Testing the Purchasing Power Parity: Evidence from the New EU Countries

*Minoas Koukouritakis**
Department of Economics, University of Crete
University Campus, Rethymno 74100, Greece

Testing the PPP for the New EU Countries

Abstract

This paper examines the validity of the purchasing power parity between each of the twelve new EU countries vis-à-vis the Eurozone. Using the Johansen cointegration methodology for a period that begins from the mid-1990s and allowing for a structural break for the countries that joined the EU on May 2004, it is found that there is a long-run equilibrium relationship among the nominal exchange rate, the domestic prices and the foreign prices, for all the new EU countries. The evidence also suggests that the PPP vector enters the cointegration space for Bulgaria, Cyprus, Romania and Slovenia, which means that only for these countries the long-run PPP vis-à-vis the Eurozone is verified. For the rest of the new EU countries the long-run PPP is violated, may due to the fact that the currencies of these countries have been pegged to the euro and cannot reflect the inflation differences vis-à-vis the Eurozone.

JEL Classification: F15, F42

Keywords: Purchasing Power Parity, EU Enlargement, Cointegration, Structural Break, Symmetry and Proportionality.

* Corresponding author: Department of Economics, University of Crete, University Campus, Rethymno 74100, Greece. Tel: +302831077435, fax: +302831077406, e-mail: minoas@econ.soc.uoc.gr . All the remaining errors are my own.

1 Introduction

On May 1, 2004, the EU has experienced its biggest expansion ever in terms of scope and diversity. Ten countries, namely Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, the Slovak Republic and Slovenia, joined the Union. On January 1, 2007, Bulgaria and Romania also joined the EU. In order to successfully join the EU these countries had to satisfy certain economic and political criteria, which include being stable democracies, respect human rights as well as having a functioning market economy.

Except for Malta and Cyprus, all the above former centrally planned economies faced many challenges during the pre-EU accession period. In the late 1990s, most of them pegged their currencies to the euro in order to strengthen their case for the EU accession. Most of these countries have already become members of the Exchange Rate Mechanism (ERM) II and plan to apply for Eurozone membership in the near future[1]. On the other hand, most of these countries are still facing serious inflation problems. These features provide an interesting research field of the purchasing power parity (PPP) for these countries.

The validity of the PPP has been extensively tested, especially for developed countries (see for example Froot and Rogoff (1995), Frankel and Rose (1996), Lothian and Taylor (1997, 2000)). In general, these studies concluded that the PPP holds in the long-run. For the transition economies, the validity of the PPP has been tested by Thacker (1995) and Solakoglu (2006). The former study uses a cointegration approach and rejects the PPP hypothesis for Hungary and Poland, while the latter one, which uses a panel approach, concludes that the PPP holds for the transition economies.

In this paper I use the most recent data available from the mid-1990s to the present and the Johansen et al. (2000) cointegration methodology in the presence of structural breaks, to test the PPP hypothesis for the twelve new EU countries. I also test the symmetry and proportionality restrictions implied by the long-run PPP. In brief, the evidence suggests that even though the nominal exchange rate, the domestic prices and the foreign prices are cointegrated for all the new EU countries, the long-run PPP hypothesis holds only for Bulgaria, Cyprus, Romania and Slovenia.

The rest of the paper is organized as follows. Section 2 describes briefly the PPP hypothesis. Section 3 describes the data and analyses the empirical results. Section 4 contains some concluding remarks.

2 PPP and Cointegration

The PPP is based on the law of one price, which states that in the absence of trade barriers, such as transportation costs, transaction costs and tariffs, competition will equalize the price of an identical and traded good across countries, when the prices are expressed in the same currency. This implies that the general level of prices, when converted to a common currency, will be the same in every country. Let E_t be the nominal exchange rate, defined as the number of units of the domestic currency needed to purchase one unit of the foreign currency, P_t the domestic price level and P_t^* the foreign price level. The strongest form of the PPP, which is called the absolute PPP, can then be expressed as $E_t = P_t / P_t^*$. Log-linearizing this expression we get $e_t = p_t - p_t^*$, where the lower case letters denote the variables in their natural logarithms. Most empirical tests of the PPP test the following linear relationship

$$e_t = \beta_0 + \beta_1 p_t + \beta_2 p_t^* + u_t \quad , \tag{1}$$

where u_t is a zero mean error term.

In the cointegration framework, the long-run PPP can be expressed as the cointegrating relationship among the nominal exchange rate, the domestic prices and the foreign prices, with the cointegrating vector being $\beta' = (1, -1, 1)'$. However, the long-run relationship may hold without the above proportionality restriction, allowing for free coefficients of the domestic and foreign prices and a free intercept shown in equation (1), which can be interpreted as the mean of the real exchange rate. In the next section empirical tests on the PPP for the twelve new EU countries vis-à-vis the Eurozone will be performed.

3 Data and Empirical Results

All the data of the present study were obtained by the European Central Bank. The sample is comprised of monthly data of varying time spans determined by data availability. The sample period is 1995:1 to 2006:12 for the Czech Republic, Estonia, Hungary, Lithuania, Romania, Slovakia and Slovenia, 1996:1 to 2006:12 for Cyprus, Latvia, Malta and Poland and 1997:1 to 2006:12 for Bulgaria. For nominal exchange rates I used euro rates[2] (i.e. units of domestic currency per euro), for domestic prices the harmonized consumer price index (HCPI) for each country and for foreign prices the HCPI for the Eurozone.

Before testing for cointegration, I tested the natural logarithm of each of the above time series for unit roots. For the Czech Republic, Cyprus, Estonia, Hungary, Malta, Latvia, Lithuania, Poland, Slovakia and Slovenia, which joined the EU on May 2004, I used the test proposed by Lanne et al. (2002), in order to allow for a structural break on that date. For Bulgaria and Romania that joined the EU on January 2007, the Augmented Dickey-Fuller (ADF) test was used. The lag length in

both tests was chosen based on minimizing the Akaike's information criterion. As shown in Table 1, I failed to reject the unit root hypothesis for all of the countries in the sample. In all the cases the null hypothesis of a second unit root was also tested. This hypothesis was rejected in all cases[3].

Having established that the nominal exchange rates and the prices indices can be taken as $I(1)$, I proceeded with the cointegration analysis, based on the Johansen multivariate framework. For each country a different vector error-correction model (VECM) was set up. In order to estimate equation (1), the Model 1* of Johansen (1994) was selected, which allows for an intercept in the cointegrating relations:

$$\Delta Y_t = \Pi \begin{pmatrix} Y_{t-1} \\ 1 \end{pmatrix} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t \quad , \qquad t = 1...T \quad , \tag{2}$$

where Π and Γ_i are $p \times p$ matrices of coefficients and ε_t is a $p \times 1$ multivariate normal random error vector with mean vector zero and variance matrix Ω that is independent across time periods. To select the appropriate lag length of each VECM, I started from a maximum length of lag $k = 12$ and I used the likelihood ratio test. Under the hypothesis $\Gamma_k = 0$, the likelihood ratio test is asymptotically distributed as χ^2 with p^2 degrees of freedom; see Johansen (1995, p. 21). Further, I allowed for a structural break in the VECM on May 2004, for the ten countries that joined the EU on that date[4].

The Trace statistics, along with the 5 percent critical values of Johansen et al. (2000) and the MacKinnon et al. (1999), are reported in Table 2. Based on these results, the null hypothesis of no cointegration $(r = 0)$ is rejected for all the countries of the sample. The evidence suggests that for Cyprus, the Czech Republic, Malta, Poland, Romania, Slovakia and Slovenia there is a unique cointegrating vector. For Bulgaria, Estonia, Hungary, Latvia and Lithuania, the null hypothesis of one

cointegrating vector $(r=1)$ is rejected at the 5 percent level of significance, which implies that may exist more than one cointegrating vectors in these cases. These results imply that the nominal exchange rate (e_t), the domestic prices (p_t) and the foreign prices (p_t^*) share a long-run equilibrium relationship, for all the countries of the sample. They also imply that there exist $p-r$ common stochastic trends that "drive" the co-movements of the variables.

The next step in the present analysis is the investigation of whether the PPP vector $\beta' = (1,-1,1)'$ spans the cointegration space. If the PPP vector enters the cointegration space, it implies that the long-run PPP is verified. In other words, the nominal exchange rate will move one-by-one with the relative prices in the long-run. To perform this test, I used the following likelihood ratio (LR) test statistic (see Johansen, 1995):

$$LR = -T\sum_{i=1}^{r} \ln\left[\left(1-\hat{\lambda}_i^*\right)\Big/\left(1-\hat{\lambda}_i\right)\right] , \qquad (3)$$

where $\hat{\lambda}_i^*$ and $\hat{\lambda}_i$ are the calculated eigenvalues of the restricted and the unrestricted models, respectively. Under the null hypothesis of symmetry and proportionality, the LR statistic is distributed as χ^2 asymptotically, with degrees of freedom equal to the number of restrictions imposed. The results are presented in Table 3, which also reports the estimating cointegrating vectors normalized on the nominal exchange rate. Based on the LR test statistic, the evidence suggests that the PPP vector enters the cointegration space for Bulgaria, Cyprus, Romania and Slovenia, which means that only for these countries the long-run PPP vis-à-vis the Eurozone is verified.

On the contrary, the symmetry and proportionality restrictions are rejected for the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland and

Slovakia. This means that for these countries, the nominal exchange rate does not move one-by-one with the relative prices and the long-run PPP is not verified. A possible explanation for these results is that, due to the intention of these countries to join the ERM II and then to the Eurozone, they have tried to stabilize their nominal exchange rates against the euro since the late 1990s, either by pegging their currencies to it (the cases of the Czech Republic, Hungary, Latvia, Lithuania, Malta, Poland and Slovakia), or by establishing a currency board vis-à-vis the euro (the case of Estonia). At the same time, these countries were facing much higher inflations than the Eurozone's, and these inflations differences might not be reflected on their nominal exchange rates, which were not allowed to extremely fluctuate against the euro.

4 Concluding Remarks

In the present analysis, the validity of the PPP for the twelve new EU countries vis-à-vis the Eurozone has been investigated. Using the Johansen cointegration methodology in the presence of a structural break on May 2004 for the ten countries that joined the EU on that date, the evidence suggests that the nominal exchange rate, the domestic prices and the foreign prices are cointegrated, for all the new EU countries. The results also imply that the long-run PPP hypothesis holds only for Bulgaria, Cyprus, Romania and Slovenia, since the symmetry and proportionality restrictions cannot be rejected for these countries.

For the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland and Slovakia, the long-run PPP hypothesis does not hold. A possible explanation for the violation of the PPP for these countries is that the difference between each country's inflation and the Eurozone's inflation may not be reflected in the

respective nominal exchange rate. This may happen because the currencies of these countries have been pegged to the euro since the late 1990s and their nominal exchange rates cannot reflect the inflation differences vis-à-vis the Eurozone.

Notes

[1] Since January 2007, Slovenia has become the thirteenth member of the Eurozone.

[2] For the period through 31/12/1998 I used the ECU instead of the euro.

[3] For the 10 countries, for which I allowed for a structural break on May 2004 due to the EU membership, the Lanne et al. (2002) critical values were used. For Bulgaria and Romania, the critical values were obtained by Davidson and MacKinnon (1993).

[4] All estimations were performed using the JMulTi software (www.jmulti.de) and the related textbook (Lütkepohl and Krätzig, 2004). For the VECMs that allow for a structural break, the critical values for all Trace tests were obtained by computing the respective response surface according to Johansen et al. (2000). For the VECMs with no structural breaks, the critical values were obtained by MacKinnon et al. (1999).

References

Davidson, R. and MacKinnon, J. (1993) *Estimation and Inference in Econometrics*. Oxford University Press, Oxford.

Frankel, J. A. and Rose, A. K. (1996) A panel project on purchasing power parity: mean reversion within and between countries, *Journal of International Economics,* **40**, 209-24.

Froot, K. A. and Rogoff, K. (1995) Perspectives on PPP and long-run real exchange rate, *Handbook of International Economics*, Vol. 3, Elsevier, The Netherlands, pp. 1647–88.

Johansen, S. (1994) The role of the constant and linear terms in cointegration analysis of nonstationary variables, *Econometric Reviews* **13**, 205-29.

Johansen, S. (1995) *Likelihood-based Inference in Cointegrated Vector Autoregressive Models*. Oxford University Press, Oxford.

Johansen, S., Mosconi, R. and Nielsen, B. (2000) Cointegration analysis in the presence of structural breaks in the deterministic trend, *Econometrics Journal* **3**, 216-49.

Lanne, M., Lütkepohl, H. and Saikkonen, P. (2002) Comparison of unit root tests for time series with level shifts, *Journal of Time Series Analysis*, **23**, 667-85

Lothian, J. R. and Taylor, M. P. (1997) Real exchange rate behavior, *Journal of International Money and Finance*, **16**, 945–54.

Lothian, J. R. and Taylor, M. P. (2000) Purchasing power parity over two centuries: strengthening the case for real exchange rate stability, a reply to Cuddington and Liang, *Journal of International Money and Finance*, **19**, 759–64.

Lütkepohl, H. and Krätzig, M. (2004) *Applied Time Series Econometrics*. Cambridge University Press, Cambridge.

MacKinnon, J.G., Haug, A.A. and Michelis, L. (1999) Numerical distribution functions of likelihood ratio tests for cointegration, *Journal of Applied Econometrics*, **14**, 563-77.

Thacker, N. (1995) Does PPP hold in the transition economies? the case of Poland and Hungary, *Applied Economics*, **27,** 477-81.

Solakoglu, E.G. (2006) Testing purchasing power parity hypothesis for transition economies, *Applied Financial Economics*, **16**, 561–68.

Table 1
Unit root tests[a]

	Nominal exchange rates		Domestic prices	
Country	Level	First difference	Level	First difference
Bulgaria	-0.80	-5.36*	-1.63	-5.28*
Cyprus	-2.13	-4.71*	-1.13	-9.42*
Czech Republic	-0.31	-4.82*	-0.61	-5.75*
Estonia	-2.12	-5.05*	-0.05	-4.12*
Hungary	-0.08	-5.19*	-0.12	-4.16*
Latvia	-1.21	-5.57*	-1.45	-4.14*
Lithuania	-2.03	-7.41*	-0.12	-6.32*
Malta	-2.16	-7.02*	-1.66	-4.26*
Poland	-2.24	-8.38*	-0.45	-4.86*
Romania	-0.44	-6.76*	-0.65	-4.23*
Slovakia	-0.79	-6.63*	-1.40	-3.94*
Slovenia	-2.06	-5.38*	-2.27	-4.28*
Eurozone	NA[b]	NA	-1.86	-6.12*

[a] The entry in each cell is the test statistic. * denotes rejection of the unit root hypothesis at the 5% level of significance. [b] NA stands for "Not Applicable". 5% critical value for the unit root test with a structural break is -2.88 (Lanne et al., 2002). 5% critical value for the ADF test is -2.86 (Davidson and MacKinnon, 1993). For the countries of the table, the sample sizes are 120 for Bulgaria, 132 for Cyprus, 144 for the Czech Republic, 144 for Estonia, 144 for Hungary, 132 for Latvia, 144 for Lithuania, 132 for Malta, 132 for Poland, 144 for Romania, 144 for Slovakia, 144 for Slovenia and 144 for the Eurozone.

Table 2
Trace statistics

$(p-r)$	Bulgaria	Cyprus	Czech Republic	Estonia
3	70.85*	56.81*	59.27*	92.57*
2	25.64*	23.77	20.23	38.53*
1	6.14	7.25	6.12	7.03
k [a]	8	9	10	7
$(p-r)$	Hungary	Latvia	Lithuania	Malta
3	80.21*	105.41*	114.98*	61.26*
2	40.80*	33.83*	41.68*	22.41
1	9.10	5.72	7.95	6.24
k	8	8	7	7
$(p-r)$	Poland	Romania	Slovakia	Slovenia
3	66.48*	58.51*	65.66*	163.91*
2	24.66	18.68	22.01	20.71
1	7.71	5.00	7.80	6.39
k	10	3	6	1
Critical values (95%) $(p-r)$	Johansen et al. (2000)		MacKinnon et al. (1999)	
3	41.72		35.19	
2	25.10		20.25	
1	12.47		9.17	

The value reported at the top of each column is for $r = 0$ (i.e. no cointegration), so that $p - r = p$, where $p = 3$ (i.e. the number of variables included). * denotes rejection of the null hypothesis of at most r cointegrating relations at the 5%level of significance. [a] k indicates the lag length in the VECM.

Table 3
Cointegrating vectors and tests for symmetry and proportionality

Country	e_t	p_t	p_t^*	Intercept	Dummy	LR	$P-$value
Bulgaria	1.00	-0.05	0.09	-0.90	NA[a]	1.10	0.294
Cyprus	1.00	-1.00	0.88	0.99	0.03	2.49	0.114
Czech Republic	1.00	-3.71	7.95	-21.23	-0.32	6.28*	0.012
Estonia	1.00	-3.37	5.73	-13.45	-0.02	43.65*	0.000
Hungary	1.00	-3.31	7.09	-22.50	-0.11	19.78*	0.000
Latvia	1.00	1.49	-4.23	12.60	-0.03	8.41*	0.004
Lithuania	1.00	-31.86	12.84	86.82	1.32	30.66*	0.000
Malta	1.00	1.13	-2.26	5.83	0.03	7.06*	0.008
Poland	1.00	6.83	-19.90	55.57	1.80	14.71*	0.000
Romania	1.00	-1.05	0.78	-8.74	NA	0.48	0.486
Slovakia	1.00	-0.57	1.94	-9.84	0.02	4.14*	0.042
Slovenia	1.00	-0.80	0.39	-3.55	-0.03	1.79	0.181

LR stands for the null hypothesis that $\beta^{/} = (1,-1,1)^{/}$ spans the cointegration space and is distributed as χ^2 with degrees of freedom equal to the number of restrictions imposed. [a] NA stands for "Not Applicable".* denotes rejection of the null hypothesis at the 5% level of significance.