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Estimation of equilibrium exchange rate in CEECs: a rolling window approach

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Abstract

The literature on equilibrium exchange rates for the Central and Eastern European Countries has blossomed in the recent years. The multitude of studies is justified by the fact that, in order to join the Eurozone, these countries have to participate to the ERM II. Therefore, the CEECs are forced to identify a sustainable central parity of their currency to the euro. Accordingly, different approaches and methods have been developed and different variables applied, providing information on the equilibrium exchange rate. However, the empirical researches reached heterogeneous and sometimes contradictory results. We consider that the outcomes of different studies are influenced by the fact that the periods when the currencies were overvalued or undervalued alternated. Therefore, the level of the constructed equilibrium exchange rate might be biased by the choice of the base period. To demonstrate this, we have calculated the real exchange rate based on the PPP theory and we have applied a rolling window approach. Afterwards, we have used a behavioral equilibrium exchange rate (BEER) for a panel of data corresponding to the eight CEECs, candidates to EMU. Our results show that in Latvia and Romania, the nominal exchange rate seems undervalued in comparison with the equilibrium exchange rate, while for the Czech Republic the exchange rate appears as overvalued.

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1. Introduction

The equilibrium exchange rates have consistently drawn the attention of both academic researchers and policy-makers in the last two decades. This is all the more true for the new EU member states of the Central and Eastern Europe (Égert and Halpern 2006). But how can be the equilibrium exchange rate defined? As Kębłowski and Welfe (2010) show, the exchange rate is close to its dynamic equilibrium level when variables crucial to establishing the exchange rate variability keep the specified proportions. Therefore, the equilibrium level of the exchange rate is defined as a value to which consecutive realizations would converge, if the other variables continued their steady states.

Estimating the equilibrium level of the exchange rate, and thus the central parity of CEECs' currencies, is important in the perspective of their accession to the Eurozone, in order to avoid the accumulation of imbalances (Kim and Korhonen 2005). If a new EU member participates to the ERM II and adopts the euro preserving an overvalued currency, it will most likely lose competitiveness. Moreover, an overvalued currency is susceptible to speculative attacks. In the opposite case, when a country joins the ERM II with an undervalued currency, it will experience inflationary pressures, because a fixed exchange rate implies that the expected real appreciation of the currency can only occur through higher inflation.

Nevertheless, identifying the equilibrium exchange rate for the CEECs is not an easy task, given the disparities of the exchange rate regimes in operation in these countries (Desai 1998, Coricelli et al. 2006, ECB, 2010). A short glance at the historical background of the CEECs' currencies evolution reveals that these currencies generally underwent a large initial real depreciation, followed by a sustained and on-going real appreciation (Coudert and Couharde 2002, Égert et al. 2006).

However, these evidences are not unanimously accepted by the academic community. Thus, the empirical methods applied to determine the equilibrium exchange rate grew more and more complex, but the outcomes obtained were not always satisfactory (Sideris 2008). The misalignments of the real exchange rate (RER) reported in literature are systematically influenced, inter alia, by the underlying theoretical concepts such as the Balassa–Samuelson effect, the behavioral equilibrium exchange rate (BEER), the fundamental equilibrium exchange rate (FEER) and the econometric estimation methods (Égert and Halpern 2006, Narayan 2008, Kębłowski and Welfe 2010).

Yet, the most important statistical problems relate, in our opinion, to the relative purchasing power parity approach (PPP) that is usually employed in assessing RER appreciation or depreciation. As Coudert and Couharde (2002) observe, the level of the constructed equilibrium exchange rate might be biased by the choice of the base period. In this context, a major contribution of our paper is the mitigation of this bias by the use of a rolling base period for the calculation of the real exchange rate.

The main purpose of our paper is to determine the equilibrium exchange rate for the eight CEECs, candidates to the Eurozone. The time span covered by the analysis refers to the last period of the transition process (1999-2009, based on annual data). We have calculated the RER using the PPP theory and implementing a rolling window method. Further on, in order to validate the equilibrium exchange rate, we have resorted to a common BEER approach. The rolling base period for the RER calculation allows us to avoid the inconvenience of the out-of-sample method, recently proposed in literature[1].

[1] The out-of-sample method is advanced by some specialists who consider that it is hard to establish an equilibrium exchange rate model for the transition countries and that it is necessary to extrapolate the results obtained for the industrialized countries. In our opinion, this technique does not solve the problem because the characteristics of the CEECs' economic systems differ considerably from those of the industrialized countries.

Another contribution of the paper resides in the use of a panel of data, which include all the Eurozone candidate countries. We have also investigated if there are disparities entailed by the different exchange rate regimes enforced in these countries, as Coudert and Couharde (2002) reported. In addition, in order to complete the overall picture, we have analyzed if the RER significantly deviated from the equilibrium level during the actual crisis period.

The remainder of the paper is structured as follows: section 2 describes the theoretical background in relation with the models and with the econometric techniques applied; section 3 mirrors the methodological issues associated with estimating equilibrium exchange rates in CEECs; section 4 presents the econometric results and section 5 highlights the conclusions.

2. Literature review

The literature on the equilibrium exchange rate in CEECs is wide. As Kim and Korhonen (2005) emphasize, part of these studies focus on the determinants of the exchange rates, while others aim at estimating the equilibrium exchange rate. In their turn, Grossmann and McMillan (2010) argue that certain studies focus on modeling the real exchange rate, which is viewed as a deviation from the PPP equilibrium, whereas another line of researches gather around modeling the relative PPP, hence backing out the equilibrium exchange rate. All these studies reveal a multitude of available econometric models and techniques to serve this purpose.

The empirical models of the equilibrium exchange rates have to consider on the one hand, the conditions specific to individual economies and, on the other hand, the available size of the time-series. We will further on briefly describe the main models encountered in literature.

The FEER model, whose bases were laid in 1994 by J. Williamson, is one of the most popular models (Égert and Halpern 2006, Saayman 2007, Rubaszek and Rawdanowicz 2009). The FEER is a macro-model based approach, where the equilibrium exchange rate is given by the real exchange rate, which causes the current account to move towards its long-term sustainable target (Aubin et al. 2003). The FEER is defined as a level of the RER that is consistent with the simultaneous attainment of internal and external equilibrium. In most studies, the internal equilibrium is defined as closed output gap, or as a successful policy of inflation targeting and the external equilibrium as the current account equal to its exogenously set target (Hallett and Richter 2004). Estimating the FEER normally requires the use of a complete macroeconomic model or of a partial equilibrium model, approaches which are both met in literature (Saayman 2007).

However, the FEER approach needs a normative judgment regarding the size of long-term capital flows, as well as a complex macroeconomic model, as we have already mentioned. In this context, a more accessible method was developed by Clark and MacDonald (1998), namely the behavioral equilibrium exchange rate (BEER). The BEER models are mostly empirical in nature and usually not very strict and explicit about underlining theoretical frameworks. As Égert and Halpern (2006) show, the BEER approach can be thought of as a statistical approach which aims to link the real exchange rate to a set of economic fundamentals. It splits the normative aspects of exchange rate modeling from behavioral aspects (Saayman 2007). A large description of the BEER models was made by Yajie et al. (2007) and Melecky and Komarek (2008)

The growing empirical literature on equilibrium exchange rates for the CEECs has predominantly applied these two approaches. Still, methods derived from these models can also be encountered: permanent equilibrium exchange rate (PEER), desired equilibrium exchange rate (DEER) or capital enhanced equilibrium exchange rate approach (CEECH), the latter being described in detail by Kębłowski and Welfe (2010).

We have chosen to develop our analysis based on a BEER approach, this method being the most common applied for the CEECs. We consider that the FEER approach can be seen as normative, in the sense that it delivers an equilibrium exchange rate consistent with ideal economic conditions. Another drawback of the FEER approach, which may be even more pronounced if it is applied to transition economies, refers to the determination of the sustainable current (or capital) account or of the sustainable external debt level (see Maeso-Fernandez et al. 2005, and Bénassy-Quéré et al. 2009). Furthermore, changes in productivity are not directly accounted for in this approach, but the catching-up process and the Balassa–Samuelson hypothesis are central behind the argument of an equilibrium real appreciation of transition countries' currencies and thus very relevant in the present context (Aubin et al. 2003).

Beside the choice of the appropriate empirical model to identify the equilibrium exchange rate, it is also important to resort to the appropriate econometric techniques. Therefore, it has to be investigated if it is to prefer a panel type analysis, time-series, fixed effects or pool mean group (PMG) or if the co-integration technique better applies.

First, the selection of panel data or of time-series analysis has to be debated. In case of the CEECs, both approaches can be used, each of them entailing advantages, as well as inconveniences. For studies resorting to panel data, both the fixed effects technique and that of dynamic heterogeneous panel model can be encountered. The second method is based on the pool mean group estimator, developed by H. Pesaran, R. Smith and K. Im in 1996. Other studies apply the panel co-integration techniques (Mark and Sul 2002).

For the CEECs, a considerable part of researchers believe that it is hard to estimate the equilibrium exchange rate and consequently, in order to calculate it, they borrow models tested on industrialized countries. Thus, authors as Maeso-Fernandez et al. (2005), Égert et al. (2006) or Maeso-Fernandez et al. (2006) propose a two-stage "out-of-sample" strategy that consists of estimating the relationship between the exchange rates and fundamentals and the extrapolation of these relationships to transition economies. Nevertheless, important discrepancies appear in this case which are related, in our opinion, to the different structure of the economic systems in the two groups of countries, making hence the comparisons inadequate.

As a result of the short data sample available for the CEECs and due to the need to generalize the results, our paper retains the panel data approach. We employ thus fixed effects and "in-the-sample" strategy. It is recommended to use the fixed effects to avoid the bias of the correlation between variables. In addition, the fixed effects model also solves the problem of unmodeled heterogeneity. Moreover, Maeso-Fernandez et al. (2006) note that the fixed effects in a panel regression collect all idiosyncratic information, i.e. all information that is specific to each unit in the sample. As a consequence, fixed-effect models cannot be used for "out-of-sample" projections. Therefore, to escape this inconvenience, we have decided to use a rolling window estimation for the RER. Applying this method also helps annihilating the problem of intervention effects which might affect the exact determination of the RER.

3. Real exchange rate in CEECs

3.1. Methods for the calculation of the RER

In order to calculate the RER, most studies refer to the purchasing power parity (PPP) approach. There are only few papers, such as Melecky and Komarek (2008), using the real uncovered interest parity (UIP) approach to determine the RER. The concept of PPP can be thought of as a very long-term approach for countries in the catching-up process (Égert

2005). According to the PPP approach, the RER is the nominal exchange rate (e) times the ratio of the Euroland price level (P*) to the local price level (P). In other words:

$$RER = e\frac{P^*}{P} \tag{1}$$

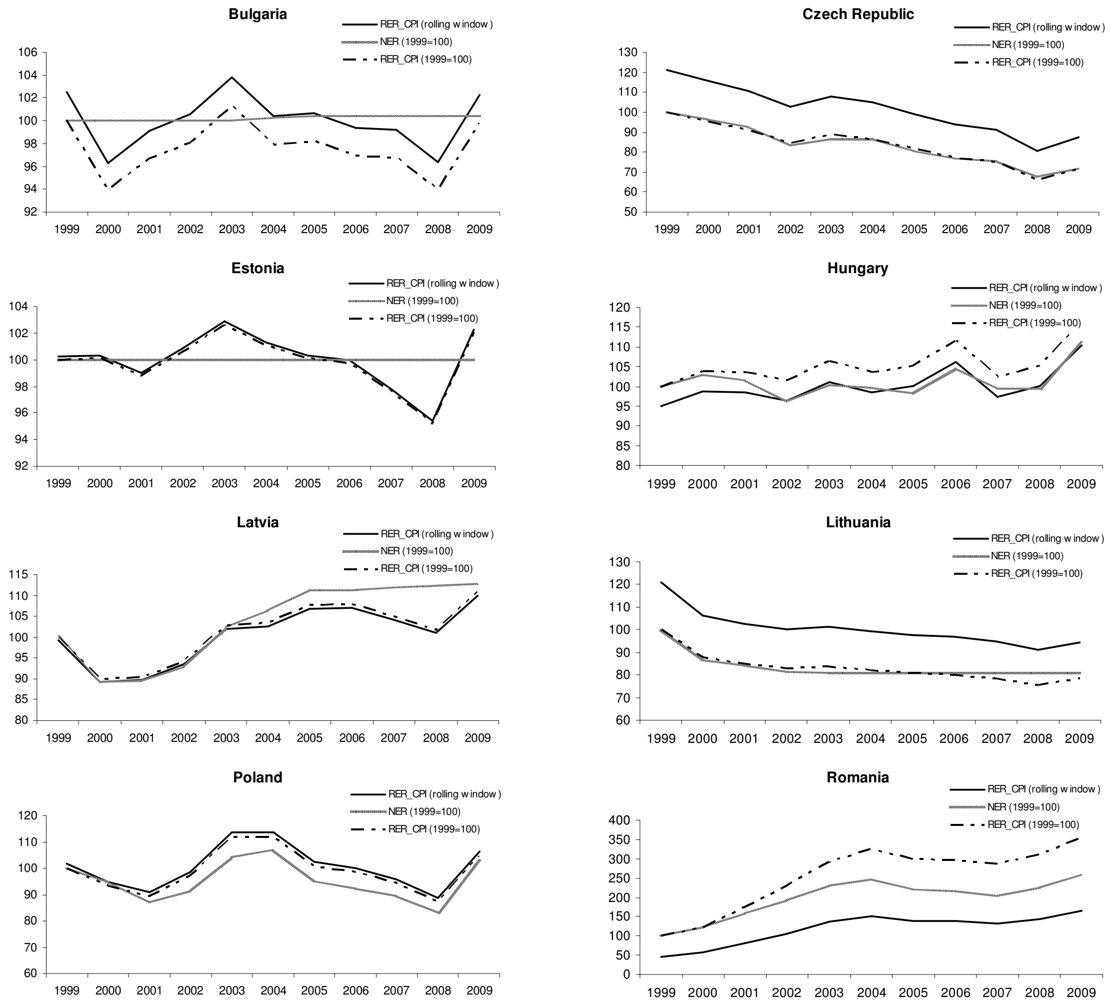
It can thus be noted that the real exchange rate denotes the ratio of prices of foreign goods to prices of domestic goods, expressed in domestic currency. An increase in real exchange rate index is associated with the currency depreciation, based on the aforementioned formula.

Following the method advanced by Grossmann and McMillan (2010), we have used a rolling base period and we have obtained 11 different equilibrium exchange rates starting with the first base period (1999). The average across all of the 11 such constructed equilibrium exchange rate series provides the equilibrium exchange rate, based on a rolling base period. Thus, by averaging a rolling equilibrium exchange rate, we have basically considered the whole sample period as a base period, which assumes that the relative PPP holds, at least over the sample period under consideration.

3.2. General RER patterns in CEECs

The dynamic process of the nominal exchange rate (NER) and real exchange rate in CEECs (calculated in the classical way, as well as following the proposed approach) is reflected in Figure 1.

Figure 1. **The nominal and real exchange rate in CEECs**



Source: ECB Database and International Financial Statistics (IMF)

Figure 1 indicates the presence of at least two different patterns in the Eurozone candidate countries. First of all, we can notice some differences between the RER, calculated based on the classical method (the first year of the sample –1999 in our case– considered as an RER equilibrium year), and the RER trend, computed based on the rolling window approach, in the case of Romania, Lithuania and Czech Republic.

Second, the "theoretic" RER appreciation calculated based on the PPP approach is not linked to the fixity of the exchange rates, as Coudert and Couharde (2002) and Ho et al. (2010) underline. Thus, we have observed that a divergent trend of the real exchange rate can be noticed during the analyzed period. For example, while the Czech Republic knew a strong appreciation, Romania experienced a real depreciation of its currency.

4. Empirical analysis

4.1. Data

Two categories of variables are used in literature in respect of the exchange rate determinants which cover the long-term variables, which influence the value of the currency, and the short-term variables, which have a transitory impact (Yajie et al. 2007). The BEER model can include these two types of variables, but the accent falls on the variables with a short run influence. In their turn, Kim and Korhonen (2005) consider that there are domestic supply-side factors associated with the long-run equilibrium real exchange rate, particularly variables relating to the Balassa–Samuelson effect. Fiscal policy measures, such as changes in the composition of government spending, may also affect the equilibrium exchange rate.

In an attempt to satisfy both classifications, we propose as determinants of the equilibrium real exchange rate an exhaustive list of variables which have been used in literature by different researchers. Table 1 presents these variables, their calculation method, the expected sign (taking into account the fact that an increase of the RER is associated in our case with a depreciation of the exchange rate) and the database from which the respective variable was taken.

We can acknowledge the fact that the main employed variables, encountered in most of the studies, are: GDP per capita as a proxy for Balassa–Samuelson effect, the price level differential, the interest rates differential, the trade openness and the net foreign assets. These variables frame within the aforementioned categories. An important variable, of which we did not make use in our paper, refers to the terms of trade but, as Kim and Korhonen (2005) show, the GDP per capita can be considered as a proxy for the terms of trade. There are also certain variables which are expressed in natural logarithm.

Table 1. Data description

Variable	*Sign*	*Description*	*Database*	*Literature*
log(gdpcap) – GDP per capita	-	It represents a *proxy* for Balassa-Samuelson effect. An increase of the GDP/capita is associated with productivity increase and exchange rate appreciation.	IFS (IMF)	Yajie et al. (2007); Călin (2004); Kim and Korhonen (2005)
log(cpd) – price convergence	-	It is the degree of price convergence with EMU. The real exchange rate appreciates along with price convergence.	Eurostat	Călin (2004)
log(open) – trade openness	+/-	Openness is obtained as the average of exports and imports of goods relative to GDP.	IFS (IMF)	Yajie et al. (2007); Égert (2005); Melecky and Komarek (2008)
log(fagdp) – foreign assets to GDP	-	It represents a *proxy* for net foreign assets to GDP. It stands for the assets of foreign banks to total banking assets.	EBRD	Rubaszek and Rawdanowicz (2009); Saayman (2007)
log(lpd) – labor productivity level	+	It shows the labor productivity level, as percentage to the Eurozone level (*proxy* for Balassa-Samuelson effect). Bigger this level is, smaller the productivity differential becomes.	Eurostat	Melecky and Komarek (2008)
ird – real interest rate differential	+/-	If the interest rate on the interbank market grows more in CEECs than in the EMU, this leads to capital inflows and currency appreciation.	ECB	Călin (2004); Saayman (2007)
log(fer) – foreign exchange reserves to GDP	+/-	An increase in foreign exchange reserve implies high demand for domestic currency, resulting in the real exchange rate appreciation. Accretion of reserves can however occur because of the currency depreciation risk.	IFS (IMF)	Saayman (2007); MacDonald (2000)
log(conp) – private consumption to GDP	+	The increase of private consumption is associated with currency depreciation, CEECs being import-oriented countries.	IFS (IMF)	Yajie et al. (2007)
log(m2) – money supply to GDP	+	An increase in money supply would cause the real exchange rate to depreciate.	Eurostat	Yajie et al. (2007); Călin (2004)
fb – fiscal balance	+/-	Depreciation might occur because improved fiscal balance would normally induce a less-than-proportional reduction in private saving.	Eurostat	Saayman (2007)
ier – importance of exchange rate regime	+/-	It indicates the importance of the exchange rate regime. It takes the value 0 for the currency board, 1 for pegs, 2 for crawling pegs, 3 for managed float and 4 for independent float.	-	Călin (2004)
cris – dummy variable	+	This is a dummy variable for the present crisis, taking the value 1 in 2008 and 2009 and the value 0 in the other periods.	-	Égert (2005)

4.2. Econometric results

From a behavioral perspective, we expect that the actual real exchange rate is in equilibrium when its movements reflect changes in those fundamentals of the economy which are related to the actual real exchange rate.

The general equation we have tested is the following:

$$\log(rer\_cpi_t) = c + \alpha Z_t + \varepsilon_t \qquad (2)$$

where: $log(rer\_cpi)_t$ – is the natural logarithm of the real exchange rate, calculated based on CPI; Z_t – represents the vector of the explanatory variables described in Table 1; ε_t – are the errors of the model.

The variables whose coefficients proved insignificant were eliminated from the equation in the second phase. Thus, the final tested equation retained for the calculation of the equilibrium real exchange rate is:

$$\log(rer\_cpi_t) = c + \alpha Y_t + \varepsilon_t \tag{3}$$

where: $log(rer\_cpi)_t$ – is the natural logarithm of the real exchange rate, calculated based on CPI; Y_t – represents the vector of the explanatory variables, namely the interest rate differential, price convergence, private consumption to GDP, trade openness, money supply to GDP and a dummy variable for the crisis period; ε_t – are the errors of the model.

In order to check the robustness of the analysis, we have also tested the equation 4, where RER is calculated based on the producer price index (PPI), using equally a rolling windows. The equation shows the same shape as the previous, with the only exception that the PPI is considered instead of CPI.

$$\log(rer\_ppi_t) = c + \alpha Y_t + \varepsilon_t \tag{4}$$

where: $log(rer\_ppi)_t$ – is the natural logarithm of the real exchange rate, calculated based on PPI.

The centralized econometric results are presented in Table 2 below.

Table 2. Results of econometric tests

Variables	***Equation (2)*** **log(rer_cpi)**	***Equation (3)*** **log(rer_cpi)**	***Equation (4)*** **log(rer_ppi)**
ird?	-0.0187***	-0.0191***	-0.0137***
log(cpd?)	-1.0666***	-0.9765***	-0.9392***
log(gdpcap?)	0.0694		
log(conp?)	0.9772***	1.0924***	0.6006*
log(lpd?)	0.4349***	0.4789***	0.3413**
log(fer?)	0.0624		
log(fagdp?)	-0.0818		
log(open?)	-0.3159***	-0.2949***	-0.2876***
log(m2?)	0.1524*	0.2107**	0.23035**
fb?	0.0005		
ier?	-0.0175		
cris?	0.0522*	0.0616**	0.0602**
Fixed Effects			
_BU--C	3.3147	2.5066	4.8176
_CZ--C	3.7742	2.9504	5.1494
_ES--C	3.9630	3.1449	5.3622
_HU--C	3.7031	2.8659	5.1604
_LI--C	3.6729	2.8618	5.1728
_LV--C	3.6895	2.8783	5.1310
_PL--C	3.6349	2.7674	5.0374
_RO--C	4.1541	3.3087	5.4241
R^2	0.87	0.86	0.71
DW	1.16	1.15	1.14

Note: *, ** and ***, mean statistic relationship significant at 10%, 5% respectively 1%.

The results in the above table reveal that the real interest rate differential between CEECs and the Eurozone influences the equilibrium exchange rate. Thus, if the interest rate on the interbank market is higher in CEECs than in the EMU, an appreciation of their domestic currencies occurs. The level of price convergence also has a significant impact on the equilibrium exchange rate. Therefore, as prices converge towards the level of prices in the

EMU, the real exchange rate appreciates, and reversely, the decrease of the price convergence level causes the depreciation of CEECs' currencies.

Private consumption to GDP influences in its turn the equilibrium exchange rate of CEECs. The indicator "governmental consumption / GDP" is usually encountered in literature. Personally, we consider "private consumption to GDP" as a more appropriate indicator because, in the analyzed period, the private consumption played a determinant role in the economic boom recorded by these countries. Hereby, the increase of private consumption is associated with the currency depreciation since CEECs are import-oriented countries.

The ratio between the levels of the labor productivity in CEECs to the Eurozone productivity level can be regarded as a *proxy* for Balassa-Samuelson effect. Higher average productivity growth in the domestic, relative to the foreign economy, is typically expected to result in an appreciation of the domestic currency, mainly due to higher domestic inflation, as a result of faster wage inflation. In other words, an increase of the productivity differential between CEECs and the Eurozone leads to an appreciation of the exchange rate in these countries, underlining the presence of Balassa-Samuelson effect (this result is in accordance with that obtained by Călin 2004).

The openness of the economy is rather associated with a depreciation of the exchange rate and the outcomes of our tests confirm it. Still, an opposite sign associated to the coefficient of this variable could have been equally registered. A relatively higher degree of openness predisposes a given country to more efficient transfers of knowledge and technology, either in a direct or indirect form. It also enables the country to benefit from its comparative advantages to a higher degree (Melecky and Komarek 2008). All these elements can result into the exchange rate appreciation.

The increase of money supply is related to price increase and, consequently, to exchange rate depreciation. As Yajie et al. (2007) show, an increase in the money supply would cause the real exchange rate to depreciate and a reduced money supply would determine the exchange rate to appreciate.

Finally, we observe that the dummy variable we have incorporated in the equation is significant. This indicates that the exchange rate in CEECs tends to depreciate during the present crisis period. It is easy to understand such an outcome, having in view the burden of speculative pressure which affected the CEECs' currencies, mainly in 2008.

5. Conclusions

In view of the heightened attention dedicated to the assessment of equilibrium exchange rates in CEECs, this paper shows that there are important pitfalls in computing the equilibrium exchange rates based on the PPP theory in the classical way (considering that the exchange rate is in equilibrium for the first year of the sample). Consequently, the use of a rolling window approach helps avoiding certain methods previously developed to correct the initial deficiencies, as they are not entirely satisfactory either (e.g. "out-of-the-sample" approach).

The RER calculation based on the rolling window method emphasizes the fact that in certain CEECs, namely Latvia and Romania, the exchange rate seems undervalued in comparison with the equilibrium exchange rate, while for the Czech Republic the exchange rate appears as overvalued.

We have applied a classical model for these countries, hence the BEER model. As econometric technique, the OLS estimation using fixed effects was selected, due to the specificity of the data included in the analysis. The results indicate that, amongst the variables retained in the analysis, significant influence is carried by the price differential, the interest rate differential and the labor productivity differential. At the same time, trade openness and money supply impact upon the equilibrium exchange rate.

To check the robustness of the outcomes, we have also used the RER calculated based on the PPI. Its trend is similar to that of the RER calculated based on the CPI, showing that the Balassa-Samuelson effect is not the only element responsible for RER appreciation in case of CEECs.

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