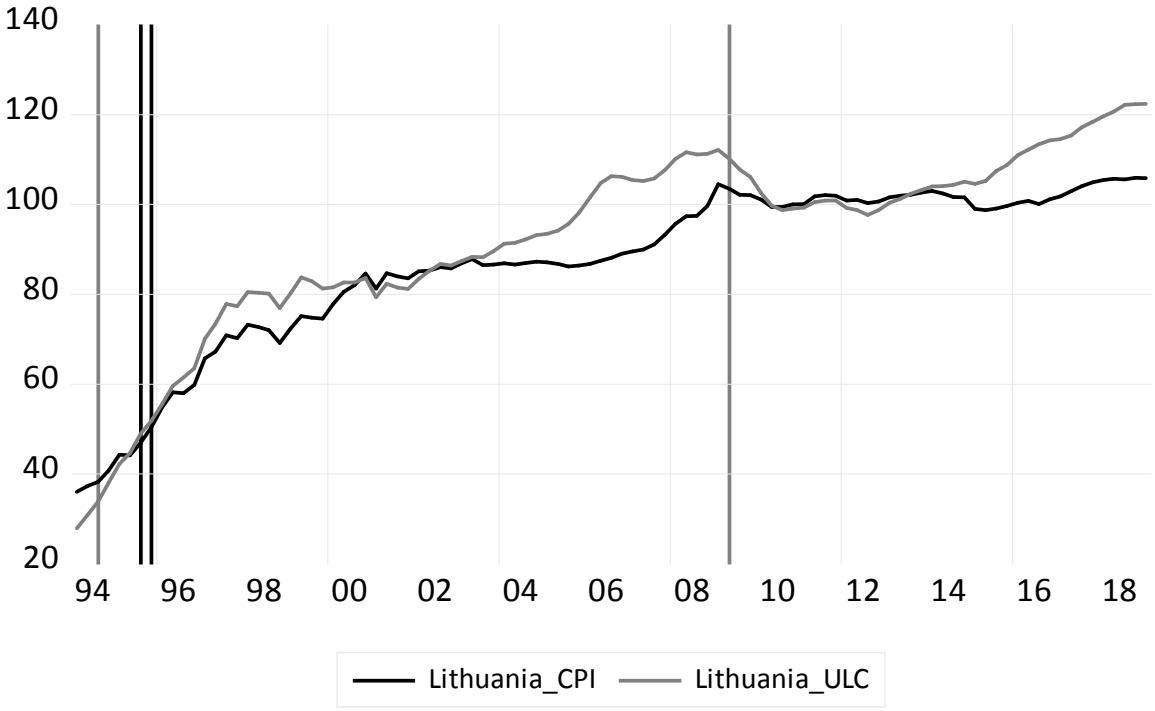
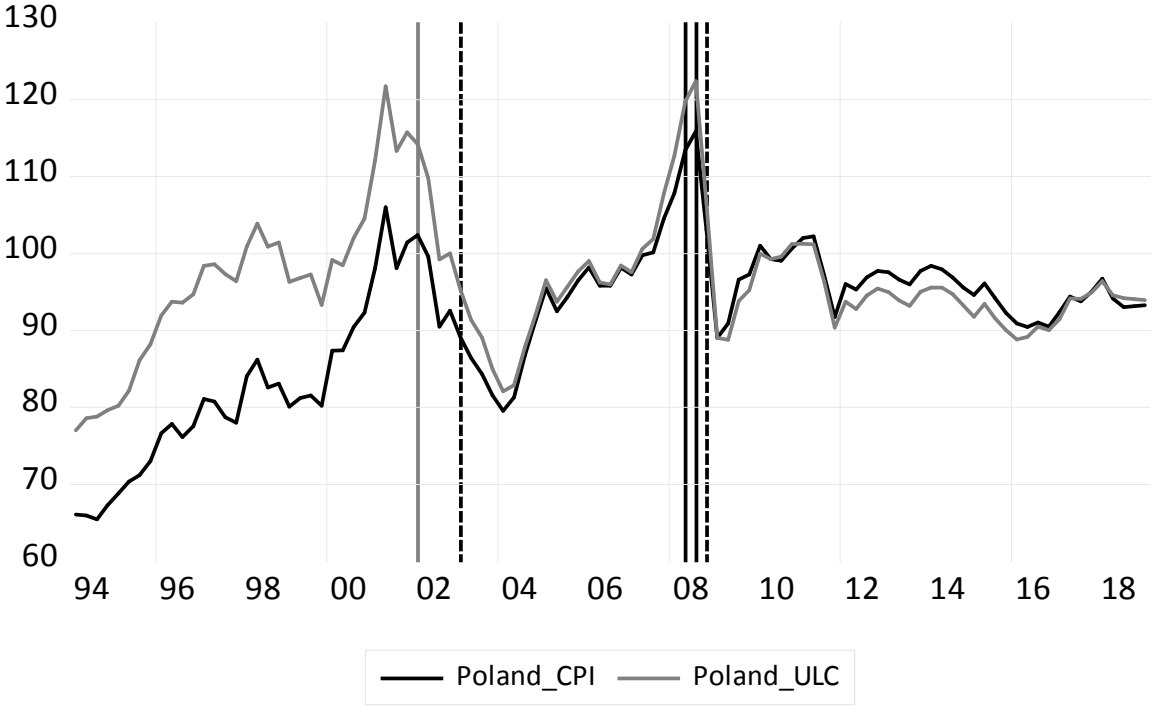


Figure 5: Real exchange rates and break dates (continued)

Note: Vertical lines are the breaks obtained with the different models. Solid lines are the breaks with the ADF with breaks test and dashed lines are the Bai and Perron method.



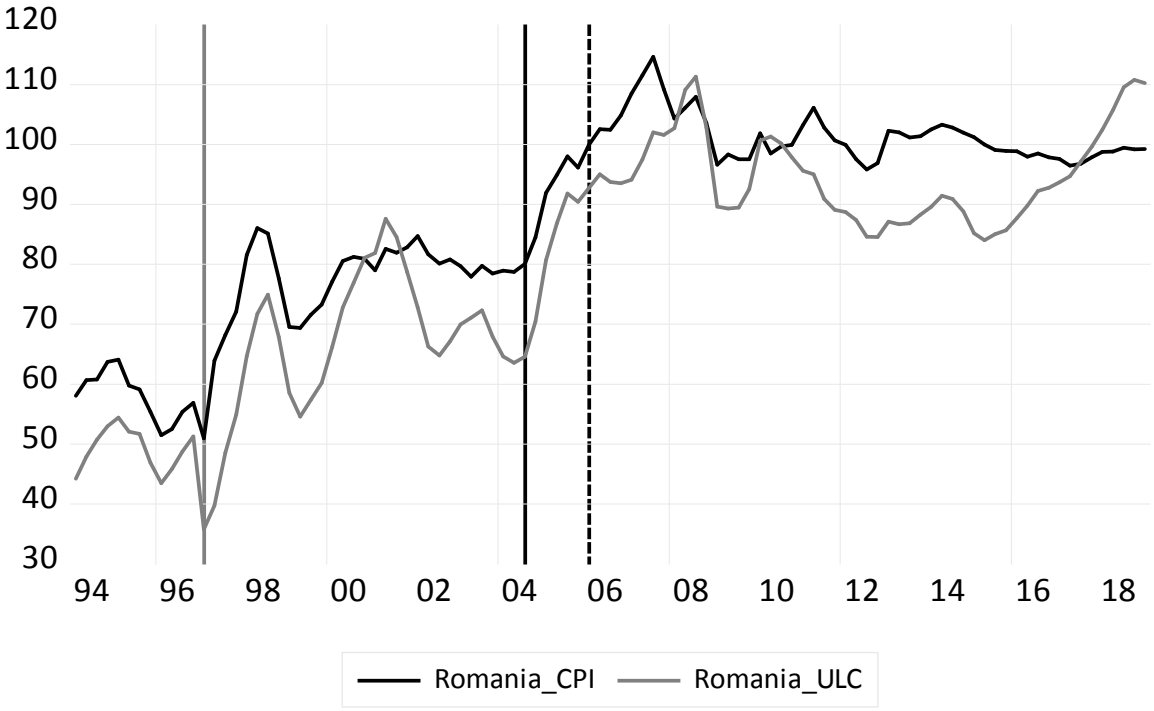
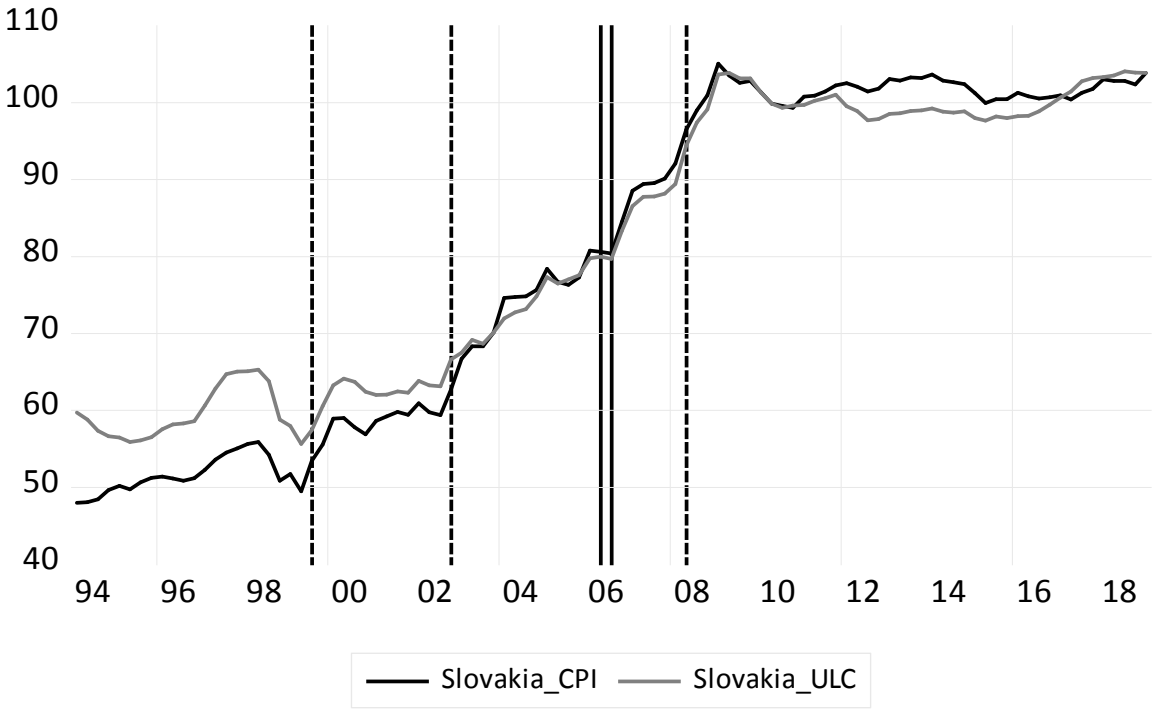


Figure 5: Real exchange rates and break dates (continued)

Note: Vertical lines are the breaks obtained with the different models. Solid lines are the breaks with the ADF with breaks test and dashed lines are the Bai and Perron method.



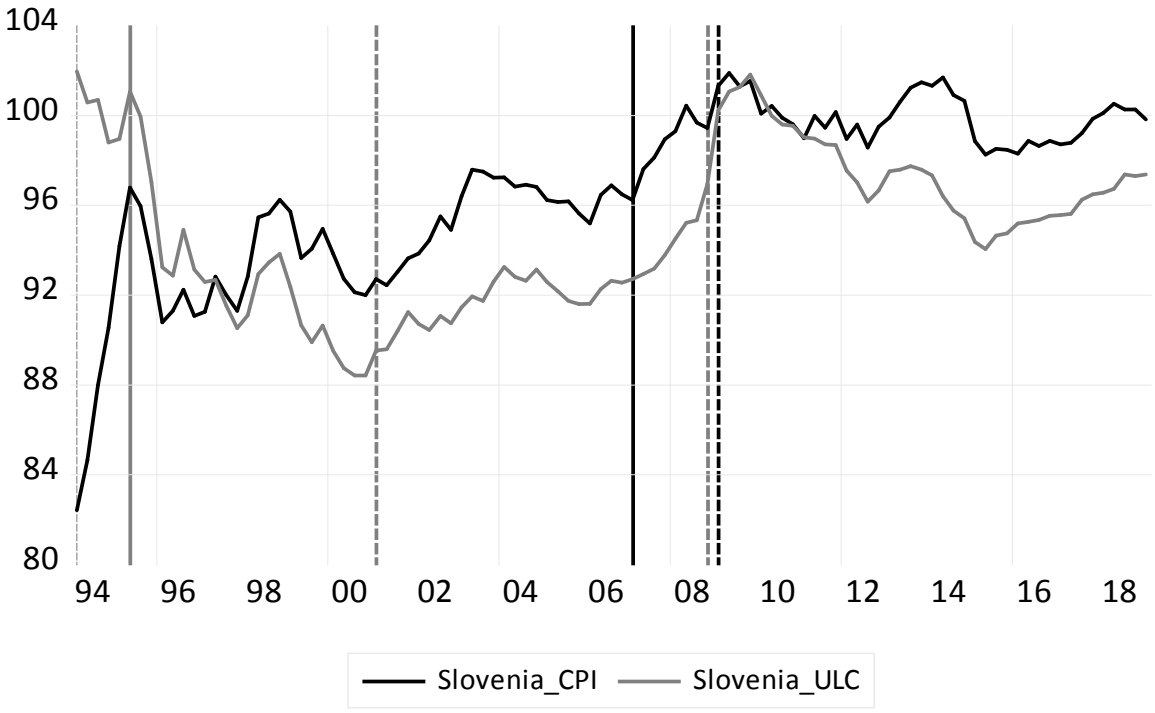


Figure 5: Real exchange rates and break dates (continued)

Note: Vertical lines are the breaks obtained with the different models. Solid lines are the breaks with the ADF with breaks test and dashed lines are the Bai and Perron method.

6. Conclusion

Analysis of the evolution of competitiveness in the CEECs gathered momentum when the countries were hit by the great recession. Since these countries have emerged from a profound process of transformation into market economies, shocks may still have quite negative consequences, and their inability to devalue in order to gain competitiveness could pose some economic difficulties. Hence this paper seeks to shed some light on the evolution of the RER as a measure of relative competitiveness.

To do this, we apply a traditional linear unit root test with structural breaks, and we estimate equations with structural breaks. The latter lets us see how all the coefficients of the regression change after the breaks, which are obtained endogenously.

Overall, we find that the Great Recession made the loss of relative competitiveness smaller, as the RER became flatter and the variable became less stationary, which may imply that deeper surveillance of the evolution of the RERs of these countries is needed.

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