Purchasing Power Parity and Cointegration: Evidence from Latvia and Slovakia[1]

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Abstract

This paper deals with the analysis of the purchasing power parity between Latvia and the euro area and between Slovakia and the euro area using the Engle-Granger and Johansen cointegration techniques. Latvia and Slovakia became members of the European Union in May 2004 and have been already the members of the Exchange Rate Mechanism II (ERM II) preparing for the euro adoption. The whole analysis was done on monthly data covering the period January 1999 – May 2008. Both the Engle-Granger and the Johansen method did not confirmed the purchasing power parity (PPP) validity in both analysed cases.

Keywords: *exchange rates, harmonized index of consumer prices (HICP), purchasing power parity, cointegration, Engle-Granger method, Johansen method*

JEL Classification: F31

Introduction

The European Union (EU) is one of the largest economies in the world. It consists of 27 Member States and has a population of 493 million. The greatest expansion of the EU took place on 1st May 2004 when 10 new countries (Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, the Slovak Republic and Slovenia) acceded to the EU. Bulgaria and Romania are the latest members, having joined on 1st January 2007. The adoption of the euro (i.e. the entrance into the Economic and Monetary Union – EMU) has become an

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important issue for all new EU Member States which are committed to ultimately adopting the euro after fulfilment of the convergence criteria among them the exchange rate stability and price stability. The exchange rate stability is connected with the membership in the Exchange Rate Mechanism II (ERM II) for at least two years. The exchange rate of the national currency against the euro must not fluctuate around the central parity more than ±15% during the ERM II membership. Estonia, Lithuania and Slovenia became ERM II members already on 28th June 2004, Latvia, Cyprus and Malta on 29th April 2005 and Slovakia on 28th November 2005 and fixed the central parities of the national currencies to the euro.

Some of these countries have already complied with all the convergence criteria and joined the EMU – Slovenia on 1st January 2007, Cyprus and Malta on 1st January 2008, and Slovakia is going to join the EMU and adopt the euro on 1st January 2009.

Another convergence criterion is the price stability measured by the inflation rate. The relationship between the development of the exchange rate and the national price levels represents an essence of the purchasing power parity (PPP) theory.

Purchasing power parity is one of the key doctrines in international economics. Many open economy macroeconomic models use PPP as a long-run equilibrium condition. PPP represents a simple relationship between exchange rate, domestic prices and foreign prices. PPP states that the equilibrium or long-run exchange rate between two countries is equal to the ratio of their relative price levels.

The concept of PPP is generally attributable to the Swedish economist Gustav Cassel, who formulated the approach in 1920s. Cassel's theory represents a synthesis of the work of the nineteenth-century British economists, among them David Ricardo (the originator of the theory of comparative advantage). The testing of the PPP has become popular in 1970s since the advent of the flexible exchange rates. Before the mid-1980s tests of PPP concentrated on parameter restrictions using the ordinary and generalized least squares methods. Around the mid-1980s, tests of PPP started to take new directions, which was connected with the sharp progress in econometrics for nonstationary time series. The studies have started to use the concept of stationarity (testing for unit roots) and cointegration. Some of the latest studies use also the panel techniques to solve the problem of the short sample size analyzing the time series data from a large number of countries (see e.g. Sideris, 2005). The analysis of the PPP testing the long-run relationship between the exchange rate and national price levels has become a very important and interesting issue also for the countries which plan to adopt the euro.

The main aim of this paper was to analyse the validity of the PPP in countries which participate(d) in ERM II in 2008 (January – July) and are preparing for the entrance into the EMU, i.e. in Baltic States (Estonia, Latvia and Lithuania) and in the Slovak Republic.[2] In Estonia and in Lithuania, the Monetary Authorities committed themselves to retain the exchange rate of Estonian kroon against the euro and Lithuanian litas against the euro, respectively, unchanged at the central parity rate during the ERM II membership in order to maintain the stability and other benefits of a fixed exchange rate regime. In case of Latvia, the Bank of Latvia unilaterally limits the lat's exchange rate against the euro to ±1% of the central rate. The central parity of the Slovak koruna against the euro in ERM II changed two times (the possible fluctuation was ±15% around the central parity). On 8th July 2008 the conversion rate between the Slovak koruna and the euro was set at 30.1260 SKK/EUR, which corresponded to the central parity of the Slovak koruna against the euro within the ERM II at that time.

Since the exchange rates of the Estonian kroon and Lithuanian litas against the euro do not change within the ERM II, the paper concentrates on the analysis of the PPP between the Latvian lat and the euro and between the Slovak koruna and the euro using the cointegration techniques (the Engle-Granger two-step method and the Johansen procedure). The analysis was done on monthly data for the period January 1999 – May 2008 in order to capture the period after introducing the euro as a virtual currency for cash-less payments and accounting purposes in 11 Member States.

1. Theoretical and Methodological Issues

1.1. The PPP Formulation

In its simplest form the absolute PPP states that the exchange rate between two currencies must equal to the ratio of price levels in these countries. Let P_t^* denote the price level in a foreign country, P_t the corresponding price level in a domestic country and E_t the nominal exchange rate defined as the domestic price of a foreign currency in time t. Then the following equation can be used to describe the PPP relationship:

$$E_t = \frac{P_t}{P_t^*} \tag{1}$$

[2] Denmark is a Member State participating in the ERM II with a special status which grants the right to choose whether or not to adopt the euro. Denmark and the United Kingdom use the so-called "opt-out clause", which means that they do not yet wish to become part of the euro area.

or alternatively as

$$P_t = E_t . P_t^* \tag{2}$$

which means that the price levels in all countries must be the same when measured in the same currency (the law of one price). If we denote F_t the domestic value of the foreign price level, i.e. $F_t = E_t . P_t^*$, the PPP of the form (2) can be written (after rearranging) in the following form:

$$F_t = P_t \tag{3}$$

The PPP can be also formulated in terms of the real exchange rate Q_t which should equal to 1 when the absolute PPP holds:

$$Q_t = E_t . \frac{P_t^*}{P_t} \tag{4}$$

The whole analysis is usually done for logarithmic transformations (denoted by small letters of variables) of the above mentioned equations. Equations (1), (3) and (4) rewritten in the empirically testable forms are as follows:

$$e_t = \theta_0 + \theta_1 \left(p_t - p_t^* \right) + \xi_t \tag{5}$$

$$f_t = \varphi_0 + \varphi_1 p_t + \varepsilon_t \tag{6}$$

and

$$q_t = e_t + p_t^* - p_t \tag{7}$$

where e_t denotes the logarithm of the exchange rate E_t, p_t and p_t^* logarithms of the price levels in domestic (P_t) and foreign country (P_t^*), f_t the logarithm of the domestic value of the foreign price level (i.e. $f_t = e_t + p_t^*$) and q_t logarithm of the real exchange rate Q_t. θ_0, θ_1, φ_0 and φ_1 are unknown parameters, ξ_t and ε_t are error terms reflecting any short-run deviations from the long-run equilibrium caused by stochastic shocks.

The long-run PPP is said to hold if the real exchange rate q_t defined in (7) is stationary. To test the stationarity of q_t various methods can be used. However the analysis is usually done using the Augmented Dickey-Fuller (ADF) test or Phillips-Perron (PP) test (see e.g. Bahmani-Oskooee and Barry, 1997; Chocholatá, 2005, 2007; Enders, 1995; Harris, 1995; Rublíková, 2003).

The analysis of the PPP validity based on cointegration theory uses usually either the Engle-Granger two-step method or the Johansen procedure (see e.g. Bahmani-Oskooee and Barry, 1997; Chocholatá, 2007; Enders, 1995; Harris, 1995; Islam and Ahmed, 1999; McNown and Wallace, 1990; Rublíková, 2003;

Sideris, 2005). If the PPP holds, the variables in equation (5) and (6), respectively must be cointegrated and the estimated parameters θ_1 and φ_1, respectively must equal to 1.

1.2. Nonstationarity and Cointegration

As it was already mentioned above, the early studies dealing with the testing of PPP used the ordinary or generalized least squares to estimate the PPP model. Later developments of econometrics in the area of nonstationarity have shown that the majority of the economic variables is nonstationary. The problem, which arise in this context is that in case of nonstationary variables the standard t-statistic can not be used to infer the significance of estimated coefficients. To avoid this issue, the cointegration approach was developed. The essence of the cointegration approach is based on analyzing whether a linear combination of nonstationary variables is stationary.

The Engle-Granger Method

The Engle-Granger method (Engle and Granger, 1987) is the simplest and nowadays widely used cointegration approach for a bivariate system defined e.g. by the equation (6). In the first step of this method the variables f_t and p_t are tested for their order of integration using e.g. the ADF or PP test. We can distinguish the three cases which will either lead us to the next step or will suggest stopping the procedure (see e.g. Asteriou and Hall, 2007; Lukáčik, Lukáčiková and Szomolányi, 2007):

- if both variables are integrated of the same order (with exception of stationarity) which requires the cointegration concept, we can proceed with the next step,
- if both variables are stationary, i.e. I(0), the classical regression analysis can be applied (we do not need to follow the cointegration concept),
- if the variables are integrated of different order, it is possible to conclude that they are not cointegrated (for more information on this area see e.g. Enders (1995).

After identification that the variables f_t and p_t are integrated of the same order d (in economics usually $d = 1$), we can estimate the long-run PPP equation (6) by the standard regression method. In case of cointegration the residuals obtained from this equation must be integrated at an order less than d.[3] The residual sequence from this equation can be denoted by $\hat{\varepsilon}_t$. We can then perform e.g. the ADF test taking into account that the residual sequence $\hat{\varepsilon}_t$ comes from a regression equation, so we do not need to include an intercept term nor a time trend, i.e.

[3] Many authors use the term cointegration to refer to the case in which both variables are I(1), so that there exist a linear combination that is I(0), i.e. stationary.

$$\Delta\hat{\varepsilon}_t = \delta\hat{\varepsilon}_{t-1} + \sum_{i=2}^{n}\delta_i\Delta\hat{\varepsilon}_{t-i+1} + \vartheta_t \tag{8}$$

Since the residual sequence $\hat{\varepsilon}_t$ is generated from a regression equation it is not appropriate to use the "classic" ADF tables. The adequate critical values are in comparison to the "classic" ADF values more negative and can be found in Mc Kinnon (1991). The acceptance of the null hypothesis that the residual sequence $\hat{\varepsilon}_t$ contains a unit root means, that the variables f_t and p_t are not cointegrated and the PPP relationship does not hold. This is because, in this case, any short-run deviation from the PPP relationship will be cumulative and permanent and that the variables will not have a common trending relationship (Islam and Ahmed, 1999). The rejection of the null hypothesis also implies that the variables are cointegrated (i.e. confirmation of the long-run equilibrium relationship between these variables).

If the variables f_t and p_t are cointegrated, the residuals from the equilibrium regression (6) can be used to estimate the error-correction model (ECM) expressing the dynamics of the equilibrium relationship between the two variables. The ECM connecting the short-run and long-run effects of the variables can be in general written as:

$$\Delta f_t = \mu + \gamma\varepsilon_{t-1} + \psi_1\Delta f_{t-1} + \ldots + \psi_p\Delta f_{t-p} + \omega_0\Delta p_t + \omega_1\Delta p_{t-1} + \ldots + \omega_q\Delta p_{t-q} + \nu_t \tag{9}$$

where f_t and p_t are nonstationary I(1) variables which are cointegrated, ε_{t-1} is the stationary lagged residual representing the deviations from the long-run equilibrium (6), ν_t is a white noise disturbance term, μ, $\psi_1,\ldots,\psi_p$, $\omega_0,\ldots,\omega_q$ are unknown parameters of the ECM model and γ represents the speed of adjustment parameter.

In the last step of this procedure it is necessary to evaluate the model adequacy. Enders (1995) presents several diagnostic tests which can be used in order to determine whether the estimated ECM is appropriate.

The Johansen Method

The application of the Engle-Granger method is adequate in a bivariate system (one cointegrating vector). In case of more than two variables there may occur more than one cointegrating relationships which the Engle-Granger method can not treat.[4] Johansen (1988) developed a more general technique applicable also in case of more than two variables (for *N* number of variables we

[4] For broad discussion about the drawbacks of the Engle-Granger approach see e.g. Asteriou and Hall (2007).

can have only up to $N-1$ cointegrating vectors). The Johansen cointegration method is based on maximum-likelihood estimation procedure which enables to capture the feedback effects between variables and is independent of the choice of endogenous variable.

The Johansen procedure is based on a vector autoregression (VAR) representation of a vector of *N* stationary variables, $\mathbf{X_t}$ ($t=1,\ 2,...,T$) as follows:

$$\mathbf{X_t} = \mathbf{\Pi_1 X_{t-1}} + \mathbf{\Pi_2 X_{t-2}} + \ldots + \mathbf{\Pi_k X_{t-k}} + \phi\mathbf{D_t} + \mathbf{u_t} \tag{10}$$

where $u_1, u_2, ..., u_T$ are *N*-dimensional i.i.d. normal variables, $\mathbf{D_t}$ contains a set of conditioning variables (e.g. constant, seasonal dummies) and the $\mathbf{X_t}$ is a vector of all the endogenous variables in the system. In this paper the vector $\mathbf{X_t}$ is of dimension $N = 2$ because it contains two endogenous variables f_t and p_t defined in equation (6).

In case that all variables in $\mathbf{X_t}$ are nonstationary and achieve stationarity after being differenced once, the model (10) can be rewritten in the form of vector error correction model (VECM) as follows:

$$\mathbf{\Delta X_t} = \mathbf{\Gamma_1 \Delta X_{t-1}} + \mathbf{\Gamma_2 \Delta X_{t-2}} + \ldots + \mathbf{\Gamma_{k-1} \Delta X_{t-k+1}} + \mathbf{\Pi X_{t-1}} + \phi\mathbf{D_t} + \mathbf{u_t} \tag{11}$$

where

$\mathbf{\Gamma_i} = -\mathbf{I} + \mathbf{\Pi_1} + \mathbf{\Pi_2} + \ldots + \mathbf{\Pi_k}$ $(i=1,\ 2,...,k-1)$ and $\mathbf{\Pi} = -(\mathbf{I} - \mathbf{\Pi_1} - \mathbf{\Pi_2} - \ldots - \mathbf{\Pi_k})$.

The $\mathbf{\Pi}$ matrix ($N \times N$) contains information regarding the long-run relationship. The rank *r* of this $\mathbf{\Pi}$ matrix, where $0 < r < N$ will determine the number of cointegrating vectors in the VAR system. We can define two matrices $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ (both $N \times r$) such that $\mathbf{\Pi} = \boldsymbol{\alpha\beta}'$ where $\boldsymbol{\alpha}$ includes the speed of adjustment coefficients and $\boldsymbol{\beta}$ is the long-run matrix of coefficients (each column of this matrix corresponds to one cointegrating vector).

Johansen developed a methodology that aims to test the rank of the $\mathbf{\Pi}$ matrix in (11). We can distinguish three different cases (see e.g. Asteriou and Hall, 2007; Lukáčik, 2007; Patterson, 2000):

1. When $\mathbf{\Pi}$ has a full rank (i.e. $r = N$), then the variables in $\mathbf{X_t}$ are I(0). The VAR model should be used in levels to model this case.

2. When the rank of $\mathbf{\Pi}$ is zero then there are no cointegrating relationships and it is appropriate to use the VAR model in first differences.

3. When $\mathbf{\Pi}$ has a reduced rank (i.e. $r < N$) and therefore there are $r < N$ cointegrating relationships. The VAR model should be formulated as the VECM.

In the first step of the Johansen approach it is necessary to test for the order of integration of the variables using e.g. the ADF test. In the next step we have to find the appropriate lag length of the VAR model (all variables in levels) using e.g. Akaike information criterion (AIC), Schwarz criterion (SC) or likelihood ratio (LR) test. The selected VAR model should also pass all the residual diagnostic tests.

Another important issue is whether to include an intercept and/or a trend in either the short-run model (the VAR model) or the long-run model (the cointegrating equation – CE), or in both models. The appropriate model can be chosen applying the so-called Pantula principle which is based on testing of the joint hypothesis of both the rank order and the deterministic components (see Asteriou and Hall, 2007; Giot and Petitjean, 2004; Johansen, 1992). It is common to decide among the three out of the five cases of the possible model specifications (see Asteriou and Hall, 2007; Harris, 1995; Lukáčik, 2007; Patterson, 2000):[5]

Model 2: Intercept (no trend) in CE – no intercept in VAR,

Model 3: Intercept (no trend) in CE and VAR,

Model 4: Intercept and trend in CE – no trend in VAR.

The model selection is based on values of the test statistics testing the hypothesis that $\mathbf{\Pi}$ is less than full rank matrix, i.e. $r < N$. The testing procedures determining the number of cointegrating relationships are based on two likelihood test statistics known as the trace test statistic (λ_{trace}) and maximal eigenvalue test statistic ($\lambda_{\max}$) which are defined as follows[6]:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{N} \ln(1-\hat{\lambda}_i) \tag{12}$$

and

$$\lambda_{\max}(r, r+1) = -T \ln(1-\hat{\lambda}_{r+1}) \tag{13}$$

where T is the number of usable observations. The null hypothesis in the first case (λ_{trace}) is that the number of cointegrating vectors is less than or equal to *r*, while in the second case ($\lambda_{\max}$) we test the null hypothesis, that the rank of $\mathbf{\Pi}$ equals *r* against the hypothesis that the rank is $r+1$. Both statistics are distributed as χ^2 with appropriate degrees of freedom $(N-r)$ where *N* is the number of endogenous variables and *r* denotes the value of the rank under the null hypothesis.

The Pantula principle is also based on estimation of all three above presented models and presentation of the results from the most restrictive alternative (i.e. $r = 0$ and Model 2) through the least restrictive alternative (i.e. $r = N-1$ and Model 4). The model selection procedure comprises of moving from the

[5] The models are marked as in EViews. The use of models 1 and 5 is from the economic theory point of view unusual (Model 1: No intercept or trend in CE or VAR and Model 5: Intercept and trend in CE – linear trend in VAR).

[6] More information about the structure of hypothesis tests for cointegrating rank can be found e.g. in Patterson (2000).

most restrictive alternative towards the least restrictive one, to compare at each stage the rank test statistic to its critical value and only stop when the first time the null hypothesis is not rejected.

An important characteristic of the Johansen method is that it enables testing for the possible linear restrictions regarding coefficients of the matrices $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$.[7]

2. Empirical Issues

In this section we try to analyse the validity of the PPP using the cointegration techniques (Engle-Granger method and Johansen method). We analysed the price and exchange rate monthly data for Latvia and Slovakia for the period January 1999 – May 2008 (113 observations). The price levels P_t and P_t^* are defined as the harmonized indices of consumer prices in domestic country (Latvia, Slovakia) and foreign country (euro area), respectively in time t relative to a base month (January 1999 = 1.00). E_t refers to an index of the domestic currency price of foreign exchange (LVL/EUR and SKK/EUR, respectively) relative to the same base month. The domestic value of the foreign price level F_t was calculated as described above. The whole analysis was done on the logarithmic transformation of the variables P_t and F_t using the equation (6). The data for analysis were obtained from the Eurostat web-page (epp.eurostat.ec.europa.eu) and the European Central Bank web-page (www.ecb.int), the whole analysis was done in econometric software EViews 5.1.

2.1. Engle-Granger Method: Cointegration Results

In the first step of this method we tested the variables f_t and p_t for their order of integration using the ADF test (see Table 1).

Table 1
ADF Test Results for Variables f_t and p_t

	Level			1st Difference
	trend and intercept	*intercept*	*neither trend nor intercept*	*trend and intercept*
Latvia				
f_t	–2.887128	0.310466	0.697841	–7.451581***
p_t	2.452016	6.836923	11.82367	–9.397838***
Slovakia				
f_t	–2.261290	–0.998073	–1.168929	–7.562946***
p_t	–2.325429	–2.730611	2.720396	–9.678821***

Note: The symbol *** denotes the rejection of the null hypothesis on the 0.01 significance level.
Source: Own calculation using EViews 5.1.

[7] For more details about testing linear restrictions in Johansen approach see e.g. Enders (1995).

The values of the ADF statistics indicate that both variables in both countries have one unit root, i.e. have a character of I(1). Since the variables from equation (6) are integrated of the same order, we can proceed in testing whether they are cointegrated. We can estimate the long-run PPP equation (6) by the standard regression method (simple OLS – Ordinary Least Squares) and then apply the ADF test on the residual sequence $\hat{\varepsilon}_t$ using the equation (8). The estimated equations (6) are as follows:

Latvia: $f_t = -0.085387 + 0.894911 p_t$

Slovakia: $f_t = 0.078942 - 0.132156\ p_t$

The analysed residuals $\hat{\varepsilon}_t$ were both for Latvia and Slovakia nonstationary with corresponding ADF statistics –1.135463 and –1.875175, respectively.[8] From the nonstationary character of the residuals in both countries it is clear that the variables are not cointegrated a therefore the PPP could not hold.

2.2. Johansen Method: Cointegration Results

In this step we tested the PPP validity in the above mentioned countries using the Johansen maximum-likelihood estimation procedure. Since the variables f_t and p_t were in part 2.1 identified in both countries to be integrated of the order 1, i.e. I(1), we can proceed with the Johansen procedure in order to find out if the variables are cointegrated.

After identification of the same order of integration of the analysed variables in both countries it follows the determination of the optimal lag length of the unrestricted VAR model. The optimal lag lengths identified by AIC, SC and LR are in Table 2 (as we use the monthly data, the maximal lag length considered was 12).

Table 2

Optimal Lag Length of the Unrestricted VAR

	AIC	SC	LR
Latvia	6 lags	1 lag	8 lags
Slovakia	2 lags	1 lag	2 lags

Source: Own calculation using EViews 5.1.

Table 2 indicates that the used information criteria suggested different appropriate lag lengths. In such cases the literature (see e.g. Patterson, 2000) recommends for VAR and VEC models to use the Schwarz criterion (SC). We also

[8] The regression with the reversed order of variables of the form $p_t = \varphi_0 + \varphi_1 f_t + \varepsilon_t$ was also estimated. The residuals $\hat{\varepsilon}_t$ from this alternative equation were also identified as to be nonstationary in both countries.

re-estimated the VAR with a lag length of 1 both in case of Latvia and Slovakia. The VAR residual serial correlation Lagrange Multiplier (LM) test values for 1 lag were 13.66906 and 11.94394, respectively which indicates the existence of the serial correlation on the significance level 0.01 and 0.05, respectively. We therefore proceeded to include 2 lags into the VAR model in both cases.[9]

The appropriate model regarding the deterministic components was chosen applying the so-called Pantula principle. The procedure of the appropriate model selection is based on the fact that we move from the most restrictive model (named Model 2),[10] at each stage comparing the trace or the maximal eigenvalue test statistic to its critical value, stopping (and therefore choosing the model) only when the null hypothesis is not rejected for the first time (see Asteriou and Hall, 2007; Giot and Petitjean, 2004; Harris, 1995; Johansen, 1992). The results from the estimated models for both countries are in Table 3.

Table 3

The Pantula Principle Test Results

r	N – r	Model 2	Model 3	Model 4
Latvia				
		Trace statistic		
0 1	2 1	35.31879 (20.26184) 0.901508 (9.164546)#	22.51281 (15.49471) 0.571611 (3.841466)	38.98027 (25.87211) 16.76892 (12.51798)
		Maximal eigenvalue statistic		
0 1	2 1	34.41728 (15.89210) 0.901508 (9.164546)#	21.94119 (14.26460) 0.571611 (3.841466)	22.21135 (19.38704) 16.76892 (12.51798)
Slovakia				
		Trace statistic		
0 1	2 1	29.24995 (20.26184) 3.089615 (9.164546)	12.73574 (15.49471)# 0.898622 (3.841466)	28.13728 (25.87211) 11.02650 (12.51798)
		Maximal eigenvalue statistic		
0 1	2 1	26.16034 (15.89210) 3.089615 (9.164546)	11.83712 (14.26460)# 0.898622 (3.841466)	17.11078 (19.38704) 11.02650 (12.51798)

Note: The MacKinnon-Haug-Michelis 0.05 critical values are in parentheses. The symbol # indicates the first time that the null hypothesis can not be rejected on the 0.05 significance level.

Source: Own calculation using EViews 5.1.

From the results in Table 3 it is clear that the appropriate model is in case of Latvia the Model 2 with one cointegrating vector (which could mean the confirmation of the PPP validity), while in case of Slovakia the Model 3 with no cointegration apparently excludes the validity of the PPP.

[9] These models already fulfilled the condition of no serial correlation.

[10] The above defined Model 1 and Model 5 were not considered here since they are not likely to happen (see e.g. Asteriou and Hall, 2007; Giot and Petitjean, 2004; Patterson, 2000).

Since the model specification without a constant term in VAR (Model 2 in case of Latvia) is very unlikely, we used the Model 3 indicating also the existence of one cointegrating vector. The estimated VECM (based on Model 3) for Latvia considering one cointegrating vector and 2 lags is as follows:

$$\Delta f_t = -0.000498(f_{t-1} + 10.971 p_{t-1} - 1.884) + 0.374\Delta f_{t-1} - 0.177\Delta f_{t-2} - \\ -0.261\Delta p_{t-1} + 0.244\Delta p_{t-2} + 0.002$$

$$\Delta p_t = 0.002009(f_{t-1} + 10.971 p_{t-1} - 1.884) + 0.037\Delta f_{t-1} - 0.090\Delta f_{t-2} + \\ + 0.035\Delta p_{t-1} - 0.001\Delta p_{t-2} + 0.005$$

The construction of the VECM enables to synthesise the statistical short-run dynamic relationships and long-run equilibrium relationships. The long-run information in above presented equations is included in parenthesis (normalized cointegrating vector) and the remaining terms (variables in first differences) represent the short-run dynamics. The coefficients –0.000498 and 0.002009 of the lagged residual are the speed of adjustment coefficients representing also the stability of the system. The absolute values of these coefficients are less than one, which indicates that the system is stable (see Islam and Ahmed, 1999). The values of the speed of adjustment coefficients are very small and indicate that only 0.0498% and 0.2009%, respectively, of any deviation from the long-run equilibrium is corrected within a month.

Finally we tested the residuals of this VECM model using the LM (Lagrange Multiplier) test and Urzua normality test.[11] Since the LM (2) = 5.553, are the residuals till the lag 2 uncorrelated (the order of 2 for the LM test was determined by the optimal lag structure which was earlier identified to be of order 2). The Urzua normality test is a multivariate extension of the Jarque-Bera residual normality test, which compares the third and fourth moments of the residuals to those from the normal distribution. The Jarque-Bera statistics and corresponding p-values (in parentheses) for individual components are 12.079 (0.002) and 0.165 (0.921) respectively. The joint test statistic (p-value in parenthesis) based on residual covariance Urzua orthogonalization is 13.646 (0.136). This means that although the hypothesis that the residuals from the first VECM equation are normally distributed can be rejected on significance level 0.2%, the hypothesis that the residuals are multivariate normal could not be rejected. The detected deviation from normality does not render the cointegration tests invalid (see Islam and Ahmed, 1999).

[11] For more precise information about these tests see e.g. EViews 5 User's Guide.

Conclusion

The main aim of this paper was to test the PPP validity between Latvia and the euro area and between Slovakia and the euro area using the two approaches of the cointegration theory – the Engle-Granger method and the Johansen method. The whole analysis was based on equation (6). The application of the Engle-Granger method based on OLS estimation showed that the residuals from equation (6) were for both countries nonstationary, and therefore the PPP could not hold. The use of the Johansen method based on maximum-likelihood estimation gives more interesting results. The cointegrating relationship between variables f_t and p_t was in case of Slovakia not confirmed which means the rejection of the PPP validity. In case of Latvia there was identified one cointegrating relationship and therefore the appropriate VECM was estimated and the residuals of this model were tested using the tests for uncorrelatedness and normality. Although the existence of one cointegrating relationship in Latvian case could speak for the PPP validity, the fact that the long-run coefficient $\hat{\varphi}_1 = -10.971$ was clearly different from 1, speaks for rejection of the PPP in case of Latvia as well.

The fact that the presented results do not support the PPP validity is not surprising and one of the main reasons could be faster growth of non-tradable to tradable prices in both analysed countries in comparison to relative prices of the euro area (the Balassa-Samuelson effect). In case of Latvia also the fixed exchange rate regime may account for deviations from the long-run PPP. In case of Slovakia Maeso-Fernandez et al. (2006) pointed out the fact that the initial central parity of the SKK/EUR exchange rate (1 EUR = 38.4550 SKK), which changed twice during the in ERM II membership, was rather far away from its equilibrium value. The dynamics of this exchange rate can be therefore characterised by the reduction of the initial disequilibrium, which may make the impression that there is no long-run relationship between analysed variables.

The problematic validity of the PPP theory was identified by several authors dealing with the PPP analysis for transition countries, inter alia, Benčík et al. (2005), Christev and Noorbakhsh (2000), Boršič and Bekö (2006) and Sideris (2005).

Benčík et al. (2005) analysed the Balassa-Samuelson effect in the Slovak Economy in 1995 – 2004. They pointed out several problems why the PPP doesn't hold and the presence of the Balassa-Samuelson effect can provide one of the possible explanations. Christev and Noorbakhsh (2000) who use the cointegration approach to analyse the PPP validity in six central and east European countries (Bulgaria, Czech Republic, Hungary, Poland, Romania and Slovakia) in 1990 – 1998 identified the productivity shocks, inflexible exchange rate regimes, non-tradable goods and services, slower domestic price adjustments to world prices and restrictive monetary policy to be responsible for the deviations from the long-run equilibrium. The invalidity of PPP found in the study of Boršič and Bekö (2006), who analysed the PPP validity for Slovenia and Hungary in 1992 – 2001, was caused by the real appreciation of the national currencies of Slovenia and Hungary. Sideris (2005) who tested the PPP validity for seventeen European countries in transition (including both Latvia and Slovakia) states that productivity shocks, non-tradable goods and services and managed exchange rate regimes may account for deviations from the long-run PPP.

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